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"No Risk No Fun?": Determinants of Satisfaction with Life in People Who Engage in Extreme and High-Risk Sports

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Abstract: (1) Background: In this paper, we attempt to identify which personality and motivational variables significantly influence the sense of quality of life of individuals who practice extreme sports (ES) and high-risk sports (HRS). In addition, we examined to what extent these relationships are moderated by the athletes' gender and experience in a given discipline. (2) Methods: A total of 363 individuals who practice ES or who practice HRS took part in the study. All of the participants were from Poland. Standardized questionnaires were used to measure the investigated personality traits (extraversion, neuroticism, psychoticism), motives, and satisfaction with life, characteristic of the practiced sports. (3) Results: A positive relationship was observed between levels of extroversion and sense of satisfaction with life in the groups of women who engage in HRS (p = 0.045) and men who engage in ES (p = 0.002). The tendency towards addiction was significantly negatively associated with sense of satisfaction with life only in men who engage in ES (p = 0.015). Individuals who engage in ES and HRS did not differ in levels of tendency towards addiction. (4) Conclusions: Individuals who practice ES differ from individuals who practice HRS in terms of personality features, motivations, and the determinants of their sense of satisfaction with life.

Keywords: psychology of sport; wellbeing; motivation

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1. Introduction

The number of people enjoying alternative, often dangerous, sports has been growing in recent years [1,2]. Traditionally, such sport disciplines are referred to as high-risk sports, extreme sports, or adventure sports. They are defined as disciplines that are characterized by an inherent risk of injury (or even death), extremely intense physical effort, and the adventurous character of the undertaken activities [3]. The will to overcome difficulties, experience intense sensations, and control extreme situations is also emphasized [2].

Despite the fact that sports of this kind fascinate recipients and are the subject of scientific research, the attempt to capture the delicate relationships between predispositions, motivation, and life satisfaction still does not provide explicit scientific explanations. The presented paper aims to connect those areas of research.

The first point that needs to be clarified is the terminology used to describe this type of activity. The terms 'high-risk sports' and 'extreme sports' are often used interchangeably to refer to the same disciplines. However, in some cases, they are distinguished on the basis of differences in levels of associated danger. This can be observed mainly in the classifications made by insurance companies, which, using injury statistics, assess the dangers associated with given sports disciplines. According to the definition given by the Ergo Hestia travel insurance company, "extreme sports shall be understood as the participation in the expeditions or excursions to the places characterized by extreme climate or natural conditions [. . .], as well as practicing the sports which require extraordinary skills, courage and operating in high-risk circumstances, often life-threatening [. . .]" [4] (ERGO-Hestia; accessed on 30 June 2022). Cohen, Baluch, and Duffy [2] emphasize the

importance of the empirical assessment of differences between those sports that are defined as extreme and those defined as high risk. Although insurance companies do not define HRS in precise way (they use only a list of disciplines (ERV/Ergo Hestia; Allianzdirect.pl)), HRS are understood as the disciplines that are more dangerous than common sports, less dangerous then ES, and are practiced in urban or non-extreme environments. The types of disciplines are often considered life-style sports (e.g., skateboarding, parkour, or windsurfing), while sports such as mountaineering, combat sports (Muay Thai or MMA), and motor sports would be considered ES. Since there is no clear distinguishing between those two categories among insurance companies, one of the main goals of this study is to determine whether those types of sports should be treated separately. This determination could contribute to better understanding of complexity of the phenomenon of ES and HRS and could also reveal the diversity of the personality determinants in people participating in these sports.

Quantitative exploration of the psychological profile of people who undertake extreme sports has usually examined the temperamental determinants for undertaking this kind of activity. Already by the 1970s, Zuckerman's theory of sensation seeking played the dominant role in explaining the involvement in ES [5]. It suggests that people who engage in HRS and ES are characterized by higher levels of this feature than individuals who engage in other, safer sports disciplines and those who do not engage in sports at all [6]. However, more recent research suggests that individuals who engage in HRS and ES are not a homogenous group in terms of their temperament [7–9]. Kerr and Mackenzie [10] suggest that these discrepancies could be explained by the individual character of different HRS or ES—some activities last for only a few seconds (e.g., bungee jumping), while others may last for months (e.g., mountaineering or sailing solo around the world). Thus, sports in which the performance lasts a few seconds can be considered a source of strong stimulation, while sports in which the action takes much longer are more often associated with the ability to endure discomfort and sometimes even avoid stimulation [11]. Moreover, researchers stress the need to describe the personalities of extreme athletes in terms of a theory and tools different to the sensation seeking scale. Guszkowska and Bołdak [12], as well as Llewellyn, Sanchez, Asghar, and Jones [13], point out that the aforementioned example statement about distinguishing different groups of extreme athletes may be tautological—it is obvious that each individual who engages in such an activity will score high on a scale of seeking adventure and dangerousness, and differences between populations engaging in particular disciplines may not be observed due to a ceiling effect. The above premises, such as basing the diagnosis of the temperament of HRS and ES people on the SSS concept [5] and the current treatment of HRS and ES together, are the rationale for undertaking the presented research.

It can be assumed that, as in the case of personality, the introduction of a distinction between HRS and ES may reveal significant differences in the type of motivation of athletes. Since Mallory's legendary "because it's there" response, the fascination with why people engage in such dangerous activities has become a focus of both the media and researchers. The research in this area relies mostly on hermeneutic qualitative studies [14–17]. Conclusions from these studies indicate that the main motives are associated with overcoming challenges and difficulties, a sense of freedom, development of courage and humility, developing a special bond with nature, getting to know and learning to control one's own emotions, and developing a sense of agency. These conclusions are in contrast to the stereotype often perpetuated by the media that the main (and maybe even only) motivation for undertaking extreme sports (ES) is sensation seeking [18]. Qualitative studies by Ewert, Gilbertson, Luo, and Voight [19] indicate that motivations for taking part in ES can vary depending on the gender of the athlete, the discipline in question, and the athlete's level of experience. These motivations include social behaviors (being in a group, meeting people), seeking sensations, and developing one's self-image. Frühauf et al. [14] indicate that the above motivations can definitely be considered to be psychological benefits of the sport one does, which may translate into a sense of wellbeing in individuals who

engage in ES. However, research to date does not indicate how participation in HRS or ES is associated with a sense of satisfaction with life, especially taking into account gender differences. According to Chang [20], strong engagement in extreme sports is associated with the experience of the state of flow [21], especially for men. Despite the large number of studies describing the motivation of HRS and ES athletes, still few studies focus on the quantitative measurement of motivation and the relationship between motivation and personality traits. The presented study is based on the theory of motivational function of an objective by Zaleski and Lipowski [22,23]. According to this theory, the individual consciously and proactively chooses goals and plans their implementation in order to achieve well-being [22,23]. The key concept in the theory of Zaleski and Lipowski is the concept of goal (objective) in motivation. Zaleski defines objective as "a future state that is cognitively represented, possible to achieve, has a value and regulatory power, and is pursued by an individual through their actions" [23]. According to Zaleski's theory, goals, when they are important for the individual, realistic to achieve, and are consistent with values, constitute a high motivational value and become visible in action.

However, it ought to be stressed that not all studies indicate beneficial consequences of extreme sports. Heirene, Shearer, Roderique-Davies, and Mellalieu [24] point out that extreme athletes, apart from the risk of serious injury, are also at risk of particular types of behavioral addiction [25]. Any time away from sports and obtaining the desired dose of sensation may lead to a withdrawal syndrome, which manifests as irritability and inability to experience pleasure. According to Willig [26], this is associated with a sense of stress and negative affect that may be compared to withdrawal symptoms in people addicted to substances.

The presented study aims to explore two fundamental questions about HRS and ES: who practices these sports and what constitutes the main motivations. Although these topics were often studied from a psychological perspective, they often focused on a single method (Zuckerman's SSS) or explored motivations in a qualitative way. Due to these limitations of the previous studies, we decided to use a questionnaire that examines the biological basis of personality, which in an accurate way (avoiding the ceiling effect) can show the difference between HRS and ES. In addition, a questionnaire was used that quantitatively measures the validity of specific motives for participation in the disciplines in question. What is also important is that there is a lack of research on how the personality profile of HRS and ES practitioners, as well as the motives they choose, translate into their sense of satisfaction with life. In addition, an important reason for undertaking the presented research is to check whether fashion as a motive for undertaking HRS in particular may be related to the fact that people with a lower demand for stimulation can engage in this type of sport.

Present Study

In the present project, we sought to identify which personality and motivation variables are important for sense of satisfaction with life in individuals who engage in extreme sports and high-risk sports. Additionally, we investigated to what extent these relationships are moderated by the participants' genders and their experience in a given sport discipline. Two hypotheses were made: H1—the personality profiles and the motivations of extreme athletes differ from the personality profiles and the motivations of individuals who engage in high-risk sports; H2—personality profiles and motivations have different impacts on satisfaction with life in extreme athletes and high-risk sports athletes.

2. Materials and Methods

2.1. Participants

Participants consisted of individuals who have engaged in high-risk or extreme sports regularly for at least two years (inclusion into HR or ES groups was based on insurance companies' classifications of disciplines as ES or HRS). Selection was purposeful, and the selection criteria were the abovementioned conditions: at least two years of experience of

participation in HRS or ES and regularity of practicing a given discipline. The research was carried out in clubs, associations, and informal groups connecting practitioners of the type of sports discussed. The list of clubs and groups was created on the basis of HRS and ES organizations available in the Pomeranian Voivodeship in Poland. The limitation to Pomeranian Voivodeship was caused by the financial resources allocated to the study, which, due to the fact analysis of sensitive data, was carried out personally by a psychologist in the subject (it was not carried out in an online form). Then, by e-mail or telephone, visits from the person conducting the examination were arranged. A total of 25 clubs and groups were contacted, of which 19 clubs agreed to participate in the study. In addition, in order to reach the largest number of respondents, the snowball method was used, which allowed for the recruitment of additional people. Given the difficulty of determining the size of the entire population of HRS and ES practitioners in the study area, it was difficult to accept a minimal research sample. Therefore, it was decided to reach the largest possible group of HRS and ES enthusiasts. A total of $N = 363$ individuals took part in the study, including $n = 120$ women and $n = 243$ men. The mean age of the participants was $M = 24.20$ years ($min = 16$; $max = 52$; $SD = 5.33$). On average, participants had been practicing their discipline for $M = 5.33$ years ($min = 2$ years; $max = 29$ years; $SD = 3.56$), devoting $M = 25.67$ h to it per month ($min = 4$ h; $max = 100$; $SD = 15.09$). In case of seasonal sports, only athletes who practiced their sport for two months per year were taken into account. Among the participants, $n = 184$ (50.69%) individuals practiced sports categorized as extreme sports (ES), and $n = 179$ (49.31%) individuals engaged in sports categorized as high risk (HRS). The categorization was made on the basis of an insurance companies list (ERV, Ergo Hestia, Allianzdirect.pl) and the assessment of competent judges ($N = 5$), specifically, experienced, retired extreme sportsmen who helped to decide about the categorization in conflict cases (e.g., snowboarding was considered HRS because participants were not practicing the freeride form of this sport). The following disciplines were categorized as high risk on the basis of insurance companies' classifications: parkour, BMX, skateboarding, snowboarding, windsurfing, kitesurfing, and boxing. The following disciplines were classified as extreme sports: MMA, Muay Thai, Krav Maga, kickboxing, mountaineering, freeride skiing/biking, motocross, off-road, parachuting, and paragliding. The following categories of disciplines were practiced by the participants: city (skateboarding; roller skating, parkour), $n = 80$; motor (off-road, motocross), $n = 18$; aerial (parachuting, paragliding), $n = 32$; cycling (freeride, downhill), $n = 40$; martial arts (MMA, Muay Thai, Krav Maga, Brazilian jiu-jitsu, kickboxing), $n = 76$; water (wakeboarding, kitesurfing, skimboarding, mountain kayaking), $n = 56$; winter (freeride skiing, snowboarding), $n = 32$; and mountain (Himalayan mountaineering, alpinism, mountaineering) sports $n = 29$.

All subjects signed a consent form in order to participate in the study. In the case of participants under 18 years old, additional consent from their parents was obtained. The study was reviewed by The Ethics Board for Research Projects at the Institute of Psychology, University of Gdańsk, no. 8/2014.

2.2. Instruments

The Polish adaptation [27] of Eysenck's Personality Questionnaire (EPQ-R) was used [28] to assess innate predispositions for taking part in extreme sports. The EPQ-R questionnaire was used because it refers to biological determinants of temperament. Furthermore, it was important for the measurement tools used in this study to be sensitive to the entire spectrum of the variability of a variable, in order to reveal potential differences within a group. Taking this into account, we chose not to use Zuckerman's Sensation Seeking Scale (SSS) [29], which, as has already been described in the theoretical part of this paper, often yields extremely high results in the case of extreme athletes. The EPQ-R measures (1) Extraversion; (2) Neuroticism; (3) Psychoticism; (4) Lying; (5) Addiction; and (6) Criminality. Participants responded to 106 questions (e.g., Do you like meeting new people? Do you suffer from insomnia?) by providing an answer of yes or no, depending on whether the sentence referred to their personality. The raw scores were converted to

sten norms, which were interpreted as follows: 1–3 low score; 4–7 mean score; 8–10 high score [30]. All of the listed scales had Cronbach's alphas above 0.75.

The Inventory of Physical Activity Objectives (IPAO) [22,31] was used in order to determine motives for involvement in extreme and high-risk sports. The respondent answers questions regarding their involvement in competitive sports (both present and previous) as well as the forms and intensity of their physical activity. The IPAO includes 12 objectives that are accompanied by a Likert scale (1–5), and the respondent is asked to assess the importance of the listed objectives, where 1 stands for completely unimportant and 5 for very important. After consulting competent judges and the authors of the original questionnaire, a list of 12 motivations was adjusted from original instrument to better suit the specifics of HRS and ES. Preliminary pilot studies showed that subjects often added missing, specific motives for HRS and ES, while rarely evaluating goals no. 10, 11, and 12 as important. On the other hand, with goal 6—pleasure from physical activity, they often added the comment that the feelings accompanying HRS and ES, although associated with pleasure, are more associated with thrill and adrenaline. After consultation with the competent judges and authors of the original questionnaire, it was decided that we would replace questions 6, 11, and 12 with the more adequate ones proposed by the experts and the pilot group. We decided to leave question 10 unchanged due to its possible adequacy to fashionable HRS. Their importance was assessed by the subjects: (1) a fit, shapely body (beauty, sculpted and firm body); (2) physical fitness, being 'in shape'; (3) the company of other people; (4) managing stress; (5) escape from everyday life; (6) extreme experiences, adrenaline (changed from 'pleasure from physical activity'); (7) boosting one's confidence, overcoming one's weaknesses; (8) health and wellbeing; (9) fashion; (10) gaining the appreciation of peers, wanting to prove oneself; (11) being together with nature (changed from 'fulfilling the need for activity'); and (12) finding the limits of human ability (changed from 'promoting physical activity'). Additionally, if the goal which was the most important for a given participant was not on the list, there was the option to add it. After a participant identifies their most important goal, they then assess 18 statements selecting the most applicable answers on a scale from 1 to 5. In addition to measuring the attitude of the subjects towards particular goals, the individual scores on the Likert scales are summed up. The final score indicates the importance of the heterogeneity of the objectives one sets. The Cronbach's α reliability coefficient for this version was 0.78. The IPAO questionnaire was used because it allows for the precise assessment of the importance of selected motivations. Importantly for the current study, it allows for the quantitative assessment of an athlete's motivations for engaging in HRS and ES.

The Satisfaction with Life Scale (SWLS) scale by Diener, Emmons, Larson, and Griffin [32], with a Polish adaptation by Juczyński [33], was used to measure participants' satisfaction with life. The subject noted how much they agree with the five statements about life satisfaction (e.g., I'm satisfied with my life) on the Likert scale from 1 (I completely disagree) to 7 (I completely agree). Overall satisfaction with life is calculated as the sum of all scores, which can be compared with sten norms. The Cronbach's alpha reliability index for this tool was 0.85, and satisfactory validity was confirmed by correlating the SWLS scores with scores on other scales measuring satisfaction with life. This tool is commonly used and, importantly for the participants, filling in the questionnaire takes very little time.

2.3. Data analysis

Statistical analyses were conducted with the Polish version of STATISTICA 12 (TIBCO, Palo Alto, CA, USA) and included general linear models, multiple regression, and indicator variables in regression. General linear models 2 $\times$ 2 ANOVA was used to examine the differences in personality profiles and motives of practicing sport with respect to gender (male or female) and sport discipline (HRS or ES). Multiple regression was used to determine whether personality traits and motivations influenced the sense of satisfaction in life of the athletes. Indicator variables in regression were used to examine the differences between genders and sport disciplines in the relationships of personality traits and motivation

with life's satisfaction. The threshold for the level of significance in statistical calculations was 0.05.

3. Results

3.1. Personality Traits

The first step of analysis was to assess the personality features of participants engaging in ES and HRS. In order to compare the personality traits of men and women who engage in various disciplines, a 2 × 2 ANOVA (gender × sport discipline) was conducted. There was an effect of gender on the Psychoticism scale, $F(4, 357) = 8.77$; $p < 0.001$. On this scale, men ($M = 12.67$; $SD = 5.78$) scored higher (post hoc: $p = 0.024$) than women ($M = 11.10$; $SD = 5.81$). The opposite relationship was observed for Neuroticism, where women ($M = 12.80$; $SD = 5.40$) scored significantly higher than men ($M = 10.42$; $SD = 5.85$); post hoc: $p < 0.001$. An effect of discipline was observed on the Psychoticism and Extraversion scales, $F(4, 357) = 5.12$; $p = 0.001$. Individuals who engage in high-risk sports scored higher on the Psychoticism scale than individuals who engage in extreme sports, post hoc: $p < 0.001$. In the case of Extraversion, there was the opposite relationship. Individuals who engage in extreme sports were characterized by higher Extraversion than those who engage in high-risk sports, post hoc: $p < 0.030$. Moreover, women also scored higher than men on the Addiction scale (post hoc: $p = 0.012$). The effect of interaction between gender and sport on personality traits was not significant.

3.2. Motivation

Analysis of the frequencies of motivations revealed that physical fitness was the most important goal for both men and women. This goal was the most important for 22.06% of women and 32.48% of men. The second most frequently selected goal was having a fit, shapely body (beauty, sculpted and firm body)—16.18% for women and 15.29% for men. For women, the third most important goal was health and wellbeing (14.71%), while for men it was escape from everyday life (8.92%).

In order to analyze the differences in the assessments of the importance of motivations for engaging in physical activity, a 2 × 2 factorial ANOVA was conducted (gender × sport discipline). The effect of gender turned out to be significant in the case of three motivations, $F(17, 326) = 2.34$, $p = 0.002$.

The first was having a fit, shapely body (beauty, sculpted and firm body), which was more important for women ($M = 4.29$; $SD = 0.76$) than men ($M = 3.81$; $SD = 1.11$; post hoc: $p < 0.001$). Likewise, boosting one's confidence and overcoming one's weaknesses was also more important for women ($M = 4.22$; $SD = 0.95$) than for men ($M = 3.87$; $SD = 1.06$; post hoc: $p < 0.001$). The last of the differences in motivations was observed in the case of health and wellbeing. As in the case of the first two, it was more important for women ($M = 4.48$; $SD = 0.70$) than for men ($M = 4.24$; $SD = 0.89$; post hoc: $p = 0.027$).

An effect of the type of sports was revealed in the case of assessments of the importance of five motives: physical fitness and being in shape; boosting one's confidence, overcoming one's weaknesses; health and wellbeing; fashion; and finding the limits of human ability, $F(17, 339) = 2.32$; $p = 0.002$. In comparison with individuals who engage in HRS ($M = 4.30$; $SD = 0.87$), ES athletes ($M = 4.57$; $SD = 0.71$) placed the physical fitness and being in shape goal higher (post hoc: $p = 0.001$). The goal of boosting one's confidence and overcoming one's weaknesses was also assessed as more important by ES athletes ($M = 4.10$; $SD = 0.98$) than by individuals who engage in HRS ($M = 3.87$; $SD = 1.08$; post hoc: $p = 0.034$). A similar relationship was observed for the health and wellbeing goal. Individuals who engage in extreme sports ($M = 4.45$; $SD = 0.66$) assessed this goal as being more important than those who engage in HRS ($M = 4.19$; $SD = 0.98$; post hoc: $p = 0.004$). The last goal that was assessed as more important by ES athletes ($M = 4.08$; $SD = 1.03$) was finding the limits of human ability (post hoc: $p = 0.020$)—individuals engaging in HRS assessed the importance of this goal as $M = 3.82$; $SD = 1.24$. Only in the case of the fashion goal did individuals who engage in HRS ($M = 2.76$; $SD = 1.36$) score higher than those who engage in ES ($M = 2.38$;

SD = 1.30; post hoc: $p = 0.005$). The effect of interaction between gender and sport on personality traits was not significant.

3.3. Satisfaction with Life

The next step of the analyses involved the assessment of the degree to which the participants were satisfied with life. Among women, those with high levels of satisfaction with life (35.83%) were significantly more numerous than those with low levels (10.00%; $p < 0.001$). A similar situation was observed in the case of men, where 24.36% of individuals had high levels of satisfaction with life and only 8.64% were dissatisfied ($p < 0.001$). In terms of gender differences, it turned out that the percentage of women who engage in ES and are highly satisfied with life was significantly higher than men ($p = 0.023$). There were, however, no differences in the percentage of individuals with low levels of satisfaction with life.

A 2 × 2 ANOVA (gender × type of sports) revealed no gender differences in average levels of satisfaction with life; however, the effect of type of sports was significant: $F(1, 360) = 8.74$; $p = 0.003$. Individuals engaging in less risky sport disciplines were characterized by higher levels of satisfaction with life (*M* = 23.98; *SD* = 5.50) than extreme athletes (*M* = 22.09; *SD* = 6.04); post hoc: $p = 0.002$.

3.4. Personality Traits and Satisfaction with Life

Multiple regression analysis was conducted to examine the relationship between personality features and sense of satisfaction with life in individuals who engage in ES and HRS. In the analysis, it turned out that after including variables such as age, lying, and criminality, the R2 index was higher than when these variables were not included. Only in the case of women who engage in HRS was no relationship observed between personality features and satisfaction with life. In all other cases, the model assuming personality determinants of satisfaction with life was significant. The regression model is summarized in Table 1, and descriptive statistics are shown in Table 2.

Table 1. Summary of the regression analysis: personality features and satisfaction with life.

	♀HRS		♂HRS		♀ES		♂ES	
	β	*p*	β	*p*	β	*p*	β	*p*
Psychoticism	0.30		0.15		0.18		0.12	
Extraversion	0.37	0.045	0.11		0.06		0.33	0.002
Neuroticism	–0.01		0.02		0.38		–0.26	
Lying	0.32		0.40	0.007	0.18		0.46	<0.001
Criminality	0.49		0.16		–0.29		0.69	0.020
Addiction	–0.40		–0.41		–0.01		–0.58	0.015
Age	0.32	0.014	0.11		–0.11		0.02	
Experience	0.14		0.09		0.50	0.002	0.10	
Summary of the regression analysis	$F = 2.37$ $R^2 = 0.25$ $p = 0.028$		$F = 2.46$ $R^2 = 0.16$ $p = 0.018$		$F = 2.33$ $R^2 = 0.29$ $p = 0.035$		$F = 4.55$ $R^2 = 0.23$ $p < 0.001$	

Table 2. Descriptive statistics of personality traits.

	♀HRS		♂HRS		♀ES		♂ES	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Psychoticism	12.68	6.69	13.88	5.50	9.17	3.75	11.62	5.83
Extraversion	14.70	5.50	13.58	5.22	15.50	4.96	15.02	4.99
Neuroticism	12.79	5.65	10.95	5.94	12.81	5.13	9.96	5.75
Lying	9.24	3.62	8.90	4.37	9.44	3.72	8.57	4.54
Criminality	6.42	1.54	6.47	1.62	5.78	1.20	6.13	1.64
Addiction	15.50	4.12	14.28	4.24	15.02	3.81	13.66	4.41

Next, dummy variable analysis was used to examine differences regarding the influence of particular personality features on sense of satisfaction with life in the groups, on the basis of gender. The analysis revealed that only age and experience variables had different influences on sense of satisfaction with life in the compared groups. Among women who engage in HRS, age determined sense of satisfaction with life to a significantly higher degree than in women who engage in ES (t = 2.32; $p = 0.021$). Differences in the influence of experience on sense of satisfaction with life were also observed—experience determined the sense of satisfaction with life to a higher degree in women who engage in ES than in men who engage in ES (t = 2.47; $p = 0.014$).

3.5. Motivation and Satisfaction with Life

Next, we analyzed the ways in which the goals formulated by the athletes translate into their sense of satisfaction with life. Interestingly, the model turned out to be significant in both men and women who engage in ES. Detailed results of the regression analysis are presented in Table 3, and descriptive statistics are provided in Table 4.

Table 3. Summary of regression analysis: importance of goals and satisfaction with life.

	♀HRS		♂HRS		♀ES		♂ES	
	β	*p*	β	*p*	β	*p*	β	*p*
Fit body	0.04		–0.03		0.07		0.16	
Physical fitness	–0.10		–0.26	0.039	0.08		0.06	
Company of others	0.00		0.02		–0.47	0.003	0.03	
Managing stress	0.05		0.09		0.05		–0.23	
Escape	–0.32		–0.24		0.00		–0.03	
Extreme sensations	0.43	0.037	0.11		0.10		0.45	<0.001
Boosting confidence	0.05		–0.05		–0.10		–0.25	0.016
Health	0.09		0.06		–0.19		0.15	
Fashion	–0.16		0.04		0.20		0.07	
Appreciation from peers	0.12		–0.18		–0.24		0.05	
Commune with nature	0.14		0.00		0.15		0.09	
Finding limits	–0.10		0.01		0.10		0.05	
Age	0.43	0.022	0.20		–0.16		0.09	
Experience	0.10		0.06		0.60	<0.001	0.12	
Summary of the regression analysis	$F = 1.39$ $R^2 = 0.28$ $p = 0.193$		$F = 1.37$ $R^2 = 0.17$ $p = 0.182$		$F = 2.58$ $R^2 = 0.49$ $p = 0.010$		$F = 3.57$ $R^2 = 0.31$ $p < 0.001$	

Table 4. Summary of regression analysis: importance of goals and satisfaction with life.

	♀HRS		♂HRS		♀ES		♂ES	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Fit body	4.33	0.75	3.66	1.12	4.24	0.78	3.94	1.09
Physical fitness	4.41	0.82	4.23	0.89	4.68	0.64	4.53	0.73
Company of others	3.95	0.97	3.95	0.96	4.04	0.95	3.81	1.11
Managing stress	4.26	0.95	4.17	0.96	4.30	0.96	4.22	0.98
Escape	3.92	1.15	4.12	1.05	4.07	1.08	4.05	1.07
Extreme sensations	4.21	1.00	4.11	1.10	4.31	0.84	4.23	1.11
Boosting confidence	4.08	1.08	3.74	1.08	4.39	0.76	3.98	1.04
Health	4.41	0.70	4.06	1.09	4.56	0.69	4.40	0.64
Fashion	2.64	1.20	2.83	1.45	2.72	1.34	2.23	1.25
Appreciation from peers	2.91	1.22	2.72	1.30	3.22	1.25	2.95	1.25
Commune with nature	3.71	1.08	3.32	1.17	3.46	1.36	3.71	1.27
Finding limits	3.68	1.30	3.90	1.21	4.15	0.96	4.05	1.07

A dummy variable analysis based on gender revealed no group differences in the assessments of separate motivations.

4. Discussion

The results justify the distinction between high-risk sports and extreme sports. This classification, proposed by insurance companies, was reflected in both the subjective perceptions of individuals who take part in such activities, as well as in differences regarding their predispositions and motivations. The first hypothesis was confirmed mostly in the group of men who engage in ES. Surprisingly, extraversion equally strongly determined satisfaction with life in women who engage in HRS. This result can be explained with reference to a meta-analysis that indicates that men are characterized by a significantly higher need for stimulation and sensation seeking [34]. Thus, it can be speculated that ES provides the optimal level of risk for extroverts, while for women this level may be beyond the optimum, making this relationship insignificant. This explanation is also applicable to the relationships observed in the HRS group. Here, a significant influence of extraversion on sense of satisfaction with life was observed only for women (optimal levels of risk), while in men, there was no relationship between these variables (not enough risk). Of course, this explanation requires further examination in future studies.

Thanks to the use of the EPQ-R tool, we did not observe extremely high results on either the Extraversion scale, which measures need for stimulation, or on the Psychoticism scale, which is associated with impulsivity and acting on the border of social adjustment. Frequency analysis for high, low, and moderate results on each of the subscales allowed us to observe that some individuals who engage in HRS and ES are characterized by low levels of extraversion and psychoticism, which, to date, has not been accounted for in the literature. Moreover, when analyzing mean sten scores for each of the groups, we were able to see that the levels of extraversion were average, which confirms the conclusions of Guszkowska and Bołdak [12] as well as Barlow et al. [7], who suggest that individuals who engage in HRS and ES are non-homogeneous in terms of their temperament and that their predispositions should be measured by a tool other than Zuckerman's SSS [29]. Moreover, these previous findings may suggest that, due to the increasing popularity and attractiveness of extreme sports [1], more individuals who are not particularly predisposed to such activities are undertaking them, which may indicate that it is not only personality that determines participation in these types of activities. Although exploring these determinants in a changing world should be the subject of future research, it can be speculated that people who are not personally assigned to ES or HRS may choose these types of activities because of possible social benefits such as popularity or social media outreach.

It is extremely important that among all the individuals who engage in ES and HRS, there were practically no individuals characterized by low predisposition towards addiction. Heirene, Shearer, Roderique-Davies, and Mellalieu [24], in a qualitative study conducted on a group of Himalayan mountaineers, found that individuals who practice such disciplines exhibit all of the symptoms of withdrawal syndrome. Barlow, Woodman, and Hardy's [7] work suggests that the need to pursue stimulation among Himalayan mountaineers is lower in comparison with other sports. Thus, it might be that in the case of more stimulating sports, the symptoms of addiction are even stronger. Schüler, Wegner, and Knechtle [35], in a study on individuals who engage in extreme endurance sports, found a positive correlation between addiction and the intensity of training, as well as a negative correlation with age. Undoubtedly, this is another argument for the addictiveness of the intense emotions associated with HRS and ES. A negative influence of tendencies towards addiction on sense of satisfaction with life was confirmed, but, again, the relationship was observed only in men who engage in ES. This result is comparable with the observations of Chang [20] regarding the relationship between levels of engagement in ES and the particular ease with which men reach the state of flow, while this relationship was weaker in women. Experiencing positive emotional reinforcement in this state may have a stronger influence on the tendencies towards addiction. However, the assumption that individuals who

engage in ES would score higher on the scale measuring predispositions toward addiction than individuals who do HRS was not confirmed. None of the listed motivations were related to the sense of satisfaction with life of individuals who do ES and HRS. However, again, in the group of women who engage in HRS and men who engage in ES, it was observed that in terms of motivations associated with extreme experiences, adrenaline has the strongest relationship with sense of satisfaction with life.

The result indicating that women score higher on the addiction scale than men may be surprising at first glance. However, if we assume that they experience emotions much more intensely than men [36], then, in effect, it may also be easier for them to become addicted—but this explanation undoubtedly requires further investigation. This lack of ambiguity in the obtained results can be explained by the limitation of the presented study—the tool used to measure the tendency towards addiction. The scale used is only an experimental tool, not one aimed at accurately measuring addiction in extreme athletes, such as the scale proposed by Ahn, Cho, and So [37].

When analyzing the motivations of individuals who engage in ES and HRS, one ought to first of all into account that in the extreme experiences, the adrenaline goal was not assessed by the participants as the most important. This result, at least at a declarative level, is in contrast to critical voices who argue that the main reason for taking part in ES and HRS is an irrational craving for intense emotions and a sense of increased arousal. For the participants of this study, the most important goals were associated with physical fitness, having a fit body, and health, and thus they were no different from those most commonly indicated by individuals who engage in forms of physical activity and sport that are not associated with increased risk [31]. This may be caused by the fact that individuals who engage in HRS and ES do not assess their sport disciplines as extremely dangerous [38], and thus their attitude is not significantly different from that of people who practice non-risky disciplines. One can speculate that providing oneself with desired levels of stimulation from risky forms of physical activity may thus be a latent and indirect motive, one that is not expressed in declarative statements about goals typical of any physical activity.

The gender differences revealed in the results of the assessments of motivations, especially those regarding the fit body and health goals, are in line with previous studies [39].

Again, the importance of distinguishing between ES and HRS was confirmed in the differences observed in the assessments of the importance of particular goals. It is notable that goals that are more important for ES were associated with a responsible and professional approach towards sport. This attitude is understood as taking care of proper preparation, warm-up, training, and diet. The higher assessment of goals related to physical fitness and health indicates that they are treated as resources that may be decisive in avoiding serious injuries in critical situations. Health and physical fitness seem to be being thought of as instruments—things without which it would be impossible to practice the sport responsibly. This is in line with the conclusions of the qualitative studies by Brymer and Schweitzer [16], who found that engaging in ES is an activity that changes an individual, increasing their humility and ability to combat fear, as well as teaching them to treat their life responsibly and respect their health. Higher scores for boosting one's confidence and overcoming one's weaknesses are not surprising—a person's confrontation with the elements, or an intense fight with an opponent in the case of martial arts, is undoubtedly a challenge that can inspire self-development and improve one's sense of self-efficacy. The motivation associated with finding the limits of human ability, which was also assessed higher by those who engage in ES, indicates that this group places more emphasis on transgression and goals that go beyond sensual experiences or intense emotions. Similar conclusions were drawn by Lebeau and Sides [40], who pointed out that ES are more often associated with motives connected to transgression than are mainstream sport.

The fashion motivation was assessed as relatively unimportant by individuals from both ES and HRS groups. However, one should note that this was the only goal whose importance was significantly higher for individuals engaging in HRS. This may suggest that this type of sport is more associated with an attractive image. Furthermore, sports

such as skateboarding, BMX, or parkour [41] are often considered a subculture and may be a part of one's identity. Engaging in niche sport disciplines definitely allows a person to be different from their peers and to identify with a group of people who have a passion or their own characteristic style. A particular paradox should be noted: youths who pursue originality through being a part of a subculture undergo a kind of uniformization and become targets for commercial concerns [42,43].

The fact that individuals who engage in HRS were characterized by higher levels of satisfaction with life than those who engage in ES could be explained by the specifics of the two categories of sport. This has been confirmed by the studies described in the doctoral thesis of Sidorova [44], who found that surfers (who, in line with the classifications of insurance companies, are representatives of HRS) score higher on most dimensions of the satisfaction with life scale than individuals who do not do HRS. Moreover, research has shown that surfers are characterized by much higher levels of autotelic activities than individuals who do not engage in such sport, which may be associated with global levels of satisfaction with life [45].

5. Conclusions

The main conclusions of the presented research indicate that the division into HRS and ES is adequate and effective. Both groups of athletes differ not only in personality traits and motives but also in the determinants of the feeling of satisfaction with life. Attempting to identify the psychological consequences of engaging in HRS and ES is important for the further development of this area of research. Examining changes in motivations by using longitudinal studies could make it possible to look at the phenomenon in a more accurate way. Motivation is a dynamic process that changes with athletes' experience and is undoubtedly associated with critical events such as injuries or threats to one's life. Including such variables in the model and making several measurements could be an interesting addition to knowledge regarding the specifics of motivations for taking part in HRS and ES. The presented study did not avoid limitations. Purposeful selection for the sample, as well as limitation to one region in Poland, may be an obstacle in extrapolating the obtained results to the entire population. Furthermore, lack of scientific definition of HRS and ES remains a topic to be resolved in subsequent studies. In addition, the measurement of sport addiction in subsequent studies should be developed using a more precise tool.

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Article

What Is an Extreme Sports Healthcare Provider: An Auto-Ethnographic Study of the Development of an Extreme Sports Medicine Training Program

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Abstract: "I remember when sex was safe and skydiving was dangerous" read a popular bumper sticker during the HIV crisis. Popular perceptions of extreme sport (ES) often include the descriptor 'dangerous'. Therefore, why is the popularity of ES increasing exponentially with "dedicated TV channels, internet sites, high-rating competitions, and high-profile sponsors drawing more participants"? More importantly, how should health practitioners respond to the influx of ES athletes with novel injuries, enquiries and attitudes. This paper describes the results of a collaborative auto-ethnographic approach to answering "what is an extreme sports medicine health care provider and what are the components of an effective Extreme Sports Medicine (ESM) training program?" The study was conducted following the first ESM university course offered in Australia with the intention of assessing the learning design and reflecting on the development and practice of ES health practitioners. We explicated three overarching themes common to both the ES health practitioner and for the effective training of healthcare providers in the support of ES endeavors and athletes. These themes were individual, task and environmental factors. The impacts of these findings confirm that ESM courses are vital and should be designed specifically to ensure that practitioners are effectively supported to develop the unique skills necessary for practice in real world extreme sports events.

Keywords: extreme sports medicine; medical education; injury; extreme sport athlete

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1. Introduction

Extreme sports have erupted onto the sporting scene over the last decade [1–4], with several new sports appearing [5,6] and the boundaries of traditional ones being radically redefined [7]. While many extreme sports are practiced as individual adventure activities, others have become organised, competitive, and occasionally commercial sports. Dedicated events like the X-Games and World BASE Race host extreme sport athletes from around the world and are watched by hundreds of millions on digital media platforms. Some sports have been mainstreamed with inclusion into the Olympic Games calendar: sport climbing, free ride BMX and surfing (Tokyo 2020) and ski mountaineering (Innsbruck Youth Olympic Games, 2020 and Milano Cortina, 2026). In the 'click bait' world of digital media, some extreme sport athletes have become superstars and popular culture has transformed athletes once regarded as the 'lunatic fringe' into 'Supermen' [8].

Extreme sports have been defined as "independent adventure activity where a mismanaged mistake or accident is most likely to result in death" [9]. In sporting events this definition has been expanded to allow for emerging and competitive activities, in these

instances the notion of "action sports" has been used to frame a broader perspective on modern extreme sports. The action sports definition then permits the inclusion of sports such as cliff diving, sport climbing, and foiling. Health practitioners working in this area need to not only understand the athletes and sports more commonly encountered, but also require a framework with strong foundations in risk management, individual athlete assessment and event planning and delivery to allow them to explore opportunities to provide care in any extreme sporting or adventurous endeavor and environment that captures their interest.

As the levels of participation within the community, and the push for increased performance amongst elite extreme sports athletes has evolved, the medical care of these athletes has begun to catch up and a new medical sub-discipline of extreme sports medicine (ESM) has been born [10]. Unsurprisingly, the leaders in this field are predominantly from Europe [11] and North America [12], but a formal university healthcare program broadening the traditional medical teaching horizons to include BASE jumping, paragliding, mountaineering, extreme skiing, skydiving, breath hold diving and ultra-endurance running, etc. has been lacking.

This paper describes an auto-ethnographic approach to answering "what is an extreme sports medicine health practitioner and how can they be trained" based on the reflections of the developers of the Extreme Sports Medicine unit that forms a part of the Certificate, Diploma or Masters in Healthcare in Remote and Extreme Environments (HREE) program through the School of Medicine at the University of Tasmania, Australia. We examine the evolution of ESM and report on findings from an ESM training program with the dual aims of answering the question "what is an ESM health practitioner" and identifying the challenges and opportunities for developing effective ESM training programs.

2. Sport and Exercise Medicine

Arguably ESM is most directly related to Sport & Exercise Medicine (SEM) which is currently a recognised medical specialty in sixteen European countries with a training period that varies between two and five years [13]. The General Medical Council (GMC) training curriculum [14] for UK SEM recognises the SEM Physician as a leader of a multidisciplinary team in the management of musculoskeletal conditions, including the care of elite athletes. Despite the wide acceptance of SEM as a specialty and the recognised role of the SEM Physician in athlete care, there is a relative lack of teaching of SEM skills at medical schools [15–20], and in an already minimally taught specialty, extreme sports medicine is a single dot point in an extensive curriculum [21].

While ESM and SEM converge in the management of athletes' health and performance, they diverge with respect to the challenge that the task and environment may present to both athlete and health practitioner and the subsequent impacts on psychology, technology and risk management. A concept explored in depth by Buckley [22] who described the difference in psychology between adventurous and extreme sports. With constrained teaching within the traditional medical school and post-graduate specialty training programs, ESM has evolved through health practitioner lead research, educational opportunities and overlap with established programs in Wilderness and Expedition Medicine [23–25]. Hoffman and colleagues have published extensively on medical coverage considerations for ultra-endurance events [26–29] and offer an online training program for medical providers, event organisers and coaches in ultramarathon medical care [30].

While there are a wide range of sources offering information and ideas related to training and psychology in various sports, texts in ESM are still few and far between, although Schoeffl et al. [31] first provided a text on rock climbing injuries as far back as 2003. More recently Feletti edited the first comprehensive Extreme Sports Medicine text [10]. Enthusiasts are also able to upskill in ESM at conferences in Europe (Feletti, UTMB) and North America (Colorado). These conferences, however, are not a prescribed syllabus, nor a framework for learning for students of ESM.

3. The Role of Medical Practitioners in Extreme Sport Events

Most organised Extreme Sport Events like the X-Games, World BASE Race and ultramarathons have doctors in attendance at the finish line. The increased participation rates, number of events, bigger cross section of participants (some with impairments and medical issues) and access to extreme sports more generally has also meant an increase in the desire for knowledge on the prevention and treatment of injuries specific to extreme sport activities [32]. Feletti and colleagues have described injury patterns specific to both dinghy-sailing on hydro-foiling boats [33] and kite buggying [34]. In addition to a focus on sport specific injuries, the University of Tasmania Extreme Sports Medicine course examines in detail medical presentations in ES athletes, including exercise associated hyponatraemia, exercise associated collapse, hyperthermia, hypothermia, frostbite, shallow water black-out, 'samba', high altitude pulmonary edema, high altitude cerebral edema, high altitude retinal hemorrhage, acute altitude related hypoxia, altitude related barotrauma and decompression sickness. These novel injury and illness problems require health practitioners with experience to manage on-site issues and work with athletes and event organisers prior to events to optimise planning and reduce risk. Most extreme sport event health care providers have an interest in the relevant sport but few have formal, extreme sport specific training. Event organisers have no way of deciding what kind of medic should be employed for 'first aid support' or 'risk management advice' and worse still, athletes do not know what health care providers they can visit for empathetic, non-judgemental information about physical training, performance, diet, risk management and mental preparation for extreme sport. Healthcare providers studying extreme sports medicine have potential to be an asset to the health of the broader community as they are more likely to prescribe their patients physical activity in nature and expand the sporting activities they can prescribe, potentially leading to greater patient engagement, especially amongst younger community members [35].

To support extreme athletes to optimal health, safety and performance, healthcare providers need to be up skilled in training methodology, nutrition, injury and illness prevention, engineering and safety equipment, management of the injured athletes and medical event coverage specific to extreme sports. Extreme sports medicine health practitioners must not only understand the physical demands and injuries of extreme athletes but the psychology of the sports, the process of risk assessment and mitigation and the role of cognitive biases, all of which can influence outcomes for the ES athlete [36]. This suggests that the training of extreme sport practitioners needs to move beyond the technical development and injury management focus of sport medicine courses into wider, sometimes novel, domains. Further training courses that aim to develop highly skilled ESM practitioners need to be carefully designed with learning that is more representative of the practitioner and task requirements, and environment context which is often practiced in remote and austere environments more similar to wilderness medicine [37,38].

4. Learning Design in Extreme Sport Medicine

Education and learning design in the field of medicine has been critiqued for relying on the traditional idea of teaching as an intervention that somehow results in achieving the specified learning outcomes [39]. According to Biesta and Braak [39] this model stems from the 'medical model' prevalent in medicine and does not do justice to how people learn. As an ESM health practitioner will be required to perform in extreme environments, learning design needs to reflect a more up to date context. As an ESM health practitioner will be required to perform a considerably expanded role compared to conventional medicine, not only does the learning design need to reflect a more up to date approach to medical education, but also take account of the specific contexts of supporting extreme sports event and endeavors. As this is the first university course to provide scope for learning ESM skills with both a sporting performance and athlete health focus, leaning design was an important consideration. The course explores the physical demands and injuries of extreme athletes as well as the psychology of the sports, the technology of the sports, the process

of risk assessment and mitigation and the role of cognitive biases. The course is designed to sit within a program of healthcare in remote and extreme environments and the focus is on caring for athletes who are undertaking their endeavors in extreme environments. The program has two key aims which, while focused on the extreme sport athlete or event, provides a template to facilitate healthcare practitioners providing care to active individuals either in a one-on-one clinical setting or through event coverage. The course design team has had previous experience designing novel and non-standard courses [40] and was cognisant of designing the structure and content to both fit into an existing program as an elective unit [25] and to be self-contained as a standalone course.

The over-arching structure for the curriculum and the assessments was provided by Miller's pyramid as a means to create a progression from knowledge through to application of knowledge and translation into clinical practice [41]. Within this hierarchy, adult learning theories were examined and those related to instrumental learning (cognitive and experiential) and social learning in particular, provided a foundation for the course design [42].

An Online learning approach [43] was necessary given the geographical spread of prospective students, although the limitations to this were appreciated and elements of the online material were extended to allow teaching of practical skills through a residential camp.

The Delphi technique is well recognised and has been used to create curricula for conventional sports medicine [21,44]. A modified Delphi process was used for UTAS ESM at two levels. Firstly, the core academic group used it to create the intended learning outcomes for the course and to create a common structure to write content for each sport (Table 1). The latter was done for several reasons. Firstly, it provided structural familiarity as students moved through the modules, secondly it was intended to help content experts contribute more effectively and consistently. Finally, it was hoped that this structure could be used for students to examine additional sports themselves (that were not included in the course). The individual sport modules were delivered following three "common themes" modules which established a base level of knowledge in areas that transected all sports, including the science of performance, nutrition, psychology, risk management, the environment, medico-legal considerations, and anti-doping as they relate to extreme sports.

Table 1. Template for individual sports and rationale for inclusion in course.

Introduction to the sport	The introduction aims to provide exposure to the sport through open access video and blog posts of extreme endeavours and events.
Legends and pioneers	An essential component of understanding a sport is to be a scholar of those who have developed and advanced the sport. Health Practitioners will need to speak the language of the athletes they work with and understand the key figures in the sport.
Environment	An understanding of the environment in which the sport is conducted assists evaluation of environmental stressors in preparation, injury and illness.
Risk assessment, cognitive bias and psychology	A case-based learning section on the role of cognitive bias in risk assessment and mitigation in the sport
Equipment	An overview of the typical equipment required for the sport and its role as a contributor to outcome (especially morbidity and mortality).
Athlete types	An understanding of the biomechanical context of the sport and how athlete form, psychological influences and cultural influences within a sport will aid appropriate Health Practitioner assessment (e.g., the ape factor of a climber)

Table 1. *Cont.*

Training routines and modalities	While a broad overview of the science and principles of training is provided in the introduction, a further exploration of training types specific to each sport is included in the template.
Common injury patterns, injury management and rehabilitation	The quality and prevalence of injury surveillance and prevention programs in extreme sports is lacking (in comparison to team and Olympic disciplines) but a review of common injury patterns and management are provided for each sport.
Sport specific screening	Musculoskeletal and medical screening can identify areas for improvement in performance or reduction in risk.
Nutrition	Fuelling and hydration strategies can be specific to the event or sport an athlete is undertaking and this is reviewed in each section (e.g., ad libitum drinking vs. programmed hydration during an ultramarathon)

The second level was to create and review the content at the level of the individual modules from multiple sources including the core academic group, additional colleagues from within the Healthcare in Remote and Extreme Environments Program and external content experts who agreed to collaborate with us.

5. Collaborative Autoethnography Methodology

The aims of our study were to examine the questions of "what is an ES health practitioner" and "how can they effectively be trained." In this paper we followed a collaborative autoethnography approach on the first extreme sport medicine course offered in Australia with the intention of identifying the characteristics of an ES health practitioner and assessing the learning design and impact of our inaugural ESM course in meeting the needs of a developing or novice ES health practitioner. Whereas autoethnography typically involves an individual researcher deliberately utilising a retrospective process to make explicit personal stories in a cultural context, collaborative autoethnography involves multiple researchers [45]. Autoethnography combines intentional and considered analysis [46] of biographical accounts and personal experience to bring to life cultural experience. Collaborative autoethnography is ideally suited to stories that provoke collaboration [47]. Collaborative autoethnography provides the opportunity for 'collective interpretation' [45] and the examination of inherent assumptions and presuppositions. It has been described as an effective methodology for advancing the understanding of the culture and practice of medical education [48,49].

In this paper, we have used a collaborative process to explicate and interpret the experiences of the first three authors reflection on the qualities of an ES health practitioner and the development and implementation of the first ESM training program. Trease, Albert and Singleman conducted an independent written reflection on their experience as ES health practitioners and in designing and facilitating Australasia's first postgraduate extreme sport medicine course designed to enhance the capacities of medical professionals to support extreme sport endeavors and events. Brymer, undertook the initial analysis by reading the reflections multiple times before commencing a thematic analysis process. A categorical-content perspective [50] was utilised first, where the text was first broken down to self-contained areas of content. The thematic analysis process then followed the recommendations outlined by Braun & Clarke [51] for generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing a summary table of themes and direct quotes. Subsequently all authors explicated the experience in an attempt to draw meaning that considered the current theoretical frames of references and interpreted the experience in light of current cultural perspectives. Brymer acted as critical collaborator [9] helping to structure the learning from Trease, Albert and Singleman's stories for an academic and practitioner audience. This article provides an analysis of

these accounts. The experience is interpreted partially from the perspective of research into learning design in medicine.

6. Results

Three overarching themes emerged from our study examining the question of "what is an ESM health practitioner" and identifying the challenges and opportunities for developing effective ESM training programs for healthcare providers. The three themes were: Individual (learner) factors, Task factors and Environmental factors (Table S1).

6.1. Individual Factors

Extreme sport medicine courses must have a strong component of learner centered relevancy. This is not just in the sense that curriculum needed to be delivered in a manner that suited individual learners but also that the learning design needed to facilitate the development of adaptable, multi-skilled and ecologically minded professionals. For example, EA reflected that an effective ESM health practitioner had multiple hats that were not necessarily related to traditional medicine or sport medicine training and that ESM was unlikely to be their sole career choice. Health practitioners are likely to bring skills from other aspects of their professional life to the ESM training context. Health practitioners could come from multiple related medical backgrounds as there was, in the words of one of the authors (EA):

> *"no single 'fit' but rather a health practitioner (and certainly not necessarily a doctor) who has the qualities of a sense of humility and discovery and who can understand the environment, understand the sport and the equipment and technology that accompanies it, understand the athlete and be able to work pro-actively as well as reactively in a setting pertinent to that sport."*

EA went on to reflect that a one-size-fits all approach to learning design would not work for ESM courses as in many cases learners are not sport experts or even recreationalists, instead they need to have a broad knowledge and a way of being able to fit that knowledge into contexts relevant to the ESM practitioner. This aligned with the reflections of another author (LT):

> *"No student, nor faculty member, nor ESM health practitioner will be an expert in all of the sports, so the course needed to allow students to do a "deep dive" (pun intended) in two or three sports but offer enough sports that every student could choose a diverse range of content to support their learning."*

One of the authors (GS) also reflected how his experience had taken him across the world in different extreme environments and different sports. He also (GS) reflected:

> *"I have come to realise that there won't be a single type of ESM health practitioner and we don't need that to enhance the health and performance of extreme sports athletes. What we need is practitioners from multiple disciplines, who are interested and knowledgeable in a (or more than one) sport, with the skills to help the athlete or event organiser, in the way that they will be working."*

Beyond the immediate impact, one of the authors (LT) expanded further reflecting that course design needed to provide a framework for lifelong learning or professional development as ESM practitioners are faced with personal challenges when participating in extreme contexts as well as problem solving medical challenges that are often specific to particular events.

6.2. Task Factors

Perhaps as would be expected in any medical training context, there is also a large focus on task related factors relevant to extreme sports. For example, injury types and aspects of risk management. However, what became clear through the course was, unlike more traditional medical training, the context of ESM required a broad set of skills, not just

providing treatment for poor outcomes, when something has gone wrong. The nature of extreme sports events and the potential for death or serious injury indicates that the ESM health practitioner needs to have the personal and technical skills to be involved early and provide advice before an event takes place.

The fact that the definition of extreme sport mandates that the practice of the sport must involve risk of severe injury or death establishes separate physical and psychological domains that team sport health practitioners may not be familiar with. An 'off-day' or 'choke' or 'error of judgement' will have different consequences for the ES athlete compared to the golfer, tennis player, cricketer or netballer.

ESM health practitioners need to be part of the planning team, to get to know the athlete(s) and advise as required. Effective ESM support might involve psychologists, engineers and nutrition experts. This was also apparent in the backgrounds of the learners in this course who heralded from diverse medical backgrounds. "Effective ESM training needs to be able to provide a meaningful space for a variety of practitioners to gain the skills required to effectively support the athlete working across the 'proactive, preventative or performance space" (LT). One of the authors (GS) summarized this as "needing to work beyond the standard medical model."

6.3. Environment Factors

The main environmental factor identified in our autoenthnographic work was the development of a culture of passion and enthusiasm for "becoming a scholar of extreme sport". This was complimented by the need for the acceptance of a wide range of expertise in ES healthcare providers, which may include experiential, rather than formal learning. Interestingly while the physical environment obviously plays an import part in participation or healthcare provision, it seemed to be less relevant in training ES healthcare providers. Instead the emphasis was on ensuring the atmosphere or culture of the course encouraged students to adopt a broader perspective on ESM.

That is, the teaching team was very important in the overall training context. Not just because of their expertise but also because of the way they approached the topic. As described by one of the authors (EA):

> *"in some extreme sports, there was a real need to seek out the nuanced expertise that couldn't be gleaned from books or papers, if we wanted our students to have an authentic learning experience."*

This meant that to create the ideal ESM faculty, EA described:

> *"you need people who have the depth of clinical experience, a deep understanding of preferably several extreme sports and the interest in education, and somehow be able to employ and stimulate these 'out of the box' non-conformist souls within a very 'closed box' conformist University setting."*

7. Discussion

Learning design in medicine has traditionally followed the path of discipline orientated specialisation (Sports Radiologist or Sports Orthopaedic Surgeon). Critics of this approach have pointed to the need for learning design that better fits the individual learner and their desired work environment and focus. This study indicates that effective learning design in ESM courses is not about creating experts with narrower specialist skills but instead facilitating a lifelong learning journey that broadens the learner's skill set, beyond that of their individual discipline. This approach can enable the ES health practitioner to pursue knowledge of an emerging ES sport, injury, technology or treatment and the importance of teaching this skill of lifelong learning is well documented in both medical [52] and non-medical education literature [53,54].

As learners will come from various backgrounds, both within medicine and broader healthcare roles, any ESM course should provide opportunities for each leaner to design their own professional journey. Our findings also show that ESM training courses need

to go beyond simply designing learner centred experiences [42] to develop a learning environment that facilitates passion for ES, the environment in which they are practiced and the values and belief systems of the ES participant. Our study identifies the importance of the faculty in creating an environment where learners are given permission and challenged to think 'out of the box', just as many ES athletes do [55]!

In contrast to traditional sport medicine [15,19] the skills required by an effective ES practitioner are arguably more aligned with those required for effective wilderness medicine. These skills include the capacity to not only understand the environment, often austere, that ES are 'played' in [55], but to be able to effectively deliver care in such an environment [38], while ensuring their own personal safety and well-being, a factor which is infrequently a consideration when providing team sports coverage on a pitch or court [21]. The implications from our study in the theme of individual factors for ESM education are quite profound in that learners need to be prepared to work effectively in unknown and austere environments where individuals might feel uncomfortable [39]. ESM training needs to effectively prepare the individual for this personal challenge, whilst equipping them with the professional skills required.

ESM health practitioners can be called on to provide both health and performance advice proactively as well as healthcare support before, during and after an event, but maybe challenged by an inability to offset the significant risk of injury or death during the endeavor [39]. In the theme of task factors in medical training focused on extreme sports, we identified the need to develop skills for identification of risk, implementation of effective prevention strategies, as well as the treatment of conditions arising during participation. The ESM health practitioner needs skills that are beyond their singular discipline, that is rather than becoming narrower through specialist extreme sports medicine training. Similar to wilderness medicine [38] the education experience needs to encourage learners to adopt a broader set of skills [39].

Extreme sports are emerging global activities that are rapidly out performing more traditional sporting activities [55]. An important impact of this is the rising need for well qualified, experienced health practitioners capable of practicing their skills in extreme environments with uncertain outcomes [39]. While there is some similarity to the development of effective wilderness medicine practitioners [38] there are unique requirements for extreme sports medicine. Coupled with the broad skill set outlined above and the capacity to react to multiple medical scenarios unique to particular sports and the environment in which they are practiced ESM practitioners need to provide care across the spectrum of prevention to rehabilitation for both the body and mind.

The implications from this study are that specific ESM practitioners and courses that train them are vital and should be encouraged. However, following a traditional medical approach to course design is not ideal for ESM training. While there is cross over with wilderness medicine practice there are also differences. ESM course designers need specialist skills to ensure that learners are effectively supported for real world extreme sport events. This study is the first to provide guidance on what that entails and principles for effective ESM course design.

8. Conclusions

In our autoenthnographical analysis of the question "what is an extreme sports medicine health practitioner" we identified that the ESM health practitioner is able to go beyond the question of 'why would you do that?' and into the territory of 'how can I help you manage the physical, emotional and psychological risk of that extreme activity?' The ESM health practitioner understands the physical risks of the sport and the psychological motivations of the athlete. The ESM health practitioner can offer non-judgemental advice on how to maximise physical preparation and flawless execution while staying within the bounds of "acceptable risk". The ESM health practitioner can help an athlete foster and maintain psychological balance in extreme environments and extreme challenges. The ESM health practitioner can help identify and mitigate cognitive bias and unacceptable

risk. The ESM health practitioner can be an objective, voice of reason more easily accepted and trusted by the ES athlete. Finally, the ESM health practitioner can be equipped with the most appropriate medication, gear and skills to provide treatment/stabilization/evacuation to the injured ES athlete at events or individual challenges. Our study highlights the importance of an ESM curriculum which instills these qualities into aspiring ESM health practitioners through a challenging and supportive environment, created by a skilled and divergent faculty with a focus on empowerment towards lifelong learning and the pursuit of a broad skill-set.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijerph19148286/s1, Table S1: Results from the thematic analysis of transcripts.

Author Contributions: All authors discussed and designed the study. L.T., G.S. and E.A. provided reflections on their experiences of the inaugural course. E.B. was primarily responsible for data extraction and analysis. All authors discussed the outcomes of the analysis and contributed to the discussion and subsequent writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Article

Behavior in Avalanche Terrain: An Exploratory Study of Illegal Snowmobiling in Norway

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Abstract: Snowmobilers make a grim and significant contribution to avalanche fatality statistics in Norway. However, there is limited knowledge on the behavior of this group in avalanche terrain and the factors influencing this behavior. Our study documents what snowmobilers do and not do in avalanche terrain, how their behavior relates to managing complex avalanche conditions and if there is a mismatch between avalanche competence, education and riding preferences. This ethnographic study observed snowmobiler tracks and thus avalanche terrain usage in Northern Norway during 2018 and 2019, supported by open-ended conversations with target group riders. Results show that high-marking lost popularity to technical riding, which seems to be perceived as safer despite increased exposure to complex avalanche terrain and conditions with persistent weak layers in the snowpack. The detected mismatch between preferences and avalanche knowledge/attitude will remain an obstacle to future accident prevention efforts unless behavioral changes are addressed. This study of a predominantly illegal activity sheds light on how to explore and observe hard-to-reach illegal activities and should be of interest to a wider audience from other research disciplines.

Keywords: avalanche education; qualitative method; illegal; snowmobiling; persistent weak layers

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1. Introduction

Snowmobilers' behavior in avalanche terrain is causing them to get killed in avalanches [1–3]. In most recreational avalanche accidents, the avalanche is triggered by the victim or someone in their party [4]. In response, new research and methods from social science are requested to better understand the human factors that determine decision making in avalanche terrain [5–9]. Even though there is a growing body of literature on human factors in avalanche terrain, studies of what snowmobilers actually do in the field is sparse.

Despite the effort from Canadian and US avalanche education to use snowmobilers to educate snowmobilers the past 20 years [10–13], avalanche education has been questioned regarding its ability to adapt to changing circumstances within snowmobiling [14,15]. A rethinking of avalanche education has been suggested in Canada due to a likely mismatch between the snowmobilers' behavior and education since more riders have easier and increased access to more complex management situations [15–18].

In Norway, snowmobilers accounted for 23% of the avalanche accidents from 2009–2019. We do not know if there is a mismatch between competence and snowmobilers' preferences, as has been reported in Canada [17,18]. However, we know that complex snowpack situations with persistent weak layers dominate Norwegian avalanche accidents [19], as in Canada [20]. Risks that are difficult to manage even for skilled avalanche professionals [21].

Riders in avalanche terrain are difficult to enlist in regular studies given the fact that this activity is mostly illegal in Norway. Survey-based studies from Canada and the USA [11,15,22] have contributed substantial knowledge about snowmobilers, but have also called for fieldwork that can deepen our understanding of actual behavior [22]. This is the aim of this research.

To study these hard-to-reach snowmobilers we used an exploratory qualitative approach, where observations of behavior were validated through ethnographic interviews with key participants. This research may be used to improve mitigation strategies and benefit educators, practitioners, policymakers and researchers in the quest of avalanche accident prevention among snowmobilers.

2. Background

The avalanche community called for more collaborative efforts with behavioral science researchers during the 2016 International Snow Science Workshop (ISSW) at Breckenridge [18]. Behavioral theory tells us that just sharing rational expert knowledge to the less knowledgeable is looked upon as insufficient if your aim is to change behavior [23]. According to Darnton [24] (pp. 31–33) you have to "understand the target behavior and the factors influencing it from the audiences' perspective" if you want to accomplish behavioral change.

Snowmobile avalanche education in Canada and the US has decades of experience trying to influence snowmobilers' behavior in avalanche terrain [13], and there is increasing knowledge about factors that are important [9,22]. However, Canadian snowmobile avalanche education has been questioned by Stewart-Patterson and Hanke [16,20], who suggested a rethink of the avalanche education as it was not keeping up with the changing riding preferences in avalanche terrain. They argued that an increasing number of people with limited experience, skills and knowledge were obtaining increasingly easier access to complex management situations due to the emerging technology that made snowmobiling easier.

This may also apply to Norway. To place this study in context, we give a more detailed background on snowmobiling, regulations, avalanche terrain, riding styles, avalanche problems and avalanche education.

Snowmobiling is using a motorized vehicle for winter travel and recreation on snow and does not require a road or trail [25]. A snowmobiler can also be referred to as a rider or sledder. When you leave the trail in the backcountry, snowmobiling is called freeriding. Riding off the tracks demands increasing personal skills and machine performance due to varied snow characteristics, the risk of getting stuck, hitting obstacles and avalanche danger. Recreational snowmobiling in Norway has been restricted to official trails since 1978, permitting a 30 m deviation alongside the trail and up to 300 m from the trail for rest stops only [26]. The official trails normally avoid avalanche terrain, thus freeriding in avalanche terrain is mostly considered illegal.

Avalanche terrain is usually defined as terrain steeper than 30 degrees [3]. In addition to the direct triggering when riding in steep enough terrain, riders can also indirectly endanger themselves and others in the less steep runout areas due to weak layers in the snowpack that can propagate up to the stepper terrain and starting zones of the avalanches.

Various freeriding styles use avalanche terrain differently [27]. Three freeriding styles have evolved during the technical evolution of snowmobiles. The first two, high-marking and hill climbing (Figure 1), typically start at the bottom of a slope and climb as high as possible to create a competitive "high mark" or climb the whole mountain without turning. High-marking has been a precipitant for numerous avalanche accidents [28] and has dominated mitigation focus [10]. During the past 15 years, a third riding style has evolved, termed technical riding (also known as boon-docking). It prefers deep loose snow to make tight turns, jumps, drops, short climbs and slope traversing/cutting, as shown in Figure 2 [29,30]. During technical riding, fellow riders are often out of sight [31] of each other, resulting in poor internal communication.

Figure 1. Typical terrain used for high-marking and hill climbing. Photo: Courtesy of participant.

Figure 2. Technical riding tracks in the focus area between the trees. Note that there are no tracks in the classic hill climbing bowl in the background. Photo: B. Michaelsen.

The most complex avalanche management situation is when there are persistent weak layers (PWLs) in the snowpack. According to Klassen, "At no time do human factors play a greater role in decision making than when dealing with persistent slab, and especially deep persistent slab, avalanche problems" [21] (p. 175). PWLs are fragile snow layers within the snowpack that can exist over longer periods in large areas and imply a greater uncertainty than other avalanche problems, regarding if and when they might collapse and trigger an avalanche. They can be triggered naturally or by human activity in steep slopes or remotely from flat areas below steeper avalanche terrain. PWLs are evident in

most avalanche accidents in Norway, e.g., the winter of 2018–2019 [32], and are a causal factor in 60–75% of avalanche fatalities in Canada [20]. The high rate of accidents due to PWLs highlights the need for improved strategies for managing this avalanche problem.

Snowmobiling can have a compacting and thus stabilizing effect on snow and therefor reduce the avalanche danger if an area experiences heavy traffic. Compaction may reduce or eliminate the PWL's ability to propagate and create an avalanche [33]. Snowmobiles penetrate the snowpack deeper than skiers [34], especially when performing technical maneuvers while freeriding [35]. This stabilizing effect is exploited in ski resorts, where bootpacking is used to prevent inbound avalanches [33,36]. The benefit of compaction is probably greater when backcountry riding is frequent between snowfalls. Snowmobilers may get fewer alarm signs from PWLs in areas more prone to snowmobiling and compaction. Firm layers protecting the deeper PWL layer can provide a false sense of safety. All three riding styles imply extreme maneuvers with unpredictable effects on PWLs [35], and thus demand more experience and a higher level of avalanche knowledge compared to riding in thoroughly compacted areas [20].

Snowmobile avalanche education started about 30 years ago [10]. Mainstream avalanche books have primarily targeted skiers (see [37] for example). Snowmobiling and high-marking strategies became more noticeable in avalanche books in early 2000 in e.g., *Staying Alive in Avalanche Terrain* [37]. Norwegian snowmobilers were addressed (2 out 86 pages) by Brattlien [38]. The increasing amount of snowmobile avalanche accidents 20 years ago in the US and Canada put more focus on communication challenges regarding skier–snowmobile perspectives. A shift toward an audience perspective was applied by using snowmobilers to educate snowmobilers [10,12]. They tried to take advantage of social comparison theory [39] so that snowmobilers would increasingly identify themselves with the need to obtain avalanche education and not only the riding skills of professional riders. The aim was that snowmobilers would take courses and know how to adjust their behavior [15] according to the avalanche danger. In Norway, the Norwegian Avalanche Warning Service started a snowmobile educational web site in 2015 [40], and the Norwegian snowmobile license education introduced a six-hour avalanche and ice safety course in 2018 [41] where the final section of the program implied basic snow knowledge, identification of avalanche terrain, how avalanche danger is influenced by snowmobiling and search and rescue. Riding styles and challenges specific for freeriding are not mentioned, probably due to the illegal aspects of this activity.

Snowmobilers' avalanche knowledge has been studied and was rated as low from a snowmobiler trail head survey in Canada [42]. Further research on snowmobilers' knowledge regarding complex snowpack management was also rated low [10]. Haegeli and Strong-Cvetich's [22] online survey in Canada found a misunderstood use of the avalanche danger scale, low perception of PWLs, the need to emphasize more on warning signs and the importance of relocation strategies at elevated danger. Despite the efforts made in Canada and the US [13], snowmobilers do not seem to take courses beyond the basics [16,17]. Since complex management situations with PWLs are not taught at introductory courses, [20] and [43] emphasized that snowmobilers could develop overconfidence in avalanche terrain. The authors of [16,20] proposed a rethinking of the snowmobile avalanche education, as it did not match the snowmobilers needs or dealt sufficiently with complex snowpack management.

Another restraint to avalanche education was stigma issues between skiers and snowmobilers, where snowmobilers were looked upon as " ... an outlier, subgroup of the avalanche community until recently" [42] (p. 1139). Being both an avalanche educator and snowmobiler, Predeger pointed out recently that "Recognizing snowmobilers as a specific user group within the official avalanche community in the US, didn't evolve earlier than a decade ago ... So ... Leave your Patagonia (ski) gear at home when showing up to a Sledneck event" [44] (p. 26). In other words, not having the audience perspective seems to be a disqualifying factor when the aim is to promote avalanche education that can change peoples' behavior.

In Norway, Ref. [45] interviewed 10 snowmobilers in Northern Norway and found that their behavior and risk management were not based on any formal avalanche education, but their own local expertise. Since freeriding is illegal in Norway, there are no avalanche courses for this type of snowmobilers and their specific challenges. If they do not attend an avalanche course for skiers, they are on their own, learning by doing.

3. Objectives

Our aim was to study the behavior of freeriding snowmobilers in avalanche terrain in Norway, as well as the factors influencing this behavior from their perspective. We raised the following three research questions:

1. What do snowmobilers do and not do in avalanche terrain?
2. How does their behavior relate to managing complex avalanche conditions?
3. Is there a mismatch between avalanche knowledge and riding preferences?

4. Method and Material

In this study, a qualitative exploratory approach was chosen since the behavior we wanted to investigate had not been studied in the field in Norway before. Thus, a case-based nonexperimental data collection was beneficial using observational methods in the field [46]. We present the methods, data collection and analysis in the following sections.

4.1. Ethnographic Approach

Since we needed data from a specific group and not the general snowmobiler, we chose a non-random participant selection, beneficial in exploratory stages of projects to increase the internal validity [47]. To be able to increase reliability, we sought several data sources to achieve what Burkve [48] and Morse [49] describe as N. Denzin's source triangulation. We also chose two different focus areas to ensure that the data that were replicated within the focus group were not only valid for one specific area [50]. Our research design took advantage of both insider and outsider perspectives regarding participant communication and data interpretation, since the lead researcher had dealt with avalanche management in the region for 20 years without being a part of the snowmobiling community. Although Strong–Cvetich pointed out in their study that "Qualitative interviews with key members of the mountain snowmobile community might offer more valuable insights to the attitudes and motivations of the hard-to-reach segments of the overall population" [11] (p. 137), we were afraid that structured interviews could feed the hard-to-reach target group with predefined topics with the risk of losing significant audience perspectives.

We chose an ethnographic approach implying unstructured open conversations such as everyday talk. This has proven useful in related research [51,52]. We used phone conversations, email and text messages. In addition to revealing what they did, it was equally important to detect what they did not do or say regarding their avalanche assessment in relation to best practice. To increase reliability, observations and interviews were "member checked" [53] by key participants. This secured their audience perspective and reduced researcher interpretation bias.

Recruitment of key participants was based on initial key participant insider suggestions and snowballing. Random participants were used to verify the key participant data and observations. Random participants were people we would meet by chance in the field during direct observations. As soon as a conversation became relevant, the study was presented, and the participants gave their consent to participate. Semi-structured conversations were used when contacting, e.g., mountain police or resources outside of the illegal snowmobile community. Media contributed with incident reports and public opinions.

Since the target group snowmobiled illegally, practical and ethical issues needed to be solved. A feasibility study [54] revealed that joining the illegal snowmobiling to gain thick descriptions [55,56] would be ethically and practically problematic. Observing from a distance at key locations was considered next. This was ruled out since the researcher had

experienced prior this research an increasingly dangerous behavior (show off effect) when meeting snowmobilers as a skier.

Due to the ethical dilemmas, we developed a new method not presented in prior research. We sought to combine insider information using key participants, with field observations of not only of tracks observed, but just as important, where in the terrain there was an absence of tracks. In contrast to recent GPS detection of legal snowmobile tracks in the US [57], this method of observation avoids the risk that participants altered their behavior knowing they were monitored during a research project.

A typical field day would be ski touring, observing where tracks were made and not made, taking pictures and seeking higher terrain to visually observe riding patterns. Tracks would provide different data depending on when the observations were made. Tracks made right after a snowfall provided reliable data regarding riding style preferences and also informed how riders interpreted the avalanche situation in relation to best practice avalanche management. Observations made when there were more accumulated tracks revealed the overarching behavioral patterns, since it became obvious what kind of terrain the riders did not use. Notes would be made on site or immediately after, depending on the weather conditions. Key participants were contacted frequently for interpretation and verification early in the fieldwork.

4.2. Data Collection

Field data were collected in Northern Norway in the western part of Finnmark County (Figure 3) between January 2018 and March 2019. Supplementary data were collected until August 2019. In the focus areas eight observational field days were performed in January, February, March and April of 2018 and 2019. The key participants (n = 7) contributed the same periods as the observations were performed. There were two random participant conversations in one of the focus areas (1b). Conversations (n = 6) with external sources outside of the target group, e.g., mountain police, were also conducted during the same periods with one exception. Reports in regional media (n = 3) provided pictures of nonfatal incidents in other areas of Finnmark in March and April of 2018.

Figure 3. Study area in Northern Norway.

4.3. Data Analysis

The analysis was a reflective cyclical process implying data collection–coding–theoretical sampling–more data collection, resulting in new theory [58,59]. The observational data collection ended in March 2019 when adequacy was achieved [49] and fieldwork only confirmed previously documented codes and categories [60].

Our data evolved from the "bottom-up" through our open-ended research questions. We had an open coding process [61] by identifying codes in our notes, e.g., events and behavior described by key participants. Similar data codes created categories that revealed the themes that are discussed in the paper.

The lead researcher and first coder performed the fieldwork and coded the data first. Next, a second coder coded the data independently. The procedure with a second coder or inter-rater should provide a more consistent interpretation and analysis of the data [50,62]. To ensure the interpretation of the key participant data, the field notes and pictures, it was significant that the primary investigator and the second coder had extensive knowledge of the phenomenon as avalanche professionals and practitioners, providing sufficient situational awareness. We considered an additional external co-coder re-check [63] unnecessary since the second coder was not part of the initial data collection design or coding.

The primary coder and investigator structured the coding in three themes based on eight categories:

- Game changer: 1. new riding style, 2. new challenges, 3. new terrain preferences
- Competence: 4. avalanche knowledge, 5. safety perception
- Consequences: 6. attitudes, 7. monetary consequences 8. accidents

The co-coder identified 21 data blocks, of which 19 matched or fit within the primary investigator's coding and complemented the categories and themes. We applied Miles and Huberman's [50] formula to our analysis: # data block agreements (=19)/total # of agreements + disagreements (=21) = 90%. An intercoder reliability score of 90% is regarded as a sufficient agreement score.

5. Results

5.1. Changed Preferences for Terrain, Snow and Riding Styles

Figure 4 illustrates our findings regarding behavior based on our field observations and was commented on and confirmed by key participants within the target group. Most of the illegal technical riding was observed within the red polygon, characterized by sparsely forested terrain and terrain traps. More tracks were observed during periods of deep powder snow conditions than when conditions were compacted by old tracks or strong wind. Tracks were seldom observed in the previously popular high-marking and hill climbing locations (yellow polygons) during our study.

The observed track pattern was explained to us by key participant no. one: "You need more snow in general to do technical riding compared to high-marking that is limited to a loaded lee face. This has changed the preferences-what to do where within the community the past years ... (since) you preferably need forest (soft snow) and terrain features to play in". Our focus areas were confirmed by key participant no. one as the most attractive areas for technical riding in the region. Especially "Øksfjordbotn (1b) is a playground for technical sledders". The qualities of the area to perform technical riding was also confirmed by key participant no. seven, who told us that sledders travel as far as 300 km from the east of Finnmark to ride 1b. People have also traveled from Finland and Southern Norway to pursue technical riding in the 1b area (key participant no. one). Technical riding has relocated the avalanche-exposed riding within the Alta region due to the deeper snow cover and more frequent snowfalls combined with the terrain features.

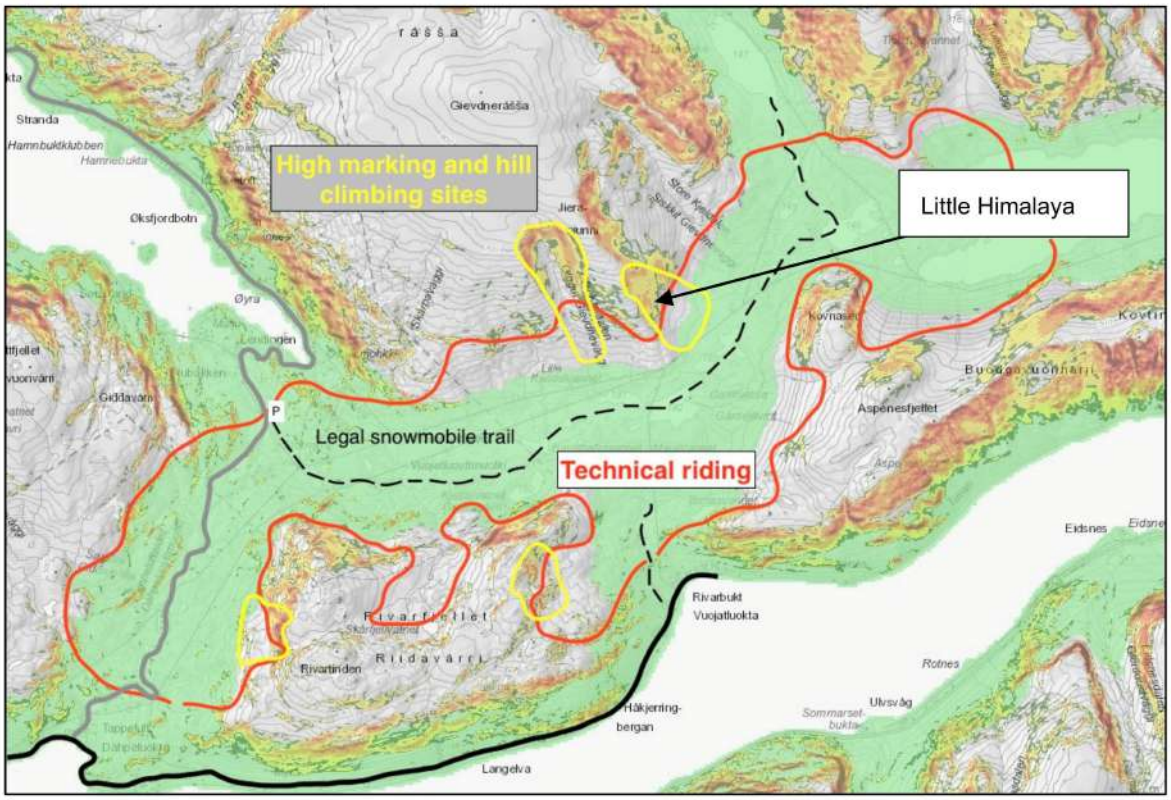

Figure 4. Focus area 1b. Yellow polygons show areas that used to be popular for high-marking and hill climbing. Red polygon shows the area which is now used for technical riding. The polygons are overlaid on a map from www.senorge.no (accessed on 6 January 2022), showing terrain steeper than 30 degrees (yellow to red) and forest/vegetation (green).

Untracked high-marking terrain indicated that high-marking had become less popular (Figure 2) in the area. We observed some high-marking and hill climbing in areas 1a and 1b, but it was limited to smaller terrain features than before. A previously popular five-hundred-meter slope named "Little Himalaya" (Figure 4) had no observed high-marking activity during our field days. This reduction in high-marking activity was confirmed by key participant no. seven. Despite favorable snow conditions with less persistent weak layers, he had not observed high-marking on Little Himalaya during 2019 (nor 2018 when a shallow snow could have explained the reduced activity).

The tracks and new behavior we observed with reduced high-marking and hill climbing were further explained by key participant no. two: "The machines have developed, and it is more fun maneuvering challenging and tricky terrain than high marking straight up". In addition to revealing the significance of the improved technology that made it more fun when performing technical riding, key participant no. seven told us that there has been a status change among the sledders regarding what is prestigious, and discredited high-marking: "Anyone with enough horsepower can ride the high marking slopes which demands less skills compared to technical riding". The change in activities from high-marking and hill climbing to technical riding indicated a game changer, as the riders have changed their riding style and terrain preferences significantly.

5.2. Concerns for Avalanche Competence and Awareness

Several of our key participants (nos. one, three and seven) expressed concern about the ongoing behavior and how their fellow snowmobilers underestimated risk and exposure. Key participants no. one and seven were disappointed regarding the attitudes and behavior the riders displayed when dealing with persistent weak layer situations (PWL). Key participant no. seven exemplified this concern since he feared that the "Riders would

go crazy with an upcoming snowfall" due to a long period of limited riding options in 2018 during a PWL situation with risk of damaging one's snowmobile.

Key participant no. two acknowledged the new complex terrain trap exposure they had to deal with: "It's also tricky many times to see the terrain traps in the forest and evaluate the terrain above. There is a lot to consider". Key participant no. one expressed a competence concern after meeting two random riders who had triggered small avalanches in location 1a, which is known for its hill climbing and high-marking and large PWL avalanches. Having advanced avalanche knowledge as a snowmobiler, he asked how their side hilling (a sled maneuver that cuts across the slope and can dig deep into the snowpack) related to the avalanche situation. They answered that "The avalanches were not dangerous that day, since they were only powder avalanches". Key participant no. one interpreted their answer as a lack of competence and respect for the dangerous PWL situation and the avalanche forecast. Best practice would have been to avoid avalanche terrain, since small avalanches could propagate or stepdown and cause large fatal avalanches when riding.

None of our key participants expressed that their fellow snowmobilers had sufficient competence, or the awareness needed to assess the avalanche danger, but rather the contrary. A random participant in the field told us about the basic avalanche courses that had been organized in the region. These were initiated within the targeted community, but there was little interest in taking more advanced courses on technical riding and managing complex avalanche situations.

5.3. Risk of Accidents, Fines and How Material Damages Influence Behavior

According to key participant no. seven, "There are rumors every season about all the near misses". Incidents and close calls are never reported officially or shared publicly since the activity is illegal. Filmed avalanche incidents have been posted on social media more or less anonymously. During field work in 2018, key participant no. three described several close calls at location 1a, implying the triggering of avalanches and partial burials. Close calls had an impact on key participant no. two. He mentioned that close calls and accidents when high-marking convinced him to shift to technical riding. Getting older and smarter with increased responsibility in life made him less willing to take the risks he and friends of his took previously when high-marking. Technical riding was presumed safer.

The police in Finnmark and Alta told us that the influence on behavior due to avalanche accidents was disappointingly short lived. There have been several fatal accidents in the region, one of which was west of our focus areas in March 2018, most likely due to technical riding. Pictures provided by the police for this study indicated that the avalanche was remotely triggered by the snowmobiler when riding at the bottom of the forested valley. The accident illustrated the feared combination of technical riding, persistent weak layers and a terrain trap mentioned by key participant no. seven. Our participants did not reveal if there were any attitudinal changes after an accident regarding the use of personal avalanche rescue gear.

What did change behavior was the fear of damaging the machine. We revealed a new risk perception due to shallow snowpack conditions in 2018. Key participant no. one explained the riding as insurance conditions or "Kaskoføre". The reasoning was that the fear of hitting rocks in the shallow snowpack limited the riding to more densely forested terrain. This forced them into terrain traps where the snow cover was thick enough to maneuver. Different from previous riding, this behavior was motivated by fear of monetary consequences.

Monetary consequences due to the risk of getting fined from police controls did make an impact on when to ride where. After viewing a closed Facebook group that warned members about possible police controls, we observed less tracks than expected after a mid-season weekend with nice weather and recent snowfall.

6. Discussion

The study provides an audience perspective of what snowmobilers do in avalanche terrain in Norway using an ethnographic approach to get as close to real life as ethically and practically possible when studying a risk-prone illegal activity. Our study has important contributions to others interested in observing hard-to-reach groups. In this section, we discuss our findings related to behavior, preferences, competence, equipment and education, as well as how our method provided access to data, we most likely would have missed otherwise.

6.1. Game Changer

After two seasons of observations, we documented a game changer regarding snowmobiler behavior in Northern Norway, as technical riding was documented for the first time. Our findings are important for education and risk management and suggest that Norwegian snowmobilers face similar challenges as those in Canada. The track patterns we observed were confusing at first but were made understandable thanks to the use of key participants. A new type of technical riding was observed during the first field season, named "insurance riding" by our key participants. A long winter with limited snow the first months made the riders focus on how to ride without damaging their machine due to few options with a shallow snowpack. Those with the right machine and skills could expand their terrain usage to include denser forests, deeper snow and more avalanche terrain traps compared to riders with poorer equipment or skills. This was a significant part of the new terrain usage and increased exposure to avalanche terrain traps with possible fatal consequences.

The missing high-marking tracks were first thought to be due to the previously mentioned very shallow snow cover the first field season. However, high-marking tracks were also missing the second season with a thick snow cover. We argue that the behavioral pattern detected could not be dismissed due to abnormal conditions or as a local phenomenon, since riders from other parts of Norway and neighboring countries visited focus area 1b without leaving high-marking tracks either. The behavioral patterns were further confirmed by Swedish snowmobile researchers [64,65] and a Norwegian target group snowmobiler [66] during their presentations at the Nordic avalanche conference in 2019. We do not claim that no one is high-marking anymore–modern snowmobiles can easily do this—but the observations suggest a behavioral change with significant implications for education, risk management and research.

Warnings of police controlling on a closed Facebook group resulted in less riding in focus area 1b. The snowmobilers obviously wanted to avoid being fined, but law enforcement did not seem to induce any behavioral change, since they just relocated the same behavior. It is likely that similar warning groups are to be found in other parts of Norway with effects on the amount of activity. Based on our findings, the snowmobilers do not alter their preferences due to the consequences of breaking the law.

We argue there are three interlinked reasons for the change in behavior: 1. the technological improvements of the snowmobile (powder snow requirements), 2. desired powder snow skills in complex terrain that replaced the simpler high-marking up and down in specific slopes, 3. the region had areas with frequent snowfalls and preferred terrain. We find similar patterns regarding behavioral change within off-piste or backcountry skiing, where improvements in technology (skis) have made it easier for more and less skilled people to enjoy deep powder conditions and relocate into steeper avalanche terrain more often.

Our findings indicated that social comparison as a strategy for behavioral change was efficient, despite not being an official policy and strategy as in the US [13,15]. In our case, the technical riders in the unofficial illegal community did this without interference by enhancing their self-image as more sophisticated and prestigious compared to high-marking.

Even though the key participants expressed a lower personal risk acceptance after close calls, they could not see that accidents within the target group had significant impact on the overall behavior regarding avalanche safety. This corresponded with the impression passed on to us from the police.

The tracks we observed during PWL periods did not reveal best practice avalanche management. The youngest riders' social comparison competence buildup seemed to be more about riding skills than avalanche management. The situation in Norway is very different from the US, since there are few public professional role models that the riders could identify themselves with that both portray avalanche safety and riding skills. An avalanche course provider for the target group in our study confirmed the studies in Canada [16,17], where they also found little interest beyond the basic avalanche course. In comparison to skiers, this might be due to the more easily accessible "learning by doing" possibilities, and, just as important, how they look upon what is relevant knowledge buildup, as pointed out by Stewart–Pattersen et al. and Staple [13,16].

6.2. Technical Riding, Snow Compaction and PWL Issues

Our study has shown that technical riding has largely replaced high-marking and hill climbing. We have documented that new terrain features have become attractive due to technical riding. This was terrain previously passed on the way to high-marking sites (Figure 4). The new preferences also revealed increased decision-making complexity and uncertainty. This indicates that a misunderstood competence buildup pointed out by Stewart-Patterson and Hanke [20] and Pawliuk [43] seems likely, and not only for those within the local target group that predominantly high-marked before. This seems even more relevant for the snowmobilers that arrived in the area 1b from other parts of the region, Norway and neighboring countries, who were most likely used to more compacted conditions. They might start riding without an update on the avalanche situation, lacking significant local knowledge.

As shown in Figure 4, terrain usage has evolved from being static and more predictable high-marking in a few small areas to become more dynamic, using a much larger area with increased uncertainty and terrain complexity. The previously popular high-marking sites were tracked frequently, with resulting compaction, reduced PWL development and an overall lower likelihood of avalanches. The high-markers could monitor avalanche slopes as ski resorts do [33,36], since the terrain usage was static, the risk was more defined and the riders would typically watch each other. Technical riding has introduced a more dynamic terrain usage. This has implied an increased use of terrain traps, typically around and below the wind-exposed tree line sections connected to avalanche terrain above. This dynamic terrain usage may render riders more vulnerable to a false sense of safety [33]. They may base their second ride on the experience from the first ride performed on a snowpack with no PWL alarm signs due to a fresh snowfall hiding old tracks, thus concluding that it is safe.

Snow compaction research [67] and focus on persistent weak layer management [68] have primarily been for skiers [33]. Since technical riding implies a more spaced-out track pattern that will reduce the stabilizing effect of the snowmobile maneuvers [35], the ongoing work in Canada by Stewart-Patterson, Exner and Hanke [35] on the effects of snowmobile maneuvers on the snowpack will hopefully provide management recommendations we can adjust to Norwegian conditions. The rider's awareness of increased uncertainty since the slopes were not tracked frequently might explain why we did not see high-marking tracks in the most popular sites. They might have known that decision expertise developed in tracked areas is not transferable to untracked snowpacks. More research is needed to grasp why they do as they do in this regard. Our findings support prior research on snowmobilers' competence regarding PWLs and complex snowpack situations [22] by revealing a low perception of PWLs and the importance of having a relocation strategy when in elevated danger. We also see that education needs to put more emphasis on misunderstood competence, false sense of safety and terrain trap management [13].

6.3. Mismatch between Preferred Snowmobiling, Competence and Education

The mismatch between the preferred snowmobile riding and education in Canada developed since new machines made it easier for less knowledgeable and less experienced riders to access more terrain and complex situations. How is this in Norway? After answering the first research question we learned that our target group has the new machines as in Canada. We learned from observations and key participant statements that they prefer technical riding, access more terrain and end up in more complex situations than before. Track observations and insider concern voiced by key participants suggest that lack of respect for PWL conditions results in annual close calls and fatal accidents.

The mismatch in education and preferred riding is obvious in Norway, as there is no avalanche education for our targeted snowmobilers since their behavior is illegal. Thus, our target group has to organize courses themselves, attend courses for skiers without snowmobile-specific issues, learn from YouTube or just continue learning by doing. As in Canada, the target group had little interest in advanced courses.

What we do not know is if the riders have had an uncritical transformation of high-marking management skills to technical riding, and this could result in the underestimated risk recognition emphasized in previous research [22]. One of our key participants did tell us that he shifted from high-marking to technical riding because he presumed technical riding to be safer. Key participants also expressed concern for their friend's behavior after a period of compacted snow with limited riding options. To obtain a better impression of the riders' avalanche knowledge, participant observation may be the preferred option to disentangle the riders often high riding skills and practical experience from their avalanche assessment skills.

This study found the same mismatch between education and behavior previously described in Canada. To remedy the situation, one of our key participants suggested that future education efforts should target the younger riders, who have the newest machines and highest riding skills, but the least experience.

6.4. Ethical and Practical Constraints and the Need for a New Tool

There is frustration among ethnographers regarding rigid ethical standards making observations in public spaces practically impossible [69]. This challenge became even more evident in our study since the behavior we wanted to observe was illegal. By changing the observational strategy from people to the tracks they made and did not make, we found the tool that did the job. Ethical safety concerns were avoided for both the researcher and participants in our study, as the researcher did not have to join the avalanche-exposed activity or risk influencing the participant behavior. Privacy and anonymity were preserved, since the old tracks did not reveal anyone, and they told the truth. Since we did not meet the key participants in the field, we avoided rumors and distrust within the community that could have influenced behavior. In addition, we wanted the participants to talk about the behavior of "others" to detect broader behavioral patterns. Despite the challenges, we argue that our ethnographic approach and method revealed a new option for research on hard-to-reach groups and studying behavior in a risk-exposed environment.

6.5. Limitations

Caution should be used when generalizing our findings beyond our case area. Hopefully, our research and field method can fuel similar research in other parts of Norway, since answers from the general snowmobiler that avoids avalanche terrain are not the data of interest. The method we used did not capture the riders' avalanche knowledge level, as presented in surveys [10,22,42]. Qualitative interviews with key members, as suggested by Strong–Cvetich [11], would most likely have provided more in depth insights regarding competence level, decision making and attitudes. Participant observation would have given a better impression of the riders' avalanche assessment and decision-making competence. The GPS tracking applied by Hendrikx and Johnson [57] could have provided a more accurate interpretation of how terrain usage correlated with avalanche problems.

Since the riding was illegal, we had to disregard this option since we feared that it would influence their behavior knowing that they were monitored. Awareness of biases on how the researchers could influence the fieldwork and analyzation procedure was essential [56]. The lead researcher's background as an avalanche course provider in the region could influence key participants to comply with the researcher and answer what he wanted to hear. Since we could combine the tracks with random participants not acquainted with the researcher, we hopefully cross checked the essential information and reduced this potential bias.

7. Conclusions

We studied the behavior of freeriding snowmobilers in avalanche terrain in Norway and the factors influencing this behavior from their perspective. Prior to this study, a common belief was that high-marking caused many of the snowmobile avalanche accidents. Our field observations, confirmed by key participants over two seasons, revealed that technical riding in a more complex environment has become more popular due to the technical evolution of snowmobiles and social comparison dynamics within the targeted group.

The transition to technical riding implies more challenging risk management, with increased complexity in terms of snow and terrain traps. The mobility and attitude of the riders raises concerns about limited self-competence and a false sense of avalanche safety, in particular during snow conditions with persistent weak layers. The situation in Norway resembles Canada, with a possible mismatch between education and actual behavior. The lack of insider snowmobile avalanche safety mentors in Norway is a major challenge if social comparison strategies are to be considered. It seems clear that the effect of existing policy and law enforcement is limited in terms of changing snowmobilers' riding preferences or increasing their avalanche knowledge level.

This study of a predominantly illegal activity also sheds light on how to explore and observe a hard-to-reach target group. The methods developed should be of interest for a wider audience in other research disciplines.

If we had only observed tracks on flat or gently sloping forested terrain, we would not have any snowmobile avalanche accidents in Norway. However, this was not the case. We fear that the observed behavioral changes are a recipe for more accidents in the future due to the mismatch between education, competence and behavior as more people with limited experience, skills and knowledge with avalanche risk management obtain easier access to more complex situations.

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Article

Mission Himalaya: Exploring the Impact of a Supported High-Altitude Mountaineering Expedition on the Well-Being and Personal Development of UK Military Veterans

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Abstract: Meaningful, positive, emotional and challenging adventurous activities may generate personal growth or recovery from ill health or injury. In this study, we used a distinctive longitudinal and immersive research approach to explore the psychological impact of a high-altitude expedition to the Nepalese Himalaya on 10 (9 males) UK military veterans with longstanding well-being concerns. In the 12 months prior to the expedition, participants took part in three training weekends in the UK mountains. During the expedition, instructors—who were all experienced health coaches—facilitated reflective practices with the beneficiaries throughout, focusing on experiential transfer to day-to-day lives after the expedition. Follow-up interviews, conducted up to 18-months post-expedition, identified that the most desirable changes aligned with the three innate psychological needs of self-determination theory: autonomy, competence and relatedness. The routines established during the preparation stage and during the expedition itself activated a renewed energy for personal improvement. At 18 months post-expedition, the key changes reflected altered perspective, employment skills and work–life balance, increased physical activity and enhanced personal awareness and mindfulness. Importantly, supported by regular health coaching and focused on the transfer of learning, expeditions can activate meaningful long-term changes to the well-being and personal development of military veterans.

Keywords: psychological well-being; veterans; behaviour change; mental health; adventure therapy; recovery; health coaching; post-expedition growth; expedition; mountaineering; psychosocial development; self-determination theory

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1. Introduction

Military personnel can experience circumstances during their time in service or as a part of their transition to civilian life that have a negative impact on their physical or mental health. A recent increase in service personnel reporting mental health concerns has identified that issues are not exclusive to those with deployment experience [1,2]. Notwithstanding, the prevalence of mental health problems is higher in deployed veterans [3]. Mental health problems are the second most prominent reason for medical discharge behind musculoskeletal disorders and injuries [4]. In the last 10 years, in the UK, medical discharges from the Army due to mental and behavioural disorders has increased from 15 to 33% [4].

The Parliamentary Defence Committee reported that some departing personnel are not adequately served by the system [5]. Many services that aim to support veterans stem from clinical models of recovery and continue to dominate rehabilitation services, focusing on symptom reduction and physical functioning [6]. Research has highlighted the need to explore additional and alternative approaches to recovery beyond conventional

practice as an adjunct to the clinical services which "are not associated with hospitals, rehabilitation centres, or other clinical settings" [1]. One such area is sport and outdoor and adventurous physical activity (OAA), which is thought to complement mainstream practices by "facilitating a faster return to healthy levels of psychological functioning" [7].

The emerging literature examining the use of OAA programmes for veterans attributes such initiatives with some success in demonstrating improved well-being. This can be achieved through OAA provision, when delivered in a way that successfully provides an immersive experience, meets the bespoke needs of participants and is evidenced in an appropriate form [8]. Several studies have shown that conditions experienced on an expedition can result in improved psychological well-being [9–12]. However, few studies have examined the impact of expeditions for people adjusting to life-changing circumstances, such as sustaining career-ending physical injuries or the diagnosis of a trauma-related mental health disorder.

Only a few studies have reported on how short-term expeditions influence well-being benefits and these are limited by focusing on the immediate expedition, meaning that longer-term impacts are unclear [9–12]. Further, only one study has addressed the unique context of expeditions involving military veterans [13]. That study focused on the psychosocial impact of a mountaineering expedition on four individuals. The expedition influenced how individuals understood their own capabilities and reshaped their personal understanding of being a veteran, encouraging them to take more responsibility for their own recovery. Greer and Vin-Ravi [14] emphasised that more research is needed to establish the viability and appropriateness of expeditions to determine the durability and "real world" relevance to their outcomes.

In response, the aim of this study was to use a high-altitude expedition to the Himalaya to investigate the impacts on personal development and well-being that occurred amongst a small group of UK military veterans with a range of mental and physical health challenges. Further, given the pre-existing skills of the expedition staff, we aimed to activate expedition impacts by deploying health coaching, emphasising increased self-determination.

2. Methods

2.1. Study Design

To assess sustained positive impacts on health and well-being arising from participation in an OAA, semi-structured interviews were conducted with participants before, during and up to 18 months after a demanding month-long Himalayan mountaineering expedition. In this longitudinal study design, interviews with participants were carried out by a single individual researcher. Pre-expedition research was conducted to understand the existing changes participants wanted to make to their lives to improve their well-being and how they believed the expedition could facilitate this. The longitudinal element of this study design allowed the effects of this OAA intervention to be examined over an extended period of time, to assess the lasting effects of the expedition on the well-being and personal development of the military veterans.

2.2. The Expedition

Through an immersive expedition to Nepal, supplemented by three UK-based training weekends, the Mission Himalaya expedition was developed in line with the theoretical framework that underpins the delivery of developmental courses for veterans at the Battle Back Centre [15]. The expedition involved a 23-day trek in the Everest region of the Nepalese Himalaya, including an attempt to summit Mera Peak (6476 m/21,247 ft).

2.3. Theoretical Orientation of Health Coaching

Beyond exploring the impact of the expedition itself, this study also explored how self-determination coaching could amplify well-being benefits over a long-term period. Ryan and Deci [16] define well-being as "a complex concept, primarily concerned with optimal psychological experience and functioning". As a key well-being theory, self-determination

theory (SDT) is concerned with the motivation of behaviours, holding that positive growth, integrity and well-being rely on an individual's basic psychological needs for autonomy, competence and relatedness [16]. Autonomy refers to the ability for an individual to make independent decisions and take control of one's actions. Competence is associated with an individual successfully achieving mastery of activities and goals. Relatedness entails an intrinsic need to feel connectedness through both care of others and experiencing a sense of belonging. These three concepts provide practical actionable levers for any health coaches seeking to optimise intervention outcomes focused on psychological well-being.

2.4. Recruitment and Ethical Consent

The only inclusion criterion was to be a veteran member of the Mission Himalaya Expedition. Initially, all veteran expedition members were invited to participate in the study on a training weekend three months prior to the expedition. Prior to acceptance, all participants received a verbal briefing about the purpose of the study, reassurances about anonymity and confidentiality, made by the expedition researcher (CK). All agreed, giving a sample of nine males and one female.

Subsequently, participants were provided with an information sheet, via email, detailing the aims and methodology of the study and explaining in lay terms what would be expected of them if they agreed to participate. Potential participants were asked to take a minimum of 24 h before acknowledging that they had read and understood the participant information sheet after which time informed consent was obtained from those wishing to take part in the study through completion of an electronic consent form. Ethical approval for the study was obtained from the Leeds Beckett University Ethics Committee (50538).

2.5. Participants

All 10 participants were UK veterans of the armed forces, all of whom had faced personal, physical or mental health difficulties in their lives, some of whom were medically discharged from service. They were members of the Royal British Legion's (TRBL) Mission Himalaya expedition to Nepal in 2018. None had trekked in the Himalaya before and only two had any mountaineering experience. The length of time since the participants had served ranged from 2 to 31 years, and participants were aged 29 to 62 years. Pseudonyms are used to maintain participants' anonymity.

2.6. Health Coaching on a High-Altitude Mountaineering Expedition

The Mission Himalaya experience was developed from the five-day Battle Back courses that support UK veterans and recovering serving personnel. The courses use adaptive sport and adventurous activities as a context for personal growth and development. Staff operate in a health coaching capacity with the participants they support and host meaningful reflective practices to facilitate sustainable positive behaviour change [17].

This ethos was transferred to the development of the Mission Himalaya trip for the 10 veteran beneficiaries. All expedition staff were experienced Battle Back health coaching staff, meaning they were fully inducted into using the self-determination theory that characterises those courses, namely that of encouraging long-term behaviour change through the improvement of participants' psychological needs of autonomy, competence and relatedness.

Three of the four expedition coaching staff were veterans themselves, with years of military experience, and all were experienced mountaineers who built close, positive working relationships with team members across the 12 months of expedition training prior to the expedition. The dual role of coach and mountaineering instructor led to a wide acceptance of their physical and emotional role in supporting the participants. Intentionally, the coaching staff worked specifically with two or three of the participants to develop a close, supportive relationship. They proactively engaged in reflective practices with their veterans at appropriate times on the expedition, on rest days and while at camp in the evenings, etc.

2.7. The Expedition Researcher

The expedition researcher (CK) was a climbing and mountaineering instructor. From three months prior to the expedition taking place, he took part in all aspects of the pre-expedition, training weekends, camping and hill walking with the participants, etc. He then participated fully in the expedition to Nepal, trekking with the participants, spending time with them on rest days and at camp. He also summited Mera Peak with one of the veterans and coaches. This immersion helped to build familiarity, trust and rapport and allowed for an in-depth account of what took place throughout the expedition. Creating the opportunity to build such a close relationship with the participants was intended to improve the likelihood of gathering meaningful and honest accounts of the participants' experiences during the research interviews. Field notes, maintained throughout the expedition, detailed key events and participant concerns, personal development progress and challenges.

2.8. Data Collection

The researcher conducted semi-structured interviews with the 10 participants in two distinct phases. Phase one interviews were conducted before and during the expedition. Phase two interviews took place after the expedition over 6–18 months. Interviews involved the researcher using a list of topics or questions as a guide to cover relevant subjects during the discussion [18]. The use of semi-structured interviews allowed continuity between meetings and gave flexibility to the themes, encouraging a more relaxed discussion, aiming for rich and detailed data [19].

The Stages of Change model, which includes a series of five stages (pre-contemplation, contemplation, preparation, action and maintenance) that an individual will experience for behaviour transformation, was used as a guide to structure the phase one interviews [20]. Phase one interviews therefore focused on participants' responses in terms of readiness to change. Conducting pre-expedition research aimed to understand what participants believed they could gain from the expedition and provided an individualised understanding of what success meant to everyone. Phase two interviews all took place via telephone, with a focus on the outcomes of the expedition and personal development of the participants.

2.9. Data Analysis

Semi-structured interviews were audio recorded, then transcribed and analysed using Braun and Clarke's [21] six-step thematic analysis (TA) method. Researchers categorised the text data into codes, which were then grouped into coding sets based on key themes. This "inductive analysis" is a data-driven form of TA, involving the coding of data beyond constrictions of a pre-existing coding frame. The resulting flexibility allowed themes to emerge from the data. To avoid overlooking close details, NVivo software package was used in the coding process. Direct quotes were taken from the interview transcripts to illustrate the participants' experiences within each key theme. To address the guiding framework of the health coaching underpinning the expedition experience, SDT concepts (autonomy, competence and relatedness) were also used as sensitising themes.

3. Results

3.1. Phase One—Before and during the Expedition

3.1.1. Worthiness of Recovery Support

Unsurprisingly, the experiences of all 10 participants varied during and after their time in the armed forces. Some participants had been medically discharged, others were diagnosed with healthcare issues or injuries and some had no clinical diagnosis of illness or injury. Despite various struggles with their mental health, when posed with the opportunity to participate in the expedition, many of the veterans felt "*undeserving of being a participant*" (Ellis) or "*a little bit of a fraud*" (Sam). This was particularly common in cases where the participants had not sustained severe physical injuries but mental or moral injuries and considered themselves "*not a veteran that has been blown up*" (Ellis). When faced with the expedition application, several of the participants demonstrated high levels of self-doubt,

stating how they had felt there was "*no point in applying*" (Ashley) and described having a "*definite lack of belief*" (Jo) that good things could come from the expedition.

The extent to which participants felt the expedition could facilitate positive changes in their lives varied from very little to complete belief that it would "*be a beneficial part of recovery*" (Ellis) and significantly benefit their well-being. Some of the participants also recognised that the expedition had the potential to benefit their physical health positively, enabling them to "*get a bit fitter*" and "*lose a bit of weight*" (Pat). The participants' lack of self-confidence in relation to their eligibility for the expedition highlights their inability to take control of their own actions or make decisions and demonstrates a low level of autonomy and competence before the trip.

3.1.2. What Did the Participants Want to Change in Their Lives? General State of Mental Well-Being

The most common desired life change mentioned by the participants during the pre-trip interviews was in relation to improving their general mental well-being and personal development or growth. For differing reasons, the grounds behind leaving the armed forces had left many of the participants in a poor state of mental ill health or a "*bad place*" (Jo). Before the expedition, some participants described their personal situation and state of mental health negatively, for instance, as "*suffering terribly from social anxiety*" (Dan) and feeling "*tearful and stressed out*" (Ellis). One participant stated that they were "*really struggling with suicidal thoughts*" (Charlie) and another described themselves back then as "*a pretty negative person*" (Pat), going on to explain that they had been "*in therapy, trying to juggle different medications*" at that time. Others similarly recalled "*things breaking down at home . . . and that's when I went off the rails*" (Jo). Following significant personal setbacks experienced around the time of being medically discharged from the armed forces, one participant explained wanting to return to "*operating at full potential*" (Ellis) following the trip. After undertaking training weekends for the expedition, the participants began to recognise the potential "*amount of time to reflect on stuff*" (Elliot) the trip would provide them with and the satisfaction they could feel from completing tasks and goals during the trip. They deduced that these tasks could enable them to "*come back in a mentally better place . . . with something concrete and say yeah I have done this or done that*" (Charlie). In speaking generally about their mental well-being, the majority of the participants hoped that the experiences on the trip would act as "*a period of growth*" (Ellis) and enable them to feel "*mentally enriched*" (Sam) on their return, with a rejuvenated sense of meaning and purpose. The descriptions of the participants' personal situations before the expeditions demonstrated that their mental state of well-being was generally quite negative. They recognised that by achieving goals associated with the trip, they would feel more satisfaction in life, which would be a result of increased competence.

3.1.3. Communication and Relationships with Others

In addition to improved general mental well-being, many of the participants expressed desires for the expedition to enable them with the skills and experiences to improve their communication and relationships with others. Before the expedition, a number of the participants described their struggles in tolerating others or "*maintaining healthy working relationships with people*" (Jo) and being "*able to work well in a team*" (Jamie). The desire to develop more empathy for others was commonly discussed amongst multiple participants, recognising how this could benefit them "*generally through life and day to day situations*" (Jamie) and reduce the risk of them getting angry. Jamie, in particular, acknowledged how, before the expedition, his angry outbursts had resulted in violent exchanges which could have resulted in imprisonment, recognising that significant changes needed to be made to avoid recurrence of this situation. In addition to improving tolerance and team-bonding skills, some of the participants recognised that the expedition could facilitate them in "*developing a social network of friends*" (Frankie) and enable them to build relationships with other veterans in a similar situation to themselves. By spending an extended period of

time with a variety of different individuals on the expedition, the participants noted that their communication skills and team-working ability would be tested. One participant commented in depth on how they imagined the expedition may help to improve their ability to interact with others:

> *"It will put me in a challenging position where I might be tired and stressed, but let's take that back to a workplace where I might be under pressure [. . .] translate that to being absolutely knackered at altitude and being sick and stressed; and the relationships might be under strain in the group. The expedition will replicate the most extreme circumstances where you will have to kind of really apply that team ethic and understanding of other people and tolerance" (Jo).*

Expressing a distinct need for improvement in their ability to interact with others and build stronger relationships through more tolerance exemplified the participants' lack of satisfaction with their basic psychological need for relatedness.

3.1.4. Employment

Many participants talked about wanting to improve their employment situation, improve their job satisfaction, find work or take up a more prolific job to increase their earnings to support themselves and their family. Many participants noted their struggles in settling into a new career since leaving the armed forces. Before the trip, participants described feeling "*fed up with the same s*** every day . . . and hated every minute*" (Ashley) of their working lives. Many of the participants displayed a level of dissatisfaction with their employment situation, for instance, Frankie expressed not having *"a career as such yet"*. Frankie did however recognise that the expedition could "*open a few doors for myself and maybe others . . . show me a new world and you never know a future career*". Four of the participants discussed wanting to use the expedition to improve their mountain skills and subsequently enhance career opportunities in the outdoor sector or as a future leader on trips such as Mission Himalaya to support other military veterans. Ellis noted that the expedition would be "*a really fantastic experience personally to get something great out of it . . . and see people doing stuff that I would like to do at some point*". The expedition was viewed by the participants as a potential opportunity to unlock knowledge about "*going to the Himalayas and being on expeditions with a group . . . all experience that goes towards my CV"* (Elliot).

Changes regarding their ability to secure employment was key for the majority of the participants. They maintained that if changes such as improving their ability to "*work in a challenging professional manner again and . . . make an impact*" (Ellis) were not made, they risked being left not working to their full potential or settling on something they would be dissatisfied with. Charlie stated that by going on the expedition and learning "*what limitations I have*" would enable a better understanding of "*what kind of career I could be best suited to*". By increasing their skills and confidence levels during the expedition, the participants foresaw that Mission Himalaya could help their future job applications, such as Ashley in "*applying for the Fire Brigade next year*". Increasing their confidence to independently undertake tasks associated with employment had the potential to address the low levels of competence that many of the participants displayed whilst also enabling them to feel a greater sense of purpose.

3.1.5. Physical Health and Routine

Physical health and fitness were also a key theme of the phase one interviews. Every participant mentioned physical health and fitness in relation to aspects of their life they wanted to change. For some, this was wanting to "*get back to who I used to be, physically . . . and use the expedition as a way of driving me back into the outdoors environment*" (Charlie). Many of the participants recalled a previously high level of physical fitness from their days in the armed forces, describing how, since becoming a military veteran, they had "*let themselves go"* (Jo) or "*got quite fat . . . and sort of been up and down with weight*" (Frankie). During the discussions about their physical health before the trip, the participants discussed in depth

how their poor state of mental health had impacted their physical health and fitness or motivation to go out and exercise:

> *"A typical day was getting up around four o'clock every morning, erm, sorting the dog out if he was at home and then going to work. Doing a twelve to fifteen hours day lorry driving and then if I wasn't sleeping out in the cab I was coming home and was basically chilling out or lying around on the settee before bed because I was knackered" (Ashley).*

In the lead up to the expedition, with the motivation of the trip and training weekends, many of the participants recognised the positive mental health benefits that resulted from them becoming more active again, stating how they "*felt happy . . . and your mind feels much clearer*" (Ashley) after exercise or outdoor physical activity. Most of the participants noted that even at this early-stage interview, having the motivation to train for the expedition helped them "*lose weight*" (Pat) and become "*so active*" (Frankie) which gave them "*more get up and go . . . and confidence to grow by the day*" (Jo). Many participants linked the aspiration to improve their fitness levels with their desire to create more routine in their lives. They surmised that the "*regular routine and getting up early*" (Jamie) during the four-week expedition would re-introduce them into the positive rhythm of having a daily routine and instil habits they wanted to maintain "*doing when I get home*" (Dan). Charlie stated that a "*mindset which involves getting up and doing physical activity is going to improve my physical and mental health*". The process of preparing for the expedition clearly aided the participants in an improved sense of confidence, physical fitness and overall mental well-being, much of which they "*largely attributed to being able to use the training weekends as short-term goal setting for fitness*" (Jo). By utilising the expedition to regain ability in controlling their own behaviours, the participants had the opportunity to improve their autonomy.

3.1.6. Readiness to Make Change

When asked if they felt ready to use the expedition to facilitate making the aforementioned positive changes to their lives, the majority of the participants demonstrated their commitment in feeling ready for change. The intensity or level of readiness for change ranged from some individuals reporting feeling slightly less confident about their ability to make these changes, to others feeling *"100% committed to those changes*" (Jo). Despite some concerns, the majority of the participants were confident in feeling "*beyond ready . . . with no hesitation*" (Sam) and many noted that the risk of not making these changes could result in lower moods, reduced motivation and well-being, described by Frankie as a *"spiral down into depression again I suppose, just not going anywhere and just going around in circles*".

The findings from the interviews before the expedition highlighted the need for improvements to the levels of autonomy, competence and relatedness for the participants, who had all struggled with their mental health to varying extents and in multiple areas of their lives, following their exit from the military. The findings from the phase one interviews highlight the desire and readiness for change in the majority of the participants.

3.2. Phase Two—6–18 Months after the Expedition

The findings from the phase two interviews are grouped based on the topic areas that emerged from the conversations. This section will present the evidence for the extent of attribution, expressed by participants, of the transfer of the experience to their day-to-day lives.

3.2.1. Altered Perspective

A key theme to emerge from the follow-up interviews was the altered perspectives of many participants, which they experienced following their involvement in the expedition. The key factors for this change in outlook were identified as emerging via mental and physical challenge, cultural exposure and learning about other people's recovery journey. Physical and mental challenges were an almost daily occurrence on the expedition, which involved being at an altitude of between 3000 and 5000 m for most of the trek. The nature of this high-altitude expedition additionally involved disturbed sleep and emotional strains of

working as a group. For many, the expedition was extremely challenging, for instance, Jamie described it as "*mentally and physically the hardest thing I have done*". Multiple participants reported that the tough moments they faced and the challenges they overcame led to a shift in their perspective of what was possible for them, both physically and mentally:

> *"If you overcome adversity in your life, then you end up being able to cope with it... I am not worried about panicking so much because I know I can control it, but I am also not worried about saying no and saying actually I don't want to do it... I don't want to push myself beyond that... whether that be exercise or whether that be at work" (Pat).*

In addition to the challenges that altered their perspectives, many participants spoke about the way in which the exposure to "*Nepal as a whole country and the people*" (Sam) influenced their perspective on their own lives, their ways of thinking and their ability to be more content with their living circumstances:

> *"If everyone could go to Nepal and sort of see how it is actually possible to be happy with very much less than what we have over here [. . .] so much stuff that we have and do is really unnecessary. I certainly look at things differently. I think we all appreciated that to a degree at the end, having the perspective that I have from Nepal, it's really helped" (Charlie).*

Learning about the recovery journey of others emerged as another way in which the perspectives of the participants were altered. The time away in Nepal presented multiple occasions in which the participants could interact with other veterans in smaller sub-groups and have open conversations, sharing experiences. For many, understanding "*the mental health issues and trauma some people have been through*" (Sam) helped to influence their perspective on their own situation and enabled these participants to "*draw strength from how others dealt with it*" (Charlie). Impacting the perspective of the participants and potentially influencing their outlook or purpose in life aligns with improved well-being, undoubtedly initiated by their experience on the expedition.

3.2.2. Employment Skills and Work Life Balance

In discussing some of the changes made in their lives as a result of the expedition, over half of the participants discussed substantial changes in their careers. One participant in particular, Pat, a veteran of the Royal Army Medical Corps, described a significant change in their employment situation. Before the expedition, Pat was unable to work and was in a state described by themself as very "*negative*", undergoing therapy and taking multiple medications. Pat had been advised to seek employment outside of medicine, since attempts to return to work had been so unsuccessful. When exploring Pat's perspective of attribution, Pat described how the expedition had enabled a "*change in where I was positioned*" which helped in being "*more confident in my ability to make choices*" and "*taking on more responsibility*". The expedition also helped Pat with learning to control anxiety attacks, providing opportunities to "*practice breathing and controlling it*". Pat attributed the expedition as partially responsible for the regained confidence in themself and their ability to work, stating, "*I don't know if I would have ended up at this point had I not gone on an expedition. I don't know if I would have ended up back at work*". The confidence in decision making described by Pat, which resulted from the experiences of the expedition and translated into the participants' daily work or lives, was supported by others who also felt they had "*more confidence*" (Jamie) in their "*own decision making ability*" (Charlie). Having a higher level of self-belief with regard to making independent decisions and feeling in control of one's behaviours and destiny illustrates the increased autonomy that resulted from the expedition and subsequently improved the participants' mental state of well-being.

Multiple other participants found they could attribute the expedition to helping them have a new perspective on the importance of their work style, which emerged when discussing the changes to their careers following the expedition. Ashley, for instance, fulfilled a long-term goal of "*working for The Fire Service*", despite the struggles in applying

for this position before the expedition. Other participants attributed the expedition to providing them with "*more structure and stuff to aim for*" (Charlie) in relation to financial security and employment. Having the ability to master tasks, such as securing new job roles and achieve goals linked to financial security, represents improved satisfaction with the basic psychological need for competence in these participants following the expedition.

3.2.3. Relationships with Others

Two key relationships on the expedition for the participants were those with the staff and those with the other team members. The influence both of those had on subsequent relationships with friends, family members and the community after the expedition was commented on widely by the participants. The verbal encouragement and support received by the staff members on the expedition was described by the participants as "*a massive pick-me-up*" (Charlie), with many mentioning how beneficial they had found being able to have multiple ongoing one-to-one conversations with staff members. Pat described these chats as useful to "*talk through things and focus on the smaller things and managing me*". In addition to the support from the expedition staff, all the participants mentioned the "*camaraderie and togetherness of the group . . . the strengths and the weaknesses that we pulled each other through, the good and the bad times*" (Sam). The strength in the relationships the participants built amongst one another were enabled through the "*shared experience*" (Charlie) and the nature of a high-altitude expedition. For instance, sharing a tent with another team member on the expedition enabled the participants to "*build those relationships and bonds*" (Ellis) that were perhaps less easy to achieve back home. The unique nature of spending three weeks walking with others enabled the veterans to "*speak to people a lot more and you got to know them a lot deeper as a person . . . it was so easy to speak about very deep things, without people being afraid*" (Sam). Charlie confirmed the depth of these relationships through the distinctive characteristics of an expedition, stating that going to Nepal was a:

> *" . . . unique experience for those involved, it's quite a long way different from the, sort of, day to day experiences of the vast majority of people. I think all of those things sum up together to make it a much stronger bonding experience" (Charlie).*

Some of the participants felt that the relationships they built with others on the expedition motivated them in wanting to help others when they got home and "*put something back into the veterans community*" (Pat). The importance of "*maintaining those contacts . . . and being amongst others, being able to talk freely and more openly*" (Charlie) was important to many participants, who used the expedition to build strong relationships with individuals that became "*lifelong friends*" (Pat). Upon returning to their partners and families after the expedition, some of the participants discussed how their experiences and the personal development they had undergone throughout the expedition and afterwards had impacted their existing relationships at home:

> *"When you come back, I certainly made more of an effort to do things together, which probably I did before, but not as much. And we make time for conversation now, and we sit outside and just talk a lot more. So yeah, so I certainly appreciate my partner a lot more" (Sam).*

Increasing the ability of the participants to feel a sense of attachment and belonging to others, during and after the trip, highlights the impact a high-altitude expedition of this kind can have on the relatedness of military veterans.

3.2.4. Behaviour Change: Physical and Mental Health

The physically demanding nature of the expedition had a generally positive influence on the activity levels and physical health of the participants. One participant described the trip to Nepal as significant because "*it revalidated me physically*" (Charlie) or encouraged the participants to "*start doing a bit more training*" (Jamie). Others described how they had maintained high levels of physical activity following the trip to Nepal and attributed their motivation to the expedition:

"I'm still probably doing somewhere between 60 and 70 km a week, walking and I don't lack motivation to do it... honestly, I don't think I would have the mental strength and the mental thinking, without doing what I was lucky enough to do on the expedition" (Sam).

These reported behavioural changes resulting from expedition participation indicate improvements in the participants' confidence to perform physical activities or tasks. All the participants made statements suggesting an improvement in their satisfaction of their psychological need to feel competent. In addition to the longer-term physical health benefits, many participants discussed the changes to their behaviours associated with mental health, such as to their enhanced personal awareness following the trip. The intentional focus that was put on personal development by the coaching staff developed participants' reflective practice after the expedition and enabled them to "*function better*" (Jo). Many of the participants described how their "*thinking process is now totally different to how it used to be . . . the whole thing made me a better thinker*" (Sam). Being a "better thinker" translated into the participants describing how they felt calmer and more relaxed in difficult situations and like they can now "*deal with stuff much better*" (Charlie). The experiences on the expedition enhanced the ability for individuals to feel independently in control of their mental health, reflecting improved autonomy.

3.3. Summary of Results

In the interviews before and during the expedition, all participants alluded to a lack of fulfilment of the basic psychological needs of autonomy, competence or relatedness. For some, it was in expressing their lack of worthiness for support, intolerance of other people, displeasure with their work circumstances or lack of self-belief. In the phase two interviews, all the participants had shifted to describing improvements in aspects of their life, behaviour and thinking that align with the basic psychological needs from the SDT. Interview evidence, drawn from multiple timepoints, indicates the ongoing and sustained change in well-being and personal development. The three needs and their alignment with the resultant themes are identified and summarised in Table 1.

Table 1. Alignment of the desired life changes prior to the expedition and subsequent reported changes by the participants with the three basic psychological needs from SDT.

Desired Behaviour Changes Prior to the Expedition					Reported Behaviour Change after the Expedition				
Autonomy	Gaining better control of their minds and thoughts	Having more routine and structure in their lives	To be liberated from external pressures		**Autonomy**	Altered perspective through the challenge of the expedition	Adjusting work–life balance and gaining routine	Improved self-worth and confidence in decision making	Personal awareness and increased mindfulness
Competence	Reducing a busy lifestyle and addressing issues with their occupation	Desire to progress in their careers	Improving physical health and fitness	Have an opportunity to succeed in a challenge	**Competence**	Altered perspective through the challenge of the expedition	Employment skills	Improved health and physical activity levels	
Relatedness	Improving relationships with others, family, work colleagues, etc.	Sense of belonging, connectedness with others	Regaining dignity	Being more understanding of others circumstances	**Relatedness**	Altered perspective through cultural tourism	Altered perspective through learning about other people's recovery journey	Relationships with others	

4. Discussion

4.1. Summary of Key Findings

The principle finding from this study, involving 18 months of engagement with members of Mission Himalaya, was that the experience of a high-altitude expedition involving intentional health coaching can facilitate long-term meaningful change for participants. This prolonged and intentionally designed experience helped participants to detach themselves from their home contexts, to focus on the context of the expedition, and as a result, to regard themselves—and describe themselves—"with more distance". Most participants had successfully begun to see themselves as a "project" and were working to become more successful back at home. Post-expedition, many had successfully adopted new behaviours, such as regular physical activity, that many in their home contexts continued to find difficult.

The findings from the pre-expedition interviews highlighted the deep desire to improve levels of autonomy, competence and relatedness. All participants had experienced some struggle with mental health—to varying extents and in multiple areas of their lives—after leaving the military. The findings also highlighted that a majority desire and have a readiness for change. Describing their histories, pre-expedition, many discussed lacking in self-belief or the ability to make independent decisions over their actions. This extended to not feeling worthwhile enough to apply for recovery support and/or to the expedition. Selection for the expedition was a powerful signal of redirection. Future expeditions should make the application process as welcoming as possible.

Early interviews highlighted the many areas where participants wanted to change; interviews afforded an opportunity to stand back and reflect on personal progress desires. These needs underlined the relevance of using the SDT to ground our health coaching approach. Equally, the scale of change that had been transferred to life back home confirms the utility of the transfer of learning approaches used.

Shortfalls in relatedness were often linked to poor communication skills, limited empathy for others and a weak sense of belonging. Competence was undermined by widespread difficulties with employment: some participants had failed to re-enter employment after leaving the military, while others lacked confidence in their work environments. It was common that physical activity had reduced upon leaving the military; lack of routine was commonly a problem here. For some, the preparatory training weekends mandated additional physical activity, and this helped to re-establish motivation and structure. Many participants also hoped the routines of the expedition would re-establish lost routines or behaviours back home, leading to improved autonomy.

The majority of the participants demonstrated a strong commitment and readiness to make changes to their lives through the Mission Himalaya expedition. Those with a greater receptiveness for change tended to experience more significant effects and changes following the expedition. The results of this study therefore support the observation of Smith et al. [11] that participants' agreeableness and openness play a key part in post-expedition growth. Despite this, one participant in particular (Pat), who expressed less readiness for change and belief the expedition may facilitate this, subsequently reported significant positive changes in their occupational circumstances, which were partly attributed to the expedition, following a "*light bulb*" (Pat) experience whilst being extremely challenged at high altitude. This illustrates that openness and readiness to change does not necessarily always correlate to the total possible change.

The findings from the follow-up interviews that took place in the 18-month post-expedition period evidence the changes that were made by the participants and to what extent they attributed the changes to the expedition. The majority of the participants discussed an altered perspective on their own lives. This change in their outlook was attributed to a number of factors. First, undertaking challenging tasks during the expedition increased their confidence and ability to undertake tasks back home. Successful mastery of tasks in specific environments has the potential to improve the self-efficacy and competence of an individual [22]. Second, cultural exposure to Nepalese people who had significantly lower

standards of living and money, compared with the participants, enabled them to feel more grateful for their own lives. Tourism literature widely supports the notion that exposure to host cultures and subsequent reflection is often a mechanism for transformation [23]. The participants supported this in reporting a greater sense of meaning and purpose in their own lives after these cultural experiences on the trip. Additionally, learning about the recovery journey of others stimulated reflective thought in the participants about their own lives, compared to the problems faced by others similar to themselves. This also influenced their perspectives and provided them with a greater sense of meaning, contributing to their ongoing personal development and enhanced well-being.

The interview conversations following the trip highlighted multiple occurrences in which the participants attributed involvement in the expedition to the changes they had managed to achieve in relation to their employment or job satisfaction. Many participants reported an improved ability to master tasks such as job applications, which they had not been able to undertake before the expedition, demonstrating an improvement in their basic psychological need for competence. Building strong relationships with the staff and other military veterans during the expedition enabled many of the participants to improve their interactions with friends, family and colleagues back home afterwards. The specific characteristics of a challenging OAA intervention of this kind, such as sharing tents, multiple days spent walking and time away with the expedition team, were all found to contribute towards the improvement of the participants' relatedness. The physically demanding nature of the expedition had numerous positive effects on the physical health of the participants, who reported training more in preparation for and as a result of the expedition. In line with positive physical health changes, many participants discussed the changes to their mental health after the expedition. This improvement to the thinking processes and mental strength of the participants was aided through the specific coaching of the staff who intentionally focused on personal development during the trip.

The findings demonstrate that Mission Himalaya is another development in the application of adventurous activities to positively influence behaviour change and the well-being of participants. Previous studies to examine the use of OAA interventions with military veterans were cross-sectional in nature and therefore, despite their results confirming the positive impacts on the personal development and well-being of veterans, the studies were unable to observe whether these findings had a longer-term effect [13]. This research addresses the shortfalls of previous research studies and is the first study to follow the participants longitudinally. The results demonstrate that the observed positive impact of the expedition on the lives of the veterans persisted over the course of the study (up to 18 months after the expedition). The results of this study address Greer and Vin-Ravi's [14] request for future OAA intervention processes and mechanisms that lead to positive outcomes to be better explained by providing a deeper insight into the ways in which this expedition facilitated enhanced well-being and personal development. Additionally, an improved understanding of life enrichment for veterans through the challenges presented by a meaningful goal, such as an expedition, could illuminate longer-term understanding and better knowledge surrounding the transition to civilian life as well as personal development [14]. This study has enhanced our understanding of the influence that challenging expedition experiences can have on participants' lives to an extent that has not previously been achieved.

4.2. Strengths and Limitations

Many expeditions have previously failed to collect satisfactory data sets regarding participant well-being [24]. The resulting database has been dominated by low compliance, short expeditions, fee-paying civilian participants and a lack of longitudinal research periods. By embedding a researcher throughout the preparatory, expedition and post-expedition periods, the study is unique. Developing the delivery to be theory-guided and to address transfer of learning to ensure prolonged impacts makes it totally unique. As a result, our study represents an unrivalled database, generated from ten UK veterans

across 18 months of qualitative data gathering. Participants will continue to be invited to contribute follow-up interviews for five years, until November 2023.

A small number of programmes, similar to Battle Back's Mission Himalaya expedition, exist in other countries, such as the USA, where veterans from recent wars reside. Some of these programmes are similar in nature to Mission Himalaya, with the use of OAA to improve the lives of military veterans. Examples of these similar programmes in the USA include the Warrior Hike Program (WHP) and "Adventure Not War". The WHP consists of a 6-month hike of the Appalachian Trail, aiming to provide a positive therapeutic effect by immersing participants in the natural environment [25]. Adventure Not War took military veterans back to Iraq for a mountaineering expedition, aiming to empower them to reclaim their lives despite their history with the country [26]. Although similar to Mission Himalaya in the context of using OAA to improve the well-being and development of military veterans, these expeditions differ in their lack of longitudinal investigation of the lasting effects on the veterans, a strength of the Mission Himalaya study.

Limitations include the significant investment of time and resources and being able to participate as an expedition member. This is likely to have built the rapport and respect that contributed to the high-retention rate in the follow-up interviews. The overall process is unlikely to be a viable research method and/or process for researchers who are not also mountaineering instructors.

An additional limitation of the study includes the gender balance of the sample. The predominance of males to females in the study sample is however reflective of the current UK Armed Forces which comprises 11% females [27]. Future studies could actively recruit more females.

An important realisation emerged through follow-up data collection; a return to normal domestic life in the UK left some members missing the social support, the physical challenges and the personal attention of the expedition. This left them framing the highs of the expedition with the lows of feeling let down when back in the UK. Expedition funders and organisers must ensure appropriate support is put in place to help participants manage post expedition "come down".

4.3. Future Application

The study confirmed that positive health coaching can support participants in a high-altitude expedition. By intentionally including health coaching that accentuated "transfer of learning", participants became skilled in applying their in-expedition learning to their day-to-day lives after the trip. This health coaching approach is suited to the expedition context as it is a principle-guided technique, meaning it can fit within the opportunities that emerge in the moment and/or unexpectedly. This research has useful transferable potential to provide a future template for expeditions centred on recovery and personal development. Practically, organisers of future OAA interventions could apply this knowledge to shorter expeditions in less extreme environments or destinations.

5. Conclusions

To our knowledge, this is the first study to research the long-term influence of participating in a high-altitude trekking expedition that involves health coaching on the lives of UK military veterans. The expedition itself is also believed to be the first of its kind. Our findings support the prolonged use of health coaching, focused on self-determination, to encourage experiential transfer back into what had often been "troubled" daily lives. The intentional blend of health coaching into a prolonged expedition was recognised as helping to make this a meaningful, long-term positive influence for these participants, beyond the expedition itself. In a mutually reinforcing way, the delivery approach and research style can be replicated in subsequent initiatives to positively influence the lives of participants.

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Article

Cases of Lightning Strikes during Mountain-Sports Activities: An Analysis of Emergencies from the Swiss Alps

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Abstract: Background: Lightning strikes are a risk during mountain-sport activities. Yet little is known about the prevalence of injuries related to lightning strikes during mountain hiking, backcountry skiing, or high-altitude mountaineering. This study therefore examined the occurrence and characteristics of lightning-strike-related emergencies during mountain-sport activities in the Swiss Alps. Methods: We analyzed 11,221 alpine emergencies during mountain hiking, 4687 during high-altitude mountaineering, and 3044 during backcountry skiing in the observational period from 2009 to 2020. Identified cases were analyzed in detail regarding age, sex, the time of occurrence, altitude, location, the severity of the injury as quantified by its NACA Score (National Advisory Committee for Aeronautics Score), and injury pattern. Results: We found no cases related to backcountry skiing. Eight cases of lightning strikes during mountain hiking (four female and four male) were identified. The mean age was 32.5 ± 17.5 years, the mean NACA Score was 2.5 ± 1.9, and the mean altitude was 1883.8 ± 425.7 m. None of these cases were fatal, and only one victim was seriously injured. Fifteen cases were identified during high-altitude mountaineering (four female and 11 male). The mean age was 38.7 ± 5.2 years, the mean NACA Score was 3.1 ± 2.5, and the mean altitude was 3486.4 ± 614.3 m. Two lightning strikes were fatal. In these two cases, rope partners were injured by a lightning strike (NACA Score = 4). Most cases were on relatively exposed terrain, such as the Matterhorn Hörnligrat or the Eiger Mittellegigrat. Discussion: The typical victims were 30–40-year-old men. It is possible that the lightning strikes are a consequence of a lower risk aversion among these alpinists, which is be supported by the fact that most of the events occurred on famous mountains such as the Matterhorn or Eiger. Furthermore, since most of the locations were on relatively exposed terrain where one could not quickly find shelter, we recommend careful tour planning with serious consultation of the weather forecast and the likelihood of thunderstorms before climbing exposed sections to prevent emergencies related to lightning strikes.

Keywords: emergency medicine; electric injuries; occurrence of lightning strikes; resuscitation; cause of death

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1. Introduction

Mountaineering in its various forms, including backcountry skiing, high-altitude mountaineering, and mountain hiking, is being practiced by an increasing number of people [1–3]. It has been estimated that around 350,000 backcountry skiers, 150,000 high-altitude mountaineers, and two million mountain hikers are active per year in the Swiss Alps [4]. These activities entail serious risks that can potentially lead to emergencies. Avalanches, falls, frostbite, rock falls, or becoming lost are known dangers that go hand in hand with these mountaineering activities [5–7]. In comparison to these frequent causes of emergencies, less is known about lighting strikes [8]. While the general risk of being struck by lightning is low, the risk is increased in the mountains due to one's proximity to the atmosphere [8–11]. Lightning strikes are electrical discharges in the earth's atmosphere [12–15]. Depending on the weather conditions, electric tensions of more than 100,000,000 volts can occur [12–15]. A lightning discharge lasts about 0.1–0.3 s, with maximum duration up to

1–2 s [12–15]. It is accompanied by currents of up to 400,000 amperes [12,13]. The air in the lightning channel heats up to around 25,000–30,000 °C [13]. In doing so, it expands explosively, causing the well-known acoustic effects of a thunderstorm [12–15]. More than 100 of these natural events occur each second worldwide, whereby most of them are intracloud flashes and only around ten percent cloud to ground flashes [8,9,15]. For Switzerland, around 60,000–80,000 lightnings (intracloud and cloud-to-ground) are reported [16,17]. Regions with an increased likelihood are along the jura, the north side of the alps and most prominent in the south of canton Tessin [16]. The effects of lightning strikes are manifold. A direct lightning strike is the most dangerous [11,18,19]. If a person is struck directly by lightning, the voltage in the body can increase up to 100,000 volts, which is normally fatal [9,12].

Furthermore, people who are under a tree or near an object struck by lightning are likewise at risk through a flashover [12]. The flashover phenomenon is observed in all modes where energy is transferred [12]. The vast majority of the voltage does not flow through victims but remains on the surface of the body [8,12,18]. Based on the current evidence, this effect accounts for why the majority of people hit by a lightning strike survive [8,12,18]. If death immediately follows the event, it is usually due to a lethal cardiac arrhythmia with ventricular fibrillation and subsequent or immediate asystole [18]. If the lightning strike is initially survived, myocardial infarction, shock from burns, secondary renal failure, and trauma-related cerebral hemorrhage may occur [18]. A lightning strike can cause numerous different lesions in survivors [18]. Injuries result from the electric energy, the high temperature, or the explosive force of the blast wave [18–21]. Injuries to the skin (burns) and the heart and affections of the central nervous system, ears, and eyes are most commonly seen in survivors [9,12,19–25]. In mountains with rocky subsoil, the lightning current can spread across long distances [12]. When touching a rock, part of the lightning can flow over the body, and cases have been described where the mountaineer was even thrown away [12].

However, emergencies due to lightning strikes are rarely discussed; they are mainly known from the stories of trees standing alone on an alpine meadow in which lightning has left its mark [20]. Nevertheless, activities in the mountains and the associated proximity to the atmosphere expose alpinists to a considerable risk. In the event of an approaching thunderstorm, protection should be sought as soon as possible [12]. Reasonable possibilities include inside huts with a lightning rod or at the foot of a rock face, where one should ideally keep a certain distance of two to three meters from the rock face [12]. Despite these known preventative measures, little is known about the likelihood of lightning strikes in the Swiss Alps during mountain-sport activities. This study therefore analyzed lightning strikes during mountain hiking, high-altitude mountaineering, and backcountry skiing in the Swiss Alps with regard to their occurrence, mechanism, injury pattern, and likelihood as compared to other causes of mountain emergencies [26].

2. Materials and Methods

2.1. Study Population

This study used data of the Swiss Alpine Club (SAC) central registry. The registry contains emergencies that occurred during high-altitude mountaineering (from 2009 to 2020), backcountry skiing, and mountain hiking (both from 2009 to 2018). The data were collected by the Swiss Air Rescue Service (REGA), Air Glaciers Lauterbrunnen, Air Glaciers Sanenland, Register SAC, KWRO (Kantonale Walliser Rettungsorganisation), Snow and Avalanche Research Institute Davos, and the cantonal police. The term "mountain emergency" covers all events involving mountaineers claiming the help of mountain rescue services or those that are affected by subjective and objective mountain hazards [6,7]. This also applies to illnesses and evacuations of uninjured mountaineers. Each case recorded in the database included information about the emergency number used, date, rescue organization, event, place, canton, activity, National Advisory Committee for Aeronautics Score (NACA Score; see Supplementary Table S1), nationality, age, sex, place of residence,

coordinates, and a short report [27,28]. For the present study, all cases of lightning strikes were filtered and analyzed in detail.

2.2. Data Preparation

Data were classified according to the cause of the mountain emergency. In the 12-year period of 2009–2020, a total of 4687 alpinists (1027 female and 3660 male) were rescued by the mountain rescue service in the Swiss Alps while high-altitude mountaineering. Furthermore, 11,125 mountain hikers (4933 female and 6192 male) and 3044 (953 female and 2091 male) backcountry skiers were rescued by the mountain rescue service in the Swiss Alps between 2009 and 2018. The classification by discipline high-altitude mountaineering versus mountain hiking versus backcountry skiing was made by the professional emergency services. All cases were subsequently analyzed in detail regarding age, sex, time of occurrence, severity of an event quantified with a NACA Score (National Advisory Committee for Aeronautics Score), location and injury pattern [29,30].

2.3. Statistical Analyses

Descriptive statistics were calculated for age and NACA Scores. A Mann-Whitney U test was used to analyze differences in the severity of injuries between high-altitude mountaineering and mountain hiking. The same procedure was performed to analyze between-sex differences in NACA Scores. A linear regression with calculating coefficient of determination (R^2) was performed in order to detect a potential alteration of the number of cases over time. Analyses were performed with Microsoft Excel 2016 (Microsoft Inc., Redmond, WA, USA) and SPSS statistics Version 27 (Armonk, New York, NY, USA).

3. Results

Out of a total of 11,125 emergencies during mountain hiking, there were eight cases (four male, four female) of lightning strikes (0.07%) in the observational period. For high-altitude mountaineering, 15 cases of lightning strikes (11 male, four female) were detected from a total of 4687 emergencies (0.32%). No cases were recorded during backcountry skiing in the observational period. The majority of all cases occurred in the summer except one case in September and one case in the beginning of November (Figure 1). Figure 2 gives an overview of the geographical location of the emergencies. Two hot spots were detected: in the Valais region and in the Jungfrau area. Furthermore, as it is the southernmost part of Switzerland, some cases in Tessin in line with other indicators suggesting that the number of thunderstorm days and lightning strikes per km^2 increases from north to south with the highest occurrence in the Canton Tessin (Figure 3) [12,16,17].

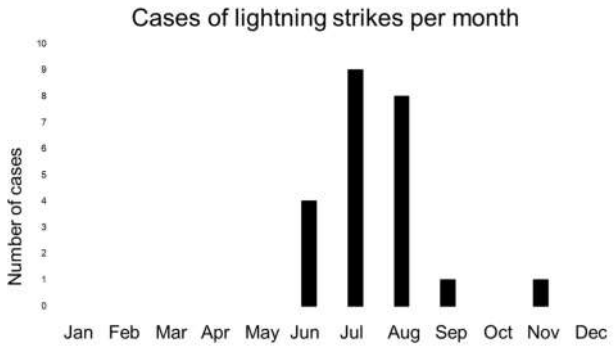

Figure 1. Occurrence of lighting-strike-related emergencies in the Swiss Alps stratified by months for all cases (high-altitude mountaineering and mountain hiking).

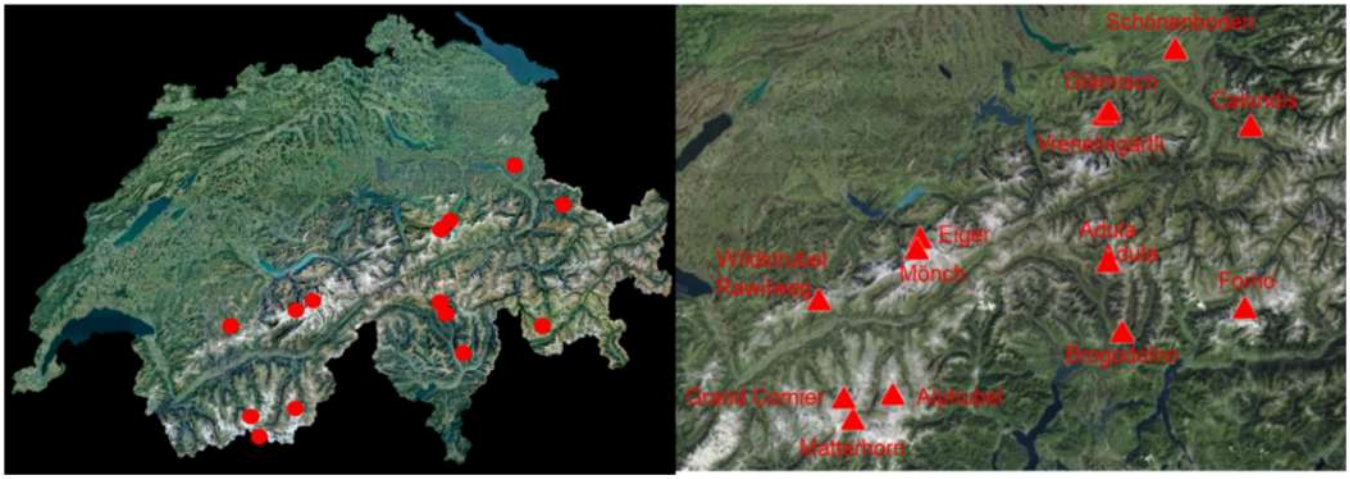

Figure 2. Geographic locations of lightning strikes in the Swiss Alps (map from Swisstopo [31]). Interestingly, cases are along the main massive of the alps.

Figure 3. The Hörnligrat on Matterhorn. Lightning strike-related emergency were identified close to the shoulder (red arrow). Seeking shelter on a ridge is sometimes simply not possible.

Regarding the eight cases during mountain hiking, the mean age was 32.5 ± 17.5 years and the mean NACA Score as indicator of the severity of an injury was 2.5 ± 1.9 (Supplementary Table S1). None of these cases were fatal. One case needed cardiopulmonary resuscitation (NACA Score = 6), which was a severe cardiac arrhythmia. All of the others had a NACA Score of only 3 or less, which indicates a non-life-threatening condition. Like most of the cases while high-altitude mountaineering (next paragraph), these cases consisted of only moderate injuries (for example fracture of a finger bone, moderate cuts, dehydration or even a femur fracture, see Supplementary Table S1) with signs of paralysis but no cardiovascular symptoms. The mean altitude of the emergencies was 1883.8 ± 425.7 m. The eight cases during mountain hiking were detected close to the Capanna Brogodone, Capanna Adula, Vorder Glärnisch, Schoenenboden Wildhaus, on the Rawilweg in the Wildstrubel area, and on the Calondis (Figure 2).

While high-altitude mountaineering the mean age of victims was 38.7 ± 5.2 years. The mean NACA Score as indicator of the severity of an injury was 3.1 ± 2.5 (Supplementary Table S1). Two lightning strikes were fatal, and in these cases other members of the rope team were also seriously injured by flashovers with a NACA Score of 4. Moderate injuries of the extremities were identified in six cases with signs of paralysis in the most-exposed extremity (hand or foot) but no obvious cardiovascular symptoms. A loss of consciousness with cardiac arrest was detected in five cases. In two cases, no detailed information concerning clinical symptoms was identified in the case reports. The mean altitude was 3486.4 ± 614.3 m. The cases were mainly on popular mountains higher than 4000 m such as the Matterhorn, Grand Cornier, Mönch, Eiger, or Alphubel. Only two cases were below 3000 m on the Vrenelisgärtli and at the Fornohütte (Figure 2). Detailed analysis revealed that most cases were relatively exposed, such as on the Mittellegigrat of the Eiger or on the Hörnligrat of the Matterhorn (Figure 3).

Concerning the nationality of the emergency victims, of the high-altitude mountaineers, nine victims were from Switzerland, five were from Germany, two were from Italy, five were from the Czech Republic, one was from the United States, and one was from Great Britain. Thus, about seventy percent (69.5%) were from countries in which the Alps are located: Switzerland, Italy, and Germany. Keeping the small n in mind limiting the clinical significance of the statements, neither the severity of the injuries ($p = 0.097$) nor the age of the victims ($p = 0.271$) was significantly different between mountain hikers and high-altitude mountaineers. In addition, NACA Scores ($p = 0.920$) and age ($p = 0.098$) were not significantly different between the sexes in both mountain hikers and mountaineers. A linear regression revealed no significant alteration of the number of cases over time for high-altitude mountaineering (number of cases = 0.0385 × year−76.397, $R^2 = 0.0057$) and for mountain hiking (number of cases = 0.007 × year−13.4, $R^2 = 0.0006$) indicating no alterations of emergencies over time.

4. Discussion

This study aimed to analyze emergencies related to lightning strikes during mountain-sport activities in the Swiss Alps. Out of a total of 11,125 emergencies during mountain hiking, there were eight cases (none fatal) of lightning strikes (0.07%) in the observational period. This translates to a prevalence of 0.8 cases per year. For mountaineering, 15 cases of lightning strikes (two fatal) were detected from a total of 4687 emergencies (0.32%), yielding 1.3 cases per year. No cases were recorded during backcountry skiing in the observational period. To conclude, the death rate was low with 8.7% (two out of 23 cases), which is in line with others' findings [13]. In principle, these values seem valid as since the 1940′s the ten-year average of fatal lightning events decreased from around 5–10 cases in the 1940′s to zero to one in the years after 2000 [32]. These findings also correspond to the detected injury pattern (not life-threatening injuries in most cases due to a flashover) in most of the identified emergencies. The overall prevalence of being struck by lightning is very low, in the same range as, for example, being bitten by a snake while hiking [33,34]. This correlates with reports from Germany [13]. While around 50–100 people died from lightning strikes per year in Germany 50 years ago, the number of fatally injured people has steadily decreased to three to seven deaths per year since the millennium, which is in line with our findings [13].

In our analyses, the typical victim was a 30–40-year-old male, which is in line with previous findings in the same context [24]. Considering the higher physical fitness of this age group as compared to, for example, seniors, alpinists in this age range might have a lower risk aversion [34]. Furthermore, a higher activity level than in older individuals during suboptimal weather conditions might further increase their likelihood of being struck by lightning [34]. Potentially supporting the argument, as most cases were on popular tours undoubtful often absolved, it is in addition likely to suggest that subjects try to climb these mountains without having the skills needed not estimating (meteorological) risks in an adequate manner.

Analyses further revealed that a considerable number of events were on highly exposed terrains, such as the Mittelleggigrat of the Eiger or the Hörnligrat of the Matterhorn (Figure 3). This is in line with the publicly available information, which stated that the alpinists struck by lightning were often on exposed terrains such as a ridge [35]. The pattern often seems to be the same [35]. A storm moves in very quickly, and alpinists hurry to descend from an exposed ridge [35]. Unfortunately, it is impossible for them to descend quickly enough, and lightning strikes a part of an extremity [35]. To conclude, on exposed terrain on a ridge, quickly seeking shelter during sudden weather changes is sometimes simply impossible. Prevention thus has to be performed in the stage of tour planning with careful consideration of the weather forecast. The influence of the weather is further supported by the trivial fact that the vast majority of cases occurred in the summer months, when mountaineering activity is at its highest; this also explains why no case was detected while backcountry skiing, which is mainly practiced in winter [8,36]. Concerning the validity of the findings, a study on the Austrian Alps also reported that lightning strikes are mainly present in summer months [8]. In that study, a total of 64 cases were detected over a ten-year observation period from 2005 to 2015 [8]. Four people died, which yields a survival rate of 93.8% [8], which is similar to the survival rate of 91.3% in our data. The slightly higher mortality in the Swiss Alps might be due to the simple fact that mountains are in general higher in Switzerland than in Austria, which results in more severe events. In addition, these differences could be associated to different meteorological conditions between Swiss and Austria [17]. However, whether this is actually the case would have to be elucidated in the future.

The validity of the study is also corroborated by an analysis on the United States [37] that reported around 20 deaths related to lightning strikes per year; a majority of them were associated with outdoor-recreational activities. The reported values of mortality were comparably low and estimated to be between 10% and 30% [9,38]. In the study on the Austrian Alps, 64 people were struck by lightning while recreationally active, most while hiking (n = 55), a few while hunting, and only one while doing occupational forestry [8]. Interestingly, the prevalence of emergencies related to lightning strikes seems higher in Austria than in Switzerland [8]. These differences might be explained by the size of their geographical areas. The Swiss Alps cover around 24,850 km^2, which is only 45% of the area covered by the Austrian Alps: 54,600 km^2 [39,40]. It is thus tempting to assume that although only cases during mountain-sport activities were analyzed, this study potentially covered a substantial share of emergencies related to lightning strikes in Switzerland. This is directly related to a limitation of the findings: only events from the registry were included in the analysis. It is probably seldom the case that someone is struck by lightning and does not contact official emergency services, but it would be informative to know how frequently alpinists are nearly struck by lightning, which is, of course, not captured by the analysis.

To summarize, alpine emergencies involving lightning strikes are rare. The typical victim is a 30–40-year-old male on exposed terrain in the summer months. Prevention seems mainly possible during tour planning, for example, in the SAC hut on the day before going on an exposed ridge. The most important factor is carefully consulting the weather forecast in order to minimize the likelihood of being caught by a thunderstorm on the mountain. To stay, for example, an SAC hut and not undertake the route during unclear weather conditions is simply sometimes the wiser choice than an attempt to reach the peak. If something happens despite these recommendations, the emergency management of apparently lifeless persons should take priority in accidents involving victims due to lightning strikes. The chances of successful cardiopulmonary resuscitation are relatively good in comparison to other causes of life-threatening emergencies [13,17,41–43]. The rule of thumb, to pay first attention to subjects with recognizable signs of living is in this special situation misleading as the chance of cardiac resuscitation of victims due to lightning strikes is considered as high [13,17,41–43].

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ijerph19073954/s1, Supplementary Table S1—Description of National Advisory Committee for Aeronautics Score (NACA-Score).

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Abbreviations

SAC	Swiss Alpine Club
NACA-Score	National Advisory Committee for Aeronautics Score
REGA	Swiss Air Rescue Service-Schweizerische Rettungsflugwacht

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Article

Personal Resources of Winter and Summer Hikers Visiting the Tatra National Park, Poland

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Abstract: To assess personal resources: Core Self Evaluations and Psychological Capital (HERO) of 95 winter Hikers (*M* age = 27.10 yrs.; *SD* = 7.30) and 98 summer Hikers (*M* age = 25.30 yrs.; *SD* = 5.40) visiting the Tatra National Park (Poland). The hikers filled in seven scales. These were: the *Delta Questionnaire for measure Locus of Control*, the *Neuroticism scale* (from the NEO-FFI), the *Rosenberg Self-Esteem Scale (SES)*, the *Hope Scale*, The *Generalized Self-Efficacy Scale (GSES)*, the *Ego Resiliency Scale*, and The *Life Orientation Test Revised (LOT-R)*. The results indicated significant differences between winter and summer hikers in the Tatras. The winter hikers scored higher on self-esteem, hope, self-efficacy, resilience, and optimism, and lower on external locus of control and neuroticism than summer hikers. This study also examined the factor structure of the personal resources in the hikers' samples. The results suggested that the scales extracted two factors: Cognitive Resources and Affective Reactivity. These factors discriminate between winter and summer hikers. The Cognitive Resources factor is more important in effective adaptation to the wild world of nature than Affective Reactivity.

Keywords: personal resources; mountain hikers; weather; core self-evaluations; psychological capital

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1. Introduction

Hiking is an outdoor activity which consists of walking on a trail in different landscapes. Hiking is increasingly popular. Every year, more and more people go on foot through mountains, hills, forests, beaches, or other natural environments. The positive consequences of hiking are multifaceted: feeling healthy, feeling relaxed, improving cognitive skills, or deeply experiencing nature. Hiking tests one's endurance and psychological capacity. However, we can observe hazards occur from time to time which can overshadow the benefits of the hiking. Hazards in hiking are connected with injuries from falls on the trail, injuries caused by animals (e.g., insects or snakes), and injuries from inclement weather, such as hypothermia and heat exhaustion. Hikers can be injured by forces of nature such as veld fires and lightning. Finally, hikers can lose the trail [1,2].

Sometimes hiking is used interchangeably with other words. For example, trekking describes multi-day hiking in the mountainous regions of Asia or South America. Nordic walking is hiking with specially designed walking poles. Bushwalking is hiking through the bush in Australia. In the United States multi-day hikes are referred to as backpacking. In New Zealand hiking for at least one overnight stay is known as tramping. Through-hiking means walking an established long-distance trail end-to-end within one hiking season. We have also dog hiking or glacier hiking [3–5].

One of the most popular types of hiking is mountain hiking [6]. Mountain hiking is the activity of going for long walks in mountainous areas with altitude differences [3], (p. 1). Every year, more and more people set off on a hiking in different mountains around the world. Mountain hiking is physically demanding and does require personal resources. Surprisingly though, personal resources of mountain hikers have rarely been analyzed in environmental research. Thus, the purpose of this investigation is to analyze personal resources of hikers visiting the Tatra National Park in the summer and in the winter.

1.1. Hiking in Tatra Mountains

The Tatra Mountains are the highest mountain range in Carpathian Mountains, which are the second longest mountain system in Europe. The Tatras are located in Poland and Slovakia, encompassing the area of 19°45′36″ E and 20°09′00″ E, as well as 49°10′42″ N and 49°20′05″ N. They are alpine-type mountains (the highest peak is Gerlach, 2655 m above sea level). The zone of bare rock occurs in the Tatras at an altitude higher than 2300m above sea level. The lower ranges of Tatra Mountains are the natural home of the amazing flora (e.g., vascular plants, fungi, mosses, or slime molds) and fauna (e.g., bears, Tatra chamois, wolf, red deer, Alpine marmot, and two hundred of species of bird). About seventy five percent of the Tatras is covered by forests [7–9].

The Tatra Mountains are protected by two national parks, namely the Tatrzański Park Narodowy (TPN) in Poland and Tatranský Národný Park (TANAP) in Slovakia.

In the Tatras, hikers can find a network of hiking trials in different levels of difficulty. Levels of difficulty vary based on seasonal weather conditions. Summer is a relatively cool season for hiking in the Tatras. During the summer months, average day temperatures usually fall between 20 °C (68 °F) and 25 °C (77 °F). There is no snow or ice on the trails. Stronger wind occurs only on mountain ridges and peaks. Rain is intensive for short periods of time, usually 30 min to a few hours. On very hot days, rain is accompanied with thunderstorms. Morning fog is a common condition in the summer period, but the trails are very well marked [10]. Hiking in the summertime in the Tatras does not require any special equipment (e.g., helmet, crampons, axes, clip hooks, ropes, etc.), but hikers must be in good physical condition.

The main risks in summer hiking relate to thunderstorms, possibilities of falls, or attacks by animals (but, in fact, attacks by, e.g., bears on hikers in the Tatras are extremely rare). Summer hikers are driven by relaxation, discovering, and experiencing new environments in relatively safe surroundings [11,12].

Hiking conditions in winter change dramatically. Heavy snow and ice on the trail are very common. Snowfall limits visibility, erases tracks, and covers trail markings. There is also a large risk of avalanches. The average temperature in the winter season is below 0 °C (32 °F). Extreme temperatures can go down to −40 °C (−40 °F). High winds are characteristic for the winter season in the Tatras [10].

Winter hiking in the Tatras usually requires more skills, competence, or attention to detail because there are more risks on route, such as avalanches, snow, intense cold and ice, or real possibilities of falls from great heights into the abyss. Winter days are much shorter than in the summer. Very often, hikers must have special equipment, such as an avalanche transceiver, probes, helmet, or ice axe. They must manage stress, pain, or injury and, thus, they need personal resources to deal with risk in winter hiking [11,13,14].

1.2. Personal Resources

The word "personal" means that individual properties can function as a way of dealing with the outside world [15]. In turn, the word "resources" means resources that can be used in stressful situations. To Pearlin and Schooler, personal resources are "personality characteristics that people draw upon to help them withstand threats posed by events and objects in their environment" [16], (p. 5). To Hobfoll, personal resources are defined as things that one values; specifically, objects, states, and conditions. People strive to maintain their current resources and pursue new resources. This author also claims that people have to invest resources, which can be personal, to protect themselves against resource loss, and to gain resource. Loss resources are disproportionately more salient than gain resources [17].

Personal resources allow people to achieve individual goals, reducing physiological and psychological costs associated with demanding conditions of surroundings and stimulating personal growth. Personal resources promote subjective well-being [18,19]. Ideas of personal resources can be found in different conceptions; for example, Core Self-Evaluations [20] and Psychological Capital [21].

Surprisingly though, wilderness adventure has rarely been studied in the context of personal resources. Researchers rather analyzed the motivational aspects of outdoor adventure: goal achievement, sensation seeking, escape from boredom, pushing personal boundaries, and overcoming fear [22,23]. They also focused on several possible psychological, social, physical, or even spiritual benefits of activity in extreme environment. These results indicate that extreme recreationists talk about a sense of freedom, a full sense of their lives, or a sense of connection with nature [24,25]. They experience deep satisfaction with life more often than anxiety, boredom, or apathy [26]. Adventure in extreme environment is a source of exciting positive emotions and deep satisfaction [27].

The most common resource research among adventurous persons concerned rather single variables, for example, self-efficacy or neuroticism [28,29]. Surprisingly, we know almost nothing about structure of personal resources or profiles of personal resources recreationists in wilderness. Therefore, in this article, personal resources of hikers will be analyzed in a more comprehensive way. In the first phase, some theories of personal resources will be presented and, following this, there is an analysis of personal resources among winter and summer hikers using some theories of personal resources.

1.2.1. Core Self-Evaluations

The concept of core self-evaluations was first introduced by Judge, Locke, and Durham [20]. This construct preliminary was developed as a dispositional predictor of job satisfaction, but has been expanded to predict a variety of other outcomes.

Core self-evaluations include four personality dimensions: locus of control, neuroticism, self-efficacy, and self-esteem. These resources appear to play a key role in adaptation to the wild nature.

The locus of control describes the tendency to attribute life's events to their own doing. People evaluate possibilities of action differently depending on whether they feel that, in a given situation, the outcomes depend on themselves, their own abilities or effort, or whether the believe that events are contingent upon chance. A selection of given courses of action will be different depending on whether one believes in the effectiveness of one's behavior (internal locus of control) or does not (external locus of control) [20].

Neuroticism is defined as an enduring tendency to experience unpleasant emotions easily. Neurotics display high sensibility, emotional instability, and low perseverance. They show little energy and tend to feel unhappy. Threat and anxiety induce them to react defensively by avoiding risk [30].

Self-efficacy is "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" [31], (p. 3). Self-efficacy beliefs determine whether individuals are optimists or pessimists in new and risky situations. Furthermore, self-efficacy influences the way people motivate themselves in achieving their goals. Individuals undertake challenges where self-efficacy is high and avoid risky goals or tasks where self-efficacy is low [31].

Finally, self-esteem is characterized by one's global self-regard and the extent to which she/he accepts herself/himself. Self-esteem includes beliefs about oneself as well as emotional states. Individuals with high self-esteem increase their efforts and persistence in the face of risk or potential failure. Thus, high levels of self-esteem sustain motivation. Self-esteem plays a key role in well-being [32].

Only some of the constructs of Core Self-Evaluations have been studied in a mountain context. For example, one study indicates that a high self-efficacy is related to free choice of climbing and to the difficulty of doing outdoor climbing [33]. Climbers with high self-efficacy can judge themselves as capable of coping with stress and they can set themselves challenging goals in the wilderness and maintain a strong commitment to them. Those who are self-efficacious may engage more easily in extreme activities, in spite of adversity [29].

Different studies indicate that climbers have lower scores on neuroticism than controls. For example, Egan and Stelmack [34] tested traits of personality among climbers during expedition on K2 peak in the summer. Climbers displayed lower scores on neuroticism

(as well as extraversion and psychoticism) compared to the controls. In the study by Levenson [35], rock climbers had lower scores on anxiety traits than norms (Robinson, 1985). Similar results were found by Tok [36].

Other components of the Core Self-Evaluations have been rarely considered in mountaineering. Saeid Bahaeloo-Horeh and Shervin Assari tested the impact of mountaineering program on self-esteem. The participants completed The Rosenberg Self-Esteem Scale (scale for diagnosing self-esteem) before and after mountaineering. Participation in a single mountaineering program improved climbers' sense of self-esteem [37].

1.2.2. Psychological Capital (HERO)

Psychological Capital is defined as examining the processes by which positive attitudes, feedback, and criticism contribute to the functioning and development of an individual, group, or corporation [21]. The four fundamental characteristics of Psychological Capital (hope, self-efficacy, resiliency, and optimism) are the key factors needed to form a psychological capital structure.

Hope is defined as a positive motivational state where two basic elements, successful feelings of agency (or goal oriented determination) and pathways (or proactively planning to achieve those goals), interact. Hope is a strong predictor of the lack of depressive symptoms, positive and negative affectivity, quality of friendship, and health as indicators of optimal functioning in one's private and professional life [38].

Self-efficacy is defined as a person's confidence in their ability to achieve a specific goal in a specific situation [39]. This construct was described in the previous section.

The concept of resilience is taken from psychiatric literature, but it is actually defined as an ordinary characteristic of normal development. Resilience is defined as an ability to recuperate from stress, conflict, failure, change, or increase in responsibility. In a broader sense resilience can be defined as a dynamic process which reflects relatively good individual adaptation, in spite of dangers or traumatic experiences that one endures. Resilience moderates the relationship between stressful events and illness. It is a trait which is developed throughout one's life as a result of various experiences [40].

Optimism refers to one's perspective on future personal and social events, in which there will be an abundance of good things and a scarcity of bad things. People with high optimism experience positive emotions, even amidst stress. They are determined and engaged in more adaptive coping strategies and less maladaptive coping than those who perceive themselves as low-optimistic individuals [41].

Hope and optimism weren't studied in a climbing context. The role of self-efficacy in outdoor adventure was described in the previous section. Studies of resilience have rarely been considered in mountaineering. Tukaiev et al. tested resilience among a group of 60 Ukrainian extreme climbers. The results indicate that extreme climbers had higher scores on resilience compared to athletes practicing non extreme sports [42]. In a recent study, psychological resilience was investigated "live" (e.g., in the moment) in challenge team members involved in a 25-day extreme endurance challenge. The results of the study highlighted the individualized, complex, and dynamic nature of psychological resilience within extreme environments [43].

As we said, personal resources of adventure participants weren't analyzed in a more comprehensive way. The most common resource research among adventurous persons concerned rather single variables. Thus, in the current study, winter and summer hikers visiting the National Tatra Park were compared on different personal resources using theories of Core Self-Evaluations and Psychological Capital. Based on the previous studies, it was hypothesized that winter hikers would score higher on personal resources than a group engaging in summer hiking.

2. Method

2.1. Participants

The total sample included two groups who hiked in Tatra Mountains. The first group of 95 winter hikers who voluntarily participated were all men (*M* age = 27.10 yrs.; *SD* = 7.30). Most of them (65 respondents) lived in cities, and the others (30 respondents) lived in the countryside. All participants had at least a secondary level of education.

They have hiked the Tatra Mountains (Poland) in winter season. All of them hike the mountains during the winter and risk being killed by very difficult mountain conditions. They use specialist equipment: axes and crampons.

The second group was of 98 men who practiced hiking in the summertime in the Tatras (*M* age = 25.30 yrs.; *SD* = 5.40). Most of them (63 respondents) lived in cities, and the others (35 respondents) lived in the countryside. All participants had at least a secondary level of education.

Mountain athletes in this group have personal experiences on relatively safe hiking trails without snow and well-marked routes in the summer period. Hikers in this group had no personal experiences in hiking during the wintertime in the Tatra Mountains.

2.2. Procedure

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the University of Szczecin Institutional Review Board before we began recruiting participants (KB 14/2019). We made contact with hikers during their stays in mountain huts in the summer and the winter periods. Winter hikers were selected on following criteria: they hiked in the winter, and they used axes and crampons; they had more than three years winter hiking experiences; and they were men.

Summer hikers were selected on following criteria: they hiked in summer period; they not used special mountain equipment during exploration of Tatras; they had a few personal experiences in summer hiking (more than three years); they hadn't personal experiences in winter hiking; and they were men.

Summer and winter hikers completed questionnaires during their stays in Polish mountain huts (Roztoka Hut, Murowaniec Hut, Hut in the Five Polish Lakes Valley, Kondratowa Hut, and Ornak Hut in the Tatra National Park). Participation was voluntary. Hikers completed the questionnaire anonymously.

2.3. Measures

2.3.1. Delta Questionnaire

The Delta Questionnaire measures locus of control (LOC) [44]. This questionnaire consists of 24 statements, 14 of which refer to the locus of control (LOC), whereas the other 10 statements make a control lie scale. High scores on the LOC scale indicate external locus of control (*Cronbach's* α = 0.76).

2.3.2. Neuroticism

Neuroticism scale (from the NEO-FFI) [30] was administered in its Polish adaptation [45]. There are 12-item scales constructed to assess individual differences in neuroticism (*Cronbach's* α = 0.81).

2.3.3. The Generalized Self-Efficacy Scale (GSES)

The GSES consists of 10 statements, included in one factor [46]. It measures the strength of an individual's general self-efficacy beliefs in the face of difficult situations and obstacles (*Cronbach's* α = 0.85). The Polish adaptation was made by Juczyński [47].

2.3.4. Rosenberg Self-Esteem Scale (SES)

The SES is a 10-item scale which consists of five positive and five negative statements [48]. The SES measures Self-Esteem. Coefficient alpha reliability in the Polish version for the SES test was *Cronbach's* $\alpha = 0.77$ [49].

2.3.5. The Hope Scale

The Hope Scale is 12-item tool that measures level of hope [50,51]. It consists of two subscales, agency (measures one's goal-directed energy to pursue one's goals) (*Cronbach's* $\alpha = 0.82$) and pathway (measures one's extent of creating ways to achieve one's goal) (*Cronbach's* $\alpha = 0.72$). These subscales are highly correlated. In this study the hope construct was measured as means of these subscales.

2.3.6. Ego Resiliency Scale

Ego Resiliency Scale was developed by Block and Kremen [52]. Kaczmarek translated this scale into Polish [53]. Ego Resiliency Scale consists of 14 items. The scale has a satisfactory internal consistency of *Cronbach's* $\alpha = 0.78$.

2.3.7. The Life Orientation Test Revised (LOT-R)

The Life Orientation Test Revised (LOT-R) is a 10-item unidimensional scale that was constructed to assess individual differences in generalized optimism. Coefficient alpha reliability in the polish version for the Life Orientation test was *Cronbach's* $\alpha = 0.73$ [47].

3. Results

The winter and summer hikers were compared on each measure using the Student *t* test (See Table 1).

Table 1. Comparisons of Core Self-Evaluations and Psychological Capital in winter and summer hikers' groups.

Personal Resources	Winter Hikers		Summer Hikers		t (191)	*p*	*Cohen's d*
	M	SD	M	SD			
			Core Self-Evaluations				
External locus of control	2.94	1.41	3.57	0.85	3.74	0.01	0.54
Neuroticism	4.43	1.20	5.26	0.96	5.28	0.01	0.76
Self-efficacy	3.32	0.45	2.79	0.44	8.15	0.01	1.19
Self-esteem	4.14	0.56	3.54	0.67	6.73	0.01	0.97
			Psychological Capital				
Hope	3.34	0.49	2.81	0.49	7.37	0.01	1.08
Self-efficacy	3.32	0.45	2.79	0.44	8.15	0.01	1.19
Resilience	3.94	0.68	3.46	0.71	4.76	0.01	0.69
Optimism	3.04	0.58	2.64	0.58	4.66	0.01	0.68

The winter hikers' group had a significantly higher mean on the self-efficacy, the self-esteem, the hope, the optimism, and the resiliency than the summer hikers' group, but lower means on the locus of control and the neuroticism than the summer hikers' mountain group ($p < 0.01$). Self-efficacy is the factor that most strongly differs betweenboth groups of hikers.

In the next step, a factor analysis was conducted for the scales. The maximum-likelihood method of parameter estimation was chosen [54]. The KMO index was found to be 0.810. Additionally, BTS reached statistical significance $\chi 2(55) = 1304.935$, $p < 0.01$. The KMO and BTS results indicated that data satisfied the psychometric criteria for factor analysis to be performed. Exploratory factor analysis using the maximum-likelihood

method of parameter estimation indicated a two-factor solution upon observing the scree plot (see Table 2).

Table 2. Exploratory Factor Analysis of the Core Self-Evaluations and Psychological Capital Scales.

	Variables	Factor 1	Factor 2
1	External Locus of Control		0.84
2	Neuroticism		0.79
3	Self-efficacy	0.88	
4	Self-esteem	0.83	
5	Hope	0.82	
6	Resilience	0.75	
7	Optimism	0.80	
	Explaining variance (%)	49.77	19.60
	Eigenvalue	3.48	1.37

Additionally, in determining the optimal number of factors to extract, Parallel Analysis (PA) was used [55]. The parallel analysis also showed a strong two-factor solution.

The two factors accounted for almost 69,37% of the total variance. The first factor, which accounted for 49.77% of the variance (eigenvalue = 3.48), is Cognitive resources (subcomponents: Self-efficacy, Self-esteem, Hope, Resilience, and Optimism). The second factor, which accounted for 19.60% of the variance (eigenvalue = 1.37), represents dimension Affective Reactivity (subcomponents: External Locus of Control and Neuroticism).

Table 3 presents scores on two factors extracted in factor analyses in the groups of the winter and summer hikers.

Table 3. Comparisons of Personal Resources in the winter hikers and in the summer hikers.

Resources	Group				t(191)	p
	Winter Hikers		Summer Hikers			
	M	SD	M	SD		
Cognitive resources	3.55	0.43	3.05	0.46	7.83	0.01
Affective Reactivity	3.69	1.09	4.42	0.71	5.49	0.01

In last step, a discriminant function analysis (DFA) was used to assess the capacity of variables for the prediction of the winter and summer hikers. The variables for the group differences were included in the discriminant function analysis. The variables were Cognitive Resources and Affective Reactivity.

One significant function was identified, with an eigenvalue of 0.49 and canonical correlation of 0.57, $F(2, 190) = 47.04$, $p < 0.01$. Table 4 indicates that 77.20% of the group cases were correctly classified, this being 73.68% of the winter hikers and 80.61% of the summer hikers.

Table 4. Classification results of the winter and the summer hikers.

Cases		Predicted Group		Total
		Winter Hikers $p = 0.492$	Summer Hikers $p = 0.507$	
Original Count	Winter hikers	70	25	95
	Summer hikers	80	18	98
% Classified	Winter hikers	73.68	26.32	100
	Summer hikers	80.61	19.39	100

Note: 77.20% of original grouped cases correctly classified.

The Discriminant Function Analysis revealed that two factors contributed significantly to the multivariate discrimination between the mountain athletes. See Table 5.

Table 5. Summary of the discriminant function analysis.

Factors	Wilks'–Lambda	Partial–Lambda	F-Remove-(1.190)	*p*-Level	Toler.	1-Toler. (R-Sqr.)
Cognitive resources	0.86	0.77	55.26	0.01	0.99	0.01
Affective Reactivity	0.75	0.88	24.95	0.01	0.99	0.01

4. Discussion

Previous research has rarely focused on the question of what personal resources help adventurers in the wildernesses to deal with demanding circumstances. The present aim is to examine personal resources among summer and winter hikers exploring the Tatra Mountains. Analysis showed that the personal resources distinguised winter mountain hikers from summer hikers. This finding supported the hypothesis.

Core Self-Evaluations differ between winter and summer hikers. The winter hikers had higher mean scores on Self-efficacy and Self-esteem, but lower mean scores on External Locus of Control and Neuroticism than summer hikers.

Higher scores on Self-efficacy and Self-esteem in the group of winter hikers indicate that they feel confident in their abilities. These beliefs can help them increase their efforts and persistence in the face of risk in natural environments or potential failure. It is probable that the above variables motivate hikers to engage in outdoor adventure. These results confirm previous studies related to self-efficacy in outdoor contexts [33].

The winter hikers control the events that influence their lives; thus, they perceive the mountain aspects of their risk to be at least partly controllable. They are more likely to take action to change the situation in a threatening environment when needed. Of course, we must remember that this isn't actual, objective control of circumstances, but only a subjective feeling about controlling the external world. Subjective control can lead to underestimation of risks and, ultimately, can lead to accidents in the mountains [56,57].

Lower neuroticism in the winter hikers' group positively relates to their internal locus of control. Winter hikers experience unpleasant emotions less often (e.g., anxiety or sadness) than controls. In this way, these emotions do not disturb their processing of information in stressful situations. This result confirms previous studies related to neuroticism in adventure contexts [36].

The winter hikers have higher Psychological Capital compared to summer hikers. This means that they have a tendency to look on the more favorable side of events in mountains, expect realization of their own goals, and perceive a capacity to find pathways to goals (higher optimism and hope). The result is both clear and understandable—without hope and optimism people will not even try to start a journey towards expressing one's own needs, particularly if these needs are risky.

The winter hikers adapt better in the face of adversity, stress or threats compared to summer hikers (higher resilience). Moreover, if they experience some difficulties, they come back to life balance relatively faster than summer hikers. It seems that winter hikers have natural resources to battle against the power of nature.

The present aim is also to examine the structure of personal resources among winter and summer hikers. The results of factor analysis indicated two factors of personal resources. These factors distinguished the winter hikers from the summer hikers. The first factor was labelled Cognitive resources and it explains the highest percent of variance in psychological functioning of hikers in the context of personal resources. This means that this factor (from a psychological perspective) is most important for adaptation to wildernesses. In other worlds, cognitive processes are relatively more important in effective adaptation to the severe world of wild nature than control of negative emotions.

This factor includes the following variables: Self-efficacy, Self-esteem, Hope, Resiliency, and Optimism. It describes positive thinking about oneself, positive thinking about the future, or positive thinking about difficult situations in mountains. The winter hikers

scored higher on this factor than to summer hikers. This means that they have a lot of cognitive resources at their disposal to cope with risks and to try to influence the outcomes of events, both positive and negative.

For them, the wilderness is probably a source of challenge and provides possibilities to express their own desires or goals. On the other hand, they probably perceive dangers in the wilderness as less risky because they strongly believe in their own competences or skills. Underestimating risk can lead to accidents in mountain environments.

These results suggest that winter hikers more often concentrate on endeavors to do something active to eliminate stressful circumstances. They try to change the nature of the stressor itself. Finally, they process information more effectively in extreme environments compared to summer hikers.

The second factor is Affective Reactivity. This factor includes the following subscales: Emotion Oriented Coping Avoidance, Oriented Coping, Locus of Control, and Neuroticism. It seems that this factor describes the emotional functioning of mountain athletes in dangerous, risky situations. A lower mean score on this factor in the winter hikers group suggests that this group can control stress more effectively than summer hikers. Winter hikers react with negative emotions (low neuroticism) significantly less often than summer hikers. This means that winter hikers do not panic in the face of inconvenience and experience less anxiety in dangerous environments compared to summer hikers. It is probable that winter hikers aren't as "sensitive" to stress signals as summer hikers. They have subjective control of the wilderness; thus, their personal safety is reduced slower in risky situations than the recreationists preferring mountain trails in the summer.

Lower scores on Affective Reactivity in winter hikers also suggests that this group can manage negative emotions better that summer hikers; they do not panic in the wilderness because they can control stress. Moreover, lower scores on the Affective Reactivity factor in winter hikers suggests that they need help or support from others less often.

Limitations of the Study and Future Directions

The first limitation of the study is the small number of participants. Another important limitation of the present study is that all of the respondents were young people. This fact limits the generalizability of the results. In future research, it will be important to assess not only young hikers, but other groups of adults.

In this study, the variable of gender was not controlled for. It seems that future research should also take into account the gender variable. Previous research suggests that variables of age and gender can play an important role in practicing outdoor recreation [58,59].

Under this study, only some of the variables of personal resources were subjected to analysis. Future research might encompass some of the concepts of personal resources which were not incorporated, such as, for example, temperamental traits, endurance, or briskness [60].

The current research focused only on mountain hikers. This means that the results can be applied to a very narrow population. Therefore, in future research, it would be interesting to compare personal resources of mountain hikers, recreationists in blue spaces (e.g., kayakers, sailors, and scuba divers), or air athletes (e.g., skydivers and paragliders).

Using comparative methodology would offer new data about adaptation to wild environment.

The data were collected in Poland. Several personal resources in this study concern specific local conditions, which are characteristic for Polish mountains. Hikers from different geographical regions may need other personal resources to explore mountains. An important limitation of the present study is that some differences between winter and summer hikers are small and should be considered more as a trend.

5. Conclusions

Research on wilderness exploration rarely focuses on the psychological traits important for adaptation in the wilderness. More often, researchers analyze the motivational aspects

of outdoor adventure. Seeking new and stimulating experiences, the need for achievements, the need for freedom, or escaping the routine of life motivates people to undertake outdoor adventure. This perspective explains why the adventurous explore wildernesses, but it says little about the mechanisms of adaptation to the wild world of nature. The present research indicates that two components describe effective functioning in the wilderness: belief in one's capabilities to explore severe surroundings, or perception dangers in the wilderness as less risky; and control of one's fears in the wilderness. These components, with connecting motivation to explore wild nature, will allow us to understand exploration of extreme environment more fully.

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What Is So Special about Wingsuit BASE Jumpers? A Comparative Study of Their Psychological Characteristics

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Abstract: For the general public, BASE jumping is considered the ultimate extreme activity. Among BASE jumpers, those using wingsuits are generally perceived as the most experienced but also as the most risk-taking. Starting from this observation, we wanted to know whether wingsuit users differed in their psychological characteristics from other BASE jumpers. More specifically, we hypothesized that wingsuit users would be characterized by higher levels of mental toughness and by lower levels of harm avoidance. We also expected them to use more mental training techniques than the other jumpers. To this end, we conducted a vast survey on a sample of 183 BASE jumpers. Contrary to our hypotheses, the results did not reveal any significant difference in psychological characteristics between wingsuit users and other BASE jumpers. This absence of significant differences is discussed and recommendations for the use of mixed or multi-methods in the study of extreme sports are proposed.

Keywords: extreme sports; personality; sports mental training; sports mental toughness; TCI; wingsuit

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1. Introduction

In the last few years, participation in extreme sports has developed rapidly. Perhaps, as a result, research on extreme sports has also experienced exponential increases [1,2]. Different disciplines such as medicine [3,4], psychology [5], sociology [6] and engineering [7] try to understand the determinants of the engagement in these activities, the experience lived by the extreme sports enthusiasts and the effects of these practices at the physiological, psychological, sociological and mechanical levels. This burgeoning body of research on a relatively new theme is exciting but raises a series of fundamental questions for scientists who are playing the role of pioneers. One of them concerns the identification of different categories of participants within the same discipline.

The starting point of this study lies in the observation of different kinds of BASE jump practices (BASE jumping involves parachuting from a fixed point, as summarized by the BASE acronym, which includes the initials of the objects from which jumps are made: buildings, antennas, spans and earth, where spans mean bridges, domes, or arches, whereas earth refers to natural formations, usually cliffs). Despite an increase in the number of participants over the years, BASE jumping remains a niche activity, with around 3000 participants in 2017 based on data from equipment manufacturers [3]. The two main types of BASE jump are jumps from low objects such as antennas, bridges, and buildings (it is conventionally understood that "low jumps" are made from objects of less than 200 m)

and jumps from higher objects such as cliffs. Within this second type of jump, one can distinguish different practices, mainly related to the type of outfit used for jumping. There are four main categories of BASE jump "outfits" which are linked to specific kinds of BASE jump practices: 1. Normal clothes (e.g., pants and jacket) are mainly worn by beginners; 2. tracksuits (i.e., pants and jacket designed for inflation) allow a modicum of stability and tracking capacity; 3. onesies (i.e., one-piece tracksuits which increase the tracking capacity and speed); and 4. wingsuits, which transform part of the vertical speed into horizontal speed. The development of high flight glide ratio wingsuits has allowed the introduction of new styles of BASE jumping. On the one hand, the use of wingsuits makes objects jumpable that otherwise would not be. On the other hand, it allows flying down mountain slopes of various conformations, along ridges or through canyons, posing the premise for a new style of flight called proximity flying [8]. Effective tracksuit, onesie and wingsuit piloting is a highly skilled activity [9,10].

From an external perspective, a fundamental difference seems to exist between wingsuit users and other BASE jumpers. Indeed, there is a widespread perception that wingsuit BASE jumping is associated with higher risk-taking than other types of cliff jumps. This perception is partly supported by videos of proximity flying, where wingsuit users fly close to objects (e.g., ground, trees, and ridges), up to 250 km/h [11]. A study of BASE jump fatalities between 2007 and 2017 also shows that 61% of fatalities are related to wingsuit BASE jumping, even though wingsuit flying is a relatively minor practice in the discipline [9]. Based on these observations, wingsuit users can be considered as taking more risks than other BASE jumpers, and, also, as much more experienced [8]. Another widely held idea is that the level of expertise required to effectively handle a wingsuit is much higher than other types of flying/falling outfits. All of this contributes to the perception that there are significantly different categories of BASE jump practice associated with different levels of risk-taking. Starting from these insights, we wanted to test whether wingsuit users have different psychological characteristics from other BASE jumpers. Specifically, we focused on psychological factors classically associated with sports practice and risk-taking, such as mental toughness, the existence of specific personality traits and the adoption of psychological strategies, including mental training.

Mental toughness is a personality trait that might be developed following critical incidents, the influence of significant others and targeted interventions [12–15]. Key attributes of this construct include "coping effectively with pressure and adversity, recovering or rebounding from setbacks and failures, persisting or refusing to quit, being insensitive or resilient, having unshakeable self-belief in controlling ones' destiny, thriving on pressure and possession of superior mental skills" [16] (p. 165). A vast body of research shows that sport experience and competency in sport are positively related to mental toughness [17,18]. More specifically, elite athletes were found to be more mentally tough than non-elite and amateur ones [19–21]. Moreover, evidence suggests that overall mental toughness and specific sub-dimensions of the construct are significantly and positively related to attitudes to risk [16,22]. If we subscribe to the assumptions that wingsuit users are more experienced than the rest of the BASE jumpers and that they take more risks over an extended period of BASE jump practice, we can expect that wingsuit users are characterized by higher levels of mental toughness than other BASE jumpers.

In addition to mental toughness, we wondered whether wingsuit users might possess personality traits that differ significantly from other BASE jumpers. Research on personality traits and participation in high-risk sports is abundant. A recent meta-analysis carried out on 149 effect sizes from 39 articles shows that, compared with either low-risk sport participants or individuals not engaged in any sport, high-risk sport participants were characterized by higher levels of sensation seeking, extraversion and impulsivity [23]. Many recent studies on the personality of extreme sports athletes have been conducted using the Temperament and Character Inventory (TCI) [24–28]. The TCI provides a comprehensive account of personality traits by measuring 7 dimensions of personality [29]: novelty seeking (i.e., tendency to seek out new experiences and active avoidance of frustration), harm

avoidance (i.e., propensity to inhibit behaviors and worry about future potential problems), reward dependence (i.e., tendency to maintain behaviors linked to the approval of others), persistence (i.e., tendency to persist in the behaviors despite frustration and fatigue), self-directedness (i.e., will-power, self-determination), cooperativeness (i.e., acceptance and identification of other individuals) and self-transcendence (i.e., feelings of something bigger than the self). Current research has shown that, although BASE jumpers are usually high on novelty-seeking, cooperativeness and self-directedness, and low on harm avoidance and reward dependence, there is no typical or narrowly defined profile of extreme athletes [24–27]. However, the proposition that wingsuit users are more experienced and take more risks than other jumpers leads us to hypothesize that they are lower in harm avoidance than the other BASE jumpers.

In addition to personality variables, we were interested in a set of psychological strategies implemented in the context of sports practice. These psychological strategies include mental training, a key factor in the athletes' performance [30]. Mental training consists of a set of skills such as attention, focus and emotion regulation—and techniques ranging from self-talk to mental imagery. The use of mental training contributes to the building of a stronger mindset through the regulation of stress and emotions [31]. A series of research has indicated that athletes high in mental toughness exhibit more effective use of psychological strategies [17] and are characterized by an enhanced ability to prevent unwanted information from interfering with cognition [21,32]. In summary, if we consider that wingsuit users are more experienced and that they take more risks than the other BASE jumpers, we can expect them to be characterized by higher levels of mental toughness and by lower levels of harm avoidance. Based on anecdotal evidence among the BASE community, we could also expect them to use more mental training techniques than the other jumpers.

Starting from the insights that wingsuit BASE jumping is both riskier and requires more experience than other types of BASE jump practices, we made three main hypotheses regarding the psychological characteristics of wingsuit BASE jumpers compared with non-wingsuit BASE jumpers.

Hypothesis 1 (H1). We expect wingsuit BASE jumpers to be characterized by higher levels of mental toughness than other BASE jumpers.

Hypothesis 2 (H2). We hypothesize that wingsuit BASE jumpers should present lower levels of harm avoidance than the other BASE jumpers.

Hypothesis 3 (H3). We expect wingsuit users to use more mental training techniques than the other jumpers.

2. Method

2.1. Procedure and Participants

A vast online survey was designed to address our hypotheses. English and French versions of the questionnaire were distributed through Facebook BASE jump groups and to the personal network of the main researcher, who is a BASE jumper himself (Regarding the French version of the questionnaire, validated French versions of most scales were used. For measures where no French validation was available, items were translated and then back-translated by a native-speaking researcher in psychology). A total of 183 BASE jumpers completed the questionnaire between 14 February and 2 March 2020. Besides one observation which was removed due to its unrealistic pattern of answers, no outlier was excluded. To test our hypotheses, participants were divided into two subsamples: Wingsuit BASE jumpers and "other" BASE jumpers. Subsamples' characteristics are available in Table 1. Formal ethical approval has been obtained from the Faculty Ethics Committee from Université libre de Bruxelles (Comité d'Éthique Facultaire, affiliated with the Faculté des Sciences Psychologiques et de l'Éducation).

Table 1. Samples' Characteristics.

Measures	Wingsuit BASE Jumpers $N = 61$	Others $N = 121$	Chi-square and *t*-Tests
Gender	7 women	8 women	1.27 (0.08)
Age	38.41 (8.63)	36.24 (9.87)	−1.52 (0.23)
Years of practice	7.98 (5.75)	4.57 (5.15)	−3.91 *** (0.64)
Frequency of practice (days/year)	70.52 (59.06)	48.79 (51.36)	−2.44 * (0.40)
Number of BASE jumps	532.13 (439.46)	259.80 (367.16)	−4.16 *** (0.69)
Other risky activity than BASE	Yes (75.4%)	Yes (87.6%)	−1.93 [a] (0.33)

Note: [a] = $p = 0.057$; * = $p < 0.05$; *** = $p < 0.001$.

2.2. Measures

Completing the questionnaire took, on average, 15 min. Most indicators consisted of short, adapted versions of existing scales to maximize the number of answers. Unless specified, all items were rated on 5-point scales ranging from 1 ("not at all") to 5 ("very strongly"). In addition to demographics, participants were asked to answer the questions listed in the following paragraphs.

Mental Toughness has been measured using an adapted short version of the Sports Mental Toughness Questionnaire [12,33]. It was composed of 9 items covering the three main dimensions of mental toughness: Confidence (e.g., "I have an unshakeable confidence in my ability"; $\alpha = 0.80$), Constancy (e.g., "I take responsibility for setting myself challenging targets"; $\alpha = 0.74$) and Control (e.g., "I get angry and frustrated when things do not go my way"; $\alpha = 0.71$). A total score of Mental Toughness was also computed ($\alpha = 0.57$).

Temperament and Character Inventory's seven dimensions were measured using a short version in 56 items [34,35]. Given their good internal consistency, seven indicators were computed: novelty seeking ($\alpha = 0.57$), harm avoidance ($\alpha = 0.77$), reward dependance ($\alpha = 0.77$), persistence ($\alpha = 0.71$), self-directedness ($\alpha = 0.68$), cooperativeness ($\alpha = 0.72$) and self-transcendence ($\alpha = 0.89$).

Sports Mental Training was measured using a 10-item adapted version of the Sports Mental Training Questionnaire [31]. Four of the five factors were included: Foundational Skills (e.g., "I know my own value, my strengths, and weaknesses, and I plan how to improve them"; $\alpha = 0.67$), Performance Skills (e.g., "When I am under pressure, I'm able to relax physically and mentally, so that I am ready to perform"; r = 0.47), Self-Talk (e.g., "I use self-talk to help myself overcome difficult times"; r = 0.56) and Mental Imagery (e.g., "During preparation for the jump I create real and accurate "inner films" planning possible obstacles and feeling sensations associated with the actual situation to come"; $\alpha = 0.70$). A total score of mental training was also computed ($\alpha = 0.77$).

3. Results

We voluntarily departed from complex multivariate analyses, as the main objective of this paper is descriptive comparative, to highlight the psychological differences between wingsuit users and the other BASE jumpers. As such, the use of comparison analyses seems especially appropriate. In a first step, we focused on demographic variables. Results of chi-squared and Welch *t*-tests show that, although wingsuit users and the other BASE jumpers do not significantly differ in terms of age and gender balance (We decided to test whether gender was a significant discriminant variable within the two jumper samples. Welch's *t*-test results show that within the two groups of jumpers, women and men differ on only one characteristic: participation in other risky activities. In the wingsuit group, women engage in significantly more other risky activities than men. The pattern is opposite for the other jumpers. Other than that, men and women do not differ on any other variable. Based on these results, we decided to compare both groups (wingsuit users and other jumpers) regardless of their gender in the subsequent analyses), the former carry out

practice for longer, jump more often and have significantly more BASE jumps than their counterparts (see Table 1). These results tend to confirm that wingsuit BASE jumpers are more experienced than the other jumpers. Interestingly, they also report fewer risky practices outside BASE jumps than the other jumpers (These self-reported practices are highly varied: Speed flying, paragliding, skydiving, mountaineering, rock climbing, big wave surfing, kite surfing, diverse forms of diving (e.g., cave, apnea) and highlining. Interestingly, practices such as walking alone, cycling in a city and sex are also mentioned by a series of participants. The mention of these last practices suggests a surprisingly realistic perception of risk-taking).

The values in brackets in the two first columns are Standard Deviations. The values in brackets in the last column are effect sizes.

In a second step, Welch *t*-tests were run to grasp the potential psychological differences between wingsuit BASE jumpers and non-wingsuit BASE jumpers. We used non-parametric tests given the imbalance in the subsamples' sizes [36]. Contrary to all our hypotheses, the results of the comparison tests show no significant differences but one between wingsuit users and non-wingsuit BASE jumpers. The only exception to this pattern is the level of self-talk which is significantly lower among wingsuit users than among the other jumpers (see Table 2).

Table 2. Descriptive Statistics and Comparison Tests for the Main Variables Considered.

Measures	WS Base Jumpers $n = 61$	Others $n = 121$	Welch *t*-Test Value	Effect Size (Cohen's d)
Mental Toughness—Confidence	3.699 (0.759)	3.548 (0.725)	−1.288 (116)	−0.204
Mental Toughness—Constancy	4.022 (0.647)	4.014 (0.664)	−0.079 (123)	−0.012
Mental Toughness—Control	2.738 (0.876)	2.625 (0.815)	−0.836 (113)	−0.133
Mental Toughness—Total	3.661 (0.547)	3.645 (0.502)	−0.187 (112)	−0.030
Mental Training—Foundational Skills	3.811 (0.822)	3.774 (0.722)	−0.300 (105)	−0.048
Mental Training—Performance Skills	4.067 (0.751)	3.933 (0.788)	−1.105 (123)	−0.173
Mental Training—Self-Talk	2.867 (1.116)	3.300 (1.127)	2.448 * (119)	0.386
Mental Training—Mental Imagery	3.722 (0.961)	3.878 (0.792)	1.083 (100)	0.177
Mental Training—Total	3.647 (0.660)	3.743 (0.580)	0.961 (106)	0.155
TCI—Cooperativeness	3.936 (0.603)	4.062 (0.597)	1.330 (119)	0.209
TCI—Self-Transcendence	2.557 (0.969)	2.481 (1.087)	−0.479 (133)	−0.074
TCI—Self-Directedness	3.924 (0.615)	3.996 (0.612)	0.744 (120)	0.117
TCI—Reward- Dependence	3.189 (0.760)	3.351 (0.724)	1.385 (115)	0.219
TCI—Harm Avoidance	2.389 (0.719)	2.413 (0.691)	0.214 (116)	0.034
TCI—Persistence	3.762 (0.622)	3.798 (0.596)	0.365 (116)	0.058
TCI—Novelty-Seeking	3.680 (0.589)	3.766 (0.623)	0.907 (127)	0.141

Note: * $p = 0.016$; Scales ranged from 1 to 5 (see above). With a single exception, mean levels of all variables of interest do not significantly differ between wingsuit users and other jumpers. The values in brackets in the two first columns are Standard Deviations. The values in brackets in the third column are degrees of freedom of Welch *t*-tests.

In a third step, given the absence of significant differences in personality and mental training dimensions between wingsuit and non-wingsuit BASE jumpers, we investigated from an exploratory point of view whether, instead of differences between categories of jumpers, there would be differences within wingsuit BASE jumpers related to experience. To carry this out, we conducted bivariate correlations to see if wingsuit users' experience level was related to their psychological characteristics. Results of the correlations show that, besides one dimension of mental toughness and one personality trait (i.e., persistence), there were no significant correlations between the number of wingsuit BASE jumps and our variables of interest (see Table 3).

Table 3. Correlations Between the Number of Wingsuit BASE Jumps and Variables of Interest.

Measures	Number of Wingsuit BASE Jumps
Mental Toughness—Confidence	−0.056
Mental Toughness—Constancy	−0.406 **
Mental Toughness—Control	−0.022
Mental Toughness—Total	−0.079
Mental Training—Foundational Skills	−0.198
Mental Training—Performance Skills	0.004
Mental Training—Self-Talk	−0.090
Mental Training—Mental Imagery	−0.203
Mental Training—Total	−0.192
TCI—Cooperativeness	0.003
TCI—Self-Transcendence	0.038
TCI—Self-Directedness	−0.068
TCI—Reward-Dependence	−0.082
TCI—Harm Avoidance	0.069
TCI—Persistence	−0.363 *
TCI—Novelty-Seeking	0.007

Note: Sig. Two-tailed: * $p < 0.05$. ** $p < 0.01$; Correlations between variables have been calculated separately for the WS BASE subsample.

4. Discussion

The purpose of this study on the largest sample of BASE jumpers mobilized to date was to consider potential psychological differences that may exist between wingsuit users and other jumpers. Based on the widespread perception that wingsuit BASE jumping is associated with higher risk-taking than other types of cliff jumps and that wingsuit users would be more experienced than other jumpers, we expected the former to differ from the latter on several psychological factors. More specifically, we hypothesized that wingsuit users would be characterized by higher levels of mental toughness and by lower levels of harm avoidance. We also expected them to use more mental training techniques than the other jumpers. Our results, however, did not reveal the existence of distinct profiles in terms of these psychological variables. This relative lack of empirical evidence of psychological differences between wingsuit users and other BASE jumpers can be explained in at least 3 ways. First, despite actual differences in "objective" experience (i.e., number of years of practice, number of total jumps, frequency of practice), wingsuit users would not actually differ from other jumpers in terms of psychological characteristics. Secondly, it is also possible that many participants who were other jumpers may eventually go on to become wingsuit users with more time in the sport and therefore confound the differences in temperament across both groups. A third explanation is that our research method and measurement tools were not able to capture such differences. We will develop these hypotheses in the remainder of the discussion.

4.1. A False Dichotomy?

This first option is that wingsuit users and the other BASE jumpers would not substantially differ in terms of personality and mental characteristics. Another possible interpretation is that psychological variables other than those we measured could explain the differences in practice. For instance, the perception of risk may be associated with the different types of practice [37,38], the emotions felt during the edge experience [39,40] and the feeling of self-efficacy [41] concerning the practice of BASE jumping. Further, the fact that wingsuit users were less involved in participation in other risk-taking activities might suggest that obsessionality is an important variable to take into account in future studies. Nevertheless, what our results suggest is that the distinction between elite (in this case the wingsuit users) and amateur athletes (in this case the other jumpers) seems less relevant in BASE jumping than in non-risk sports. In the latter, high-achievement athletes are frequently distinguished from amateurs in terms of their psychological characteristics [42–46]. In BASE jumping, moving into wingsuit BASE may be a natural progression

from extended practice and a result of opportunity, rather than based on participants' psychological characteristics and that effective performance in wingsuit BASE jumping is likely to require a very similar set of characteristics as effective performance in other BASE disciplines.

4.2. A Plea in Favor of Mixed or Multi-Methods

In the case of this study, the use of standardized questionnaires and basic quantitative analyses (statistical methods such as latent profiles analyses could have been used if sample's size was close to 500 [47] did not allow us to capture the psychological specificities of different types of BASE jumpers. We have hypothesized above that this lack of observation of differences may be due to a real absence of psychological specificities. However, since the non-observation of statistically significant differences does not mean that there are no real differences, the use of additional data collection methods, statistics (an important limitation of the present study lies in the lack of multigroup measurement invariance analysis due to small sample sizes [48]. Treating the French- and English-speaking subsamples as a whole might have influenced the final results of our analyses), and even, of different psychological models, would have been of considerable value. History has shown on several occasions that while extrapolating ideas from one field to another field can have broad application, it is often the case that important nuances are missed. In sport, a good example is the early extrapolation of knowledge from mainstream psychology to sport psychology [49]. Although research in the early days was broadly helpful, important nuances were missed which triggered the move to the development of sport-specific models. Arijs and colleagues [50] argued that extreme sports need to be recognized as different enough from mainstream sport that specific models need to be developed for extreme sports. The need for different models is often accompanied by the need for different research methods. The present study highlights the limits of purely quantitative designs and suggests that qualitative methodologies able to draw out nuances are important [50]. Challenges for research in this area include the fact that quantitative and qualitative research are often framed by different ontological and epistemological frameworks [51]. Although many have argued that truly mixed methods are potentially incompatible, studies that utilize one or the other or collaborative studies that draw on both might provide the evidence required to produce models suitable for extreme sports. One example of this practice is a study by Monasterio and Brymer [52] which adopts an autoethnographic approach to explicate a rock-climbing accident. Their findings show that beyond personality factors—traditionally measured through quantitative questionnaires—effective climbing is also determined by the reinforcement of humility and self-awareness.

5. Conclusions

The current research addressed the psychological specificities of wingsuit users compared with the other BASE jumpers. Our results showed that wingsuit users and the other jumpers displayed quite similar psychological patterns. We tried to explain these results in at least three ways, one of which constitutes a plea in the favor of the use of mixed methods for studying the extreme sports experience. In our view, the combination of understanding real-life motivators and decision-making of individuals, with quantitative data in populations, is the goal of longer-term research and will enrich not only extreme sports research but also research into complex behaviors.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The dataset, questionnaire, and ethical approval form have been made publicly available on the OSF and can be accessed at https://osf.io/umc7j/?view_only=e40404996f534ce0a0336ae7d5214081 (accessed on 20 January 2022).

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Review

The Ecological Dynamics Framework: An Innovative Approach to Performance in Extreme Environments: A Narrative Review

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Abstract: (1) Background: Uncertainty in extreme sports performance environments, such as climbing, provides considerable psycho-emotional and physiological demands, notably due to the many different environments in which climbing can be performed. This variety of environments, conditions of practice and engagement would challenge the acquisition of perceptual-motor skills; (2) Methods: To better understand how perceptual-motor skills are controlled and acquired in climbing, we proposed a narrative review anchored in the ecological dynamics theoretical framework and showed how this theoretical framework would support a nonlinear pedagogy to skill acquisition and to design safe learning and training situations that are representative of extreme performance contexts; (3) Results: We explained three theoretical pillars and we provide examples for design intervention following nonlinear pedagogy, notably (i) to set a constraint-led approach (in particular task constraint), (ii) to implement conditions of practice (constant vs. variable, imposed vs. self-controlled), (iii) to promote adaptive and creative behavioral variability during practice; (4) Conclusions: The challenge for the extreme sport practitioner is how to set up conditions of practice for efficient exploration in a manner that manages the dangers of performing in uncertain environments. Representing uncertainty within the relative safety of indoor settings may be one approach for preparing climbers for performance in extreme environments.

Keywords: perception–action coupling; complex system; movement variability; motor control and learning; climbing

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1. Introduction

Uncertainty in extreme sports environments, such as climbing, provides considerable psycho-emotional and physiological demands, notably due to the many different environments in which climbing can be performed. Indeed, climbing can be performed indoor and outdoor, for differing heights, altitudes, surfaces (rock, snow, ice or mixed), tools as support (e.g., ice axes, crampons), protection and engagement (with or without bolts, solo, top-rope or on-sight). This variety of environments, conditions of practice and engagement would challenge the acquisition of perceptual-motor skills. To better understand how perceptual-motor skills are controlled and acquired, an ecological dynamics theoretical framework is proposed. Ecological dynamics is a multi-disciplinary framework that adopts concepts and tools of dynamical system theory, ecological psychology and complex system in neurobiology to investigate and model the relationships that emerge in extreme sports between athletes and their environment. In this relation, the performed behavior emerges through the continuous and active exploration of the environmental properties according to the individual intentions, body properties, perceptions and action capabilities.

In this narrative review, we present the framework of the ecological dynamics and how this theoretical framework would support a nonlinear pedagogy to skill acquisition

and to design safe learning and training situations that are representative of extreme performance contexts. Second, we provide principles and examples to design intervention following nonlinear pedagogy, notably (i) to set a constraint-led approach (in particular task constraint), (ii) to implement conditions of practice (constant vs. variable, imposed vs. self-controlled), (iii) to promote adaptive and creative behavioral variability during practice.

2. An Ecological Dynamics Framework for Extreme Sport Understanding

The ecological dynamics theoretical framework is a multi-disciplinary framework based on the dynamical systems theory [1,2], ecological psychology [3] and a complex systems approach to neurobiology [4,5], and is supported by three main pillars [6–8]. The first pillar considers that movement coordination patterns are a dynamically functional relationship emerging from a set of interacting constraints, including the environment, the task and the resources of a performer [9]. Therefore, climbing performance should be analyzed on the ecological scale, which implies that the performer–environment coupling is the smallest unit of analysis to investigate climbing performance and expertise [10,11]. For example, in rock climbing, the rolling motion of the body is examined in reference to the surface of a climbing wall or cliff, rather than according to the longitudinal axis passing from the head to the feet of the climber, because this eco-physical variable would indicate whether the climber is facing the wall or is side on to the wall (for more details, see [12]).

Second, the ecological dynamics framework considers the performer–environment coupling as a complex adaptive system which means that the perceptual-motor behavioral organization exhibits *non-linear* and *non-proportional* properties [13]. This second pillar examines whether performance and skill acquisition improve linearly and proportionally with the increase in the constraints of the environment, the task and the performer [1]. The *non-proportionality* that exists between behavior and performance could be exemplified by sensitivity to initial conditions, in particular when during practice a small change in behavior can lead to a transition in performance and, conversely, switching between two behavioral patterns can lead to a marginal change in the performance outcome [14]. The *non-linear* relationship between behavior and performance can be observed in sudden transitions between two behavioral states, such as the change from walking to running on a treadmill, the task constraint increases linearly (the speed imposed by the treadmill rising incrementally), however, the movement changes in a non-linear manner [2]. Such non-linear behavioral changes could also be observed in climbing as climbers switched from a "face" body position to a "side" body position when the climbing holds orientation increases linearly from horizontal to vertical [12]. Based on previous findings [15], it can be postulated that a linear decrease in the depth holds would lead climbers to switch between grasping patterns. In the same vein, a linear increase in the steepness of a rock cliff from a positive inclination (i.e., ramp) to a negative inclination (i.e., overhang) would lead climbers to switch from biped to quadruped locomotion. Specifically, a particular ramp might favor smearing (i.e., using climbing shoe friction) whereas an overhang often involves actions such as arm pumping and feet hooking for improving one's position on the surface.

Non-linearity could also relate to the presence of "multi-stability" [2,16] induced by the inherent degeneracy of perceptual-motor systems, suggesting that the behavioral structure can vary without compromising function in achieving the task/goal [4,5,17]. Multi-stability means that there is no one stable behavioral state to match a set of constraints in interaction; rather, there are multiple stable performance solutions that can emerge, depending on opportunities of action offered by the environment and perceived by the climbers according to their capabilities [3]. Finally, when interacting with the environment, climbers' behavior dynamics exhibit periods of stability, destabilization and reorganization toward new coordination states that completely reshape the perceptual-motor repertoire [6]. Multi-stability in rock climbing could be observed in the large range of hand grasping patterns and body positions regularly used to grasp a hold [18,19]. In the same vein, multi-stability could be also observed in ice climbing, as climbers used several stable coordination patterns (e.g., horizontal-, diagonally-, vertical- and cross-located angular positions of the

ice tools and crampons) and several types of actions (i.e., swinging, kicking or hooking) to anchor ice tools [20,21]. This multi-stability demonstrates the functional adaptation to dynamic environmental properties of the icefall, which changes in thickness, density and shape with air temperature, number of previous ascents (i.e., holes made by previous climbers), sun exposition, etc. For instance, the anchorage locations and the type of actions were selected to protect the icefall structure. Notably, climbers usually separate their ice tools from each other (e.g., by using diagonally and vertically angular positions between two ice tools) by 20 cm to protect icefall surface structure, which might be fragile in some parts. When the ice is dense without any holes, climbers usually swing their ice tools and kick their crampons. Conversely, when the ice is hollow and fragile, climbers hook holes with their ice tools and crampons. Thus, expertise in an extreme sport such as ice climbing could relate to the functional ability of the climber to exhibit multi-stability of coordination patterns to anchor ice tools in relevant locations and by using relevant types of action. This example is of particular interest because it suggests that minimizing risks in extreme sport could be achieved by switching between motor solutions without compromising function in achieving the task/goal. It highlights the importance of multi-stability as a mark of expertise, as an expert could use multi-stability as a "back-up plan".

This second pillar suggests that learning and training in extreme sports would aim to safely explore new motor solutions in order to develop a larger motor repertoire (i.e., multi-stability). More than that, it invites us to reconsider the role of behavioral variability in skill acquisition. The ecological dynamics framework has highlighted that behavioral variability should not necessarily be considered as a deviation from expert behavior that should be corrected, nor as noise from an expert model that should be minimized to enable the production of a consistent, automatic and economic movement pattern. Instead, several studies (presented later in this narrative review) have provided evidence for the adaptive and functional role of movement and coordination variability in order to satisfy interacting constraints.

The third pillar suggests that coordination variability emerges from a continuous co-regulation of perceptual and motor processes, referred to as perception–action coupling. The use of information is founded on picking-up information for affordances that can "solicit" and "constrain" behaviors in a specific performance environment [3,22,23]. Considering an ecological scale of analysis, which implies the definition of an eco-physical variable to examine the relationships between an individual and an environment define affordances. Therefore, affordances are both objective and subjective to each performer since they are ecological properties of the environment picked up relative to an individual's own action capabilities, i.e., they are body-scaled and action-scaled [24,25]. On one hand, body-scaled affordances relate to the relations between the body of the climber (such as height, limb sizes, hand area, which can influence the distance and shape of the hold that a climber can reach and grasp) and a relevant property in the environment. On the other hand, action-scaled affordances relate to how the climbers exploit their capabilities and how they behave relative to their environment [24]. For instance, Warren [26] emphasized that despite differences in body size, young adults accurately perceived stairs as no longer climbable in a bipedal fashion, when the step height exceeded 88% of their lower limb length. Regarding action-scaled affordances, other research investigated how individuals perceive maximal reach-and-grasp in rock climbing tasks [27,28]. The authors found that individuals with low levels of experience underestimated their maximal boundary of grasp, i.e., they miscalibrated their reach and grasp actions according to how far away they perceived the hold. More recently, in a reaching-and-grasp task, Seifert et al. [29] showed that advanced climbers had greater maximal action capability but did not act nearer to their maximal action capability than intermediate climbers. The authors suggested two possible reasons. First, because of their greater maximal action capability, advanced climbers perceive different opportunities for action (as they exploit degeneracy of perceptual-motor system and exhibit multi-stability) than intermediate climbers, notably in the case of more complex grasping tasks. Therefore, advanced climbers engage in different modes of action

reflecting more effective chaining movements. Second, because in climbing the consequence of overestimation means falling and could cause injury or worse, climbers might safely scale their actions within their action boundaries to succeed and to prevent injury [30]. This could explain why both advanced and intermediate climbers scaled their action at the same ratio of their maximal action capability. Thus, skill acquisition in extreme sports would correspond to the improvement of perceptual accuracy toward better perceptual attunement and calibration according to maximal action capability, in order to functionally (re)organize and continuously regulate their motor behavior to achieve successful (i.e., safe) performance outcomes and to minimize risk-taking. Attunement relates to the pickup of more reliable information patterns in the energy arrays to guide action, while calibration concerns the appropriate scaling between information and an individual's action capabilities [30,31]. Scaling to action capabilities allows the distinction between possible and impossible opportunities for action [24,32]. For instance, the wrong calibration might lead to "dyno" (i.e., dynamic move) whereas the edge of the hold is too small (such as a crimp) and not holly (such as a jug), which can be considered as a maladaptive behavior because it leads to failing to grasp and eventually to a fall. Such kind of wrong calibration is of great consequence in extreme climbing, such as "free soloing" (i.e., climbing without a rope), as any fall could cause death.

3. Nonlinear Pedagogy to Design Learning and Training in Extreme Sport: The Case of Climbing

3.1. Manipulating Constraints: Functional Exploration and Adaptability

Achieving a particular intended goal, such as reaching the top of a climbing route, requires exploiting the performance constraints through functional adaptation of movements. The set of constraints in which outdoor climbers perform are dynamically evolving over the course of their performance: surfaces, size and shape of the holds change along the route, fatigue in forearms rises as the climbing lasts, and weather conditions are liable to change. These dynamically evolving constraints from the environment and the organism invite continuous adaptation of climbers' behavior [1]. Adaptability requires an appropriate balance between flexibility and stability in movements according to the performance context, that is, varying coordination patterns fitting in the set of constraints and maintaining a coordination pattern undergoing disturbances [33].

Functional adaptations to the performance context characterize skilled behaviors in climbing. For example, expert ice-climbers are able to demonstrate a larger range of interlimb coordination patterns during performances in comparison to novices, who appear to be stuck into a smaller set of possible patterns [20,21]. Such difference in motor repertoire was also found in indoor climbing where skilled climbers were shown to be able to use various trunk orientations while climbing while novices rarely used alternatives to a face-to-the-wall trunk orientation [12]. These observed larger repertoire in skilled climbers support the exploitation of the performance constraints as they can demonstrate functional variability according to their intended goal and the performance context.

Adapted coordination patterns emerge from the performer–environment system. Interactions of the climber with the climbing route generate information specifying what are the possibilities of action (i.e., affordances [3]) that the environment offers. With practice, performers learn to pick up information more reliable for action and to scale this information to their action capabilities [24,34]. These learning processes are respectively called attunement and calibration and enable the accurate perception of affordances. Perception of affordances in the climbing environment was shown to be skill-level-dependent [35,36]. Indeed, when climbers were asked to recall the sequence of holds of climbing routes, expert climbers showed better performances than novices when recalling a difficult route. However, when the route was easy or impossible to climb, novice and expert performance did not differ in the recall task [35]. These results emphasize that affordance perception in climbing is specific to performers' action capabilities. Using a similar recall task, another study asked both inexperienced and expert climbers to think aloud while recalling the

route [36]. The results showed that while inexperienced participants focused on structural features of the holds (i.e., their size, shape, location on the wall . . .), the expert climbers recalled the possible actions they could perform with the holds or with a series of holds [36]. Thus, one challenge in climbing skill acquisition is to develop learners' ability to perceive and act on climbing affordances, that is, perceives the climbing route not as a series of handholds with different shapes placed next to each other, but in a functional term as a possible chain of climbing actions.

Perception of affordances is an active process that relies on the performer's exploratory activity [37]. Looking at the route, touching the surfaces of the holds or changing the trunk orientation are all ways to generate information while climbing [8]. More precisely, these actions enable the performer to pick up patterns of stimulation (e.g., optical, or mechanical) structured by the properties of the environment and his/her motion [38,39]. That way, performers can engage with their environment through different modes of exploration that support the specification of the affordances in their surroundings. For example, a study proposed to differentiate five climbing states according to hip and limbs movement or immobility: (i) looking at the route or resting (limbs and hip are immobile), (ii) adjusting the center of mass (limbs are immobile and hip is moving), (iii) determining which hold to use (position or orientation of the limb is changing), (iv) hold changing (moving limbs but not the hip) and (v) performing (the hip and at least one limb are moving simultaneously) [8]. These climbing states were assumed to participate to affordance perception on the climbing route by informing climbers about holds *reach-ability* (is the hold too far or can I reach it?), holds *grasp-ability* (is it a foot or a hand-hold? which grasping pattern should I perform?) and holds *use-ability* (what movement can I perform to exploit the holds and progress on the route?).

However, the modes of exploration can be engaging and threatening to the climber's safety. For example, exploration from a distance with the visual system is certainly safe whereas touching a handhold to try a grasping pattern or to get information about friction on a foothold implies that the limb used for exploration purposes is no longer used as support, which can be potentially threatening the postural stability of the climber [40]. In the literature about the development of locomotion, Kretch and Adolph [41] proposed the ramping-up hypothesis to capture how the modes of exploration are organized to specify affordances. This hypothesis argues that modes of exploration are organized in space and time so that performers progressively use more engaging modes. That is, the visual mode is usually the first one used as it can be performed from a distance. For example, occasional glances can be sufficient for humans to control locomotion on regular and safe terrain [42,43]. However, if the visual information is not sufficient to perceive what actions can be performed, then more engaging modes are used, such as touching the surfaces or testing alternative motor solutions [41,43]. This organization of exploration appears to fit what is observed in climbing. Notably, the number of exploratory hand movements was shown to decrease with practice [12,40] suggesting that as soon as climbing affordances can be perceived by other means, this engaging mode of exploration is avoided.

Additionally, the changes observed in climbers' exploratory activity with practice are associated with attunement to the route affordances. If the number of exploratory hand movements decreases with practice, it is certainly because the holds *grasp-ability* and *use-ability* can be specified more reliably with visual information than they could during early practice [8]. Practice also affects the climber's gaze behavior by decreasing the number of visual fixations performed and by reducing the randomness in the gaze path during climbs [40,44], supporting that climbers improved their ability to differentiate reliable optic information to guide their movements on the route.

These effects of climbing experience on exploratory activity are also supported by transversal studies comparing climbers with different skill levels. Indeed, more skilled climbers were shown to explore more with their hip than less skilled climbers who explore both at the hand and hip levels [45] and in ice-climbing, experts demonstrated more sensitivity to the environmental properties which helped them limit the number of ice tools

and crampon actions they performed while climbing [21]. Such differences in exploratory activity are also due to the larger range of coordination patterns that skilled climbers can demonstrate. For example, as mentioned previously, the expert ice-climbers could limit their number of actions because they could both perceive opportunities for hooking holes in the ice and perform the inter-limb coordination patterns to exploit these opportunities [21]. Thus, conditions of practice should both guide learners' attention toward relevant information for action and discover various coordination patterns to attain their intended goals.

One solution proposed to enhance climbers' exploration of the available information and of new coordination patterns is to manipulate constraints in the practice environment to provide meta-stable conditions of performance. For example, handholds orientation was shown to directly affect the body postures [12]. A horizontal edge enables climbers to climb facing the wall (such as when climbing a ladder), whereas when the handholds edge is vertical, the climbers require climbing side to the wall to exploit the handholds properties. The latter pattern of trunk rolling motion is less common in beginners who reduce their adaptability to a route composed of handholds with a vertical edge, as shown by the greater number of exploratory and performative movements performed and the lower climbing fluency in comparison to how they perform on a route designed with handholds with a horizontal edge [12]. However, designing the same route with double edge handholds (i.e., handholds with both a vertical and a horizontal edge) provides a meta-stable condition that both enables novices the use of stable trunk rolling motion pattern, and to explore safely (i.e., to try a new pattern with the opportunity to draw back to former pattern) the side to the wall climbing pattern [12,45].

3.2. Implementation of the Conditions of Practice: Constant vs. Variable Practice, Imposed vs. Self-Controlled

Ecological dynamics emphasized the functional role of behavioral variability in learning in order to enhance skill transfer. The rationale is that exploration of various behavioral solutions during practice would support the development of the learners' behavioral repertoire. The resulting broader behavioral tendencies would support a more cooperative relationship with new task dynamics, supporting specific or general transfer to a new performance environment [6,46]. Specific transfer reflects an appropriate fit between the learner's intrinsic dynamics and the new task whereas general transfer expresses that the learner can further improve the fit with the new performance environment relying on the preexisting behavioral repertoire [46]. For example, the behavioral repertoire of indoor climbers was shown to support performance in ice climbing tasks, but this new activity (notably the tools manipulation and the exploitation of the environmental properties) required further practice for indoor climbers to functionally exploit the specific constraints and information–movement couplings of ice climbing, illustrating a general transfer of skill [21,46]. Thus, beyond increasing the number of coordination patterns discovered during practice, inducing behavioral variability aims to confront learners to various information–movement couplings. This would support learners' attunement to more reliable information so that they could better specify the fit between the environmental properties and their action capabilities [47].

More broadly in the motor learning literature, externally induced variability in practice was originally hypothesized to improve learning (i.e., transfer and/or retention) in comparison to more repetitive practice protocol, such as constant practice or blocked schedule of practice, by supporting the optimization of a recall and a recognition schema [48] or by increasing the contextual interference between trials [49]. More recently, evidence advocated that the effects of external variability on learning may be more complex and would depend on the nature of the variations (for a review on the topic, see [50]). However, recent research highlighted some limitations of constant practice protocols in the context of the acquisition of complex perceptual-motor skills such as those required by climbers.

First, although the motor learning literature emphasized that constant practice protocol generates better performances on average during practice than variable practice conditions, it was also showed that the performance dynamics at an individual level could be quite different. For example, a constant learning protocol of a climbing task showed that individual learners could demonstrate three different dynamics of climbing fluency scores: (i) progressive improvement, (ii) sudden improvement characterized by initially stable performances and a later positive change in climbing fluency, and (iii) repetitive failure in task completion resulting in the absence of improvement in climbing fluency [51]. When authors looked at the behavioral repertoire of the learners, they could highlight that learners' initial repertoire (here reflected by their tendencies to use different trunk rolling motions while climbing) was linked to the performance dynamics. More precisely, climbers able to vary between face-on and side-on postures could progressively improve their performances whereas those who were initially limited to face-on postures were required to discover alternative means to climb before improving their climbing fluency. However, climbers who could not discover these alternatives during practice kept on failing or showed a lack of improvement [51]. This relationship between an individual's intrinsic dynamics and task dynamics highlights the need to provide variability in practice conditions to foster the discovery of new coordination patterns and to avoid failing learners to be maintained into unsuccessful performance environments.

Second, even when practicing an indoor climbing task, usually designed with different shapes of climbing holds offering various opportunities for action along the route, we showed that learning outcomes would be limited in terms of transfer to new climbing routes [40]. In this study, we showed that transfer of skill following such a constant practice protocol was limited to a new climbing route inviting low-order changes in climbing movements, i.e., the distances between handholds were increased so that more amplitude in climbing movements were required. The two other transfer routes were designed to either induce high-order changes in climbing actions (i.e., handholds were turned to invite new postures to use them) or no changes in climbing actions but the handholds shape was changed so that the grasping pattern would not change but would be less obvious. The results showed that changing environmental properties to design these two routes affected climbers' performances by both deteriorating learners' climbing fluency and increasing their visual search in comparison to the learning route on post-tests [40]. This highlights that the repetition of confrontations to a single learning environment restrained learners from developing perceptual-motor skills very specific to it, limiting their ability to overcome perturbations of their information–movement couplings in this performance context.

Thus, confronting learners with various performance environments may be an adequate solution to engage learners in the discovery of alternative movement solutions and to broaden the range of their experienced information–movement couplings with the aim of facilitating future confrontation to unknown performance environments [47]. Recently, we investigated the effect of both constant and variable practice protocol of a novel climbing task on the performance and visual activity of novice participants [52]. In this study, the constant practice condition consisted in repeating trials on a single climbing route whereas the variable practice condition involved that learners were confronted to both the same route as the constant practice group (but to a lesser extent) and to a new variant of this route on each session. Participants were tested on a transfer route and the learning route (i.e., the route on which both groups trained) at the start and the end of the protocols. As expected, the improvement in the climbing fluency scores on the learning route was higher for the constant practice group but interestingly, the results showed that the two practice conditions affected differently the learners' gaze patterns on this route. First, participants in the constant practice group tended to keep their gaze on the handholds until their hand touched it whereas participants in the variable practice group were more proactive as their gaze shift occurred earlier in relation to hand contact. The gaze pattern of the variable practice group was also more proactive on the transfer route, whereas the constant practice did not change its gaze pattern between pre and post-transfer tests. Although the

performance of the two groups was not different on the transfer test, these results suggest that variable practice conditions support the development of the generalizable exploratory activity. More specifically, here the change in the gaze pattern offered more time to the climbers to look for the next climbing actions, potentially facilitating the chaining of climbing actions in unknown routes. In contrast, the absence of transfer of the gaze pattern used by the constant practice group on the learning route suggests that although it may have participated in developing the better fluency scores on the learning route, it competed with the demands induced by the confrontation with a new environment. Thus, further research in this direction is needed to reveal the change in exploratory activity induced by variable practice conditions underlying positive transfer to a new performance environment.

Most of the variable practice protocol provides new practice conditions at a regular time interval for all participants in the intervention group. However, we preceded to highlight interindividual differences in learning dynamics. Moreover, a case study that used the same variable practice protocol as in [52] within additional post sessions phenomenological interviews, revealed that participants can also voluntarily limit their exploration of some climbing coordination patterns during practice if they feel unsafe when performing them [53]. Thus, although inducing external variability may "force" exploration, exploration in engaging activities such as climbing also requires the participants to intend to it. Developing a learning protocol more respectful of individual learning dynamics is a challenge that fully makes sense in engaging activities (i.e., extreme sports).

A proposed solution is to give learners the opportunity to choose when to be confronted with a new performance context. In the motor learning literature, such protocols were tested and the results showed that (i) learners adapted the task difficulty to their skill level, which resulted in a better success rate than those following a progressive and regular increase in task difficulty [54], (ii) learners tended to start practice with low levels of contextual interference and to increase this level at the end of practice [55] and (iii) learners showed better learning outcomes than those following imposed protocol [56–58]. The benefits of having control over the practice schedule were attributed to the autonomy-supportive learning environment in such condition [58,59], see also the OPTIMAL learning framework proposed in [60] and to the better fit between the learner's progression and task difficulty [54,55], see also the Challenge Point hypothesis in [61]. Although these interventions appeared successful when learning laboratory tasks, we may expect that the level of engagement needed to perform in a new route may prevent some individuals to challenge them with novelty. In [52], a self-controlled variable practice group was also implemented. The results did not reveal any benefits in terms of performances on the learning route and the transfer route but, the participants in this group showed various trends in their gaze patterns, with some developing more proactive gaze patterns, such as those in the variable practice group, while others demonstrated gaze patterns closer to the constant practice group. These results suggest that some participants may have used the given control on their practice schedule to maintain themselves in a comfort zone rather than challenging themselves. However, we may expect that such protocol could also promote for others (notably more skilled participants) more active self-regulation during performance as learners are given the opportunity to engage with the design of their learning environment and they have the possibility to explore this environment [62]. In sum, the effects of self-controlled practice on individual learning dynamics may be a direction to further investigate in engaging activities such as (extreme) rock climbing, notably because it might (i) maintain a high level of attention, and (ii) help to focus attention on the most relevant information for action.

3.3. Conditions for Promoting Adaptive and Creative Behavioral Variability

Adapted and adaptive behaviors have recently been linked to creativity [63,64]. Interestingly in extreme environments, when optimizing a behavior that is already present in the repertoire to fit a new situation (i.e., to adapt) can be challenging, looking for and trying something totally new (i.e., to create) may even be more challenging but potentially

necessary because of unknown and unexpected environmental conditions (e.g., changing weather, changing of ice properties). Commonly, creativity is understood to be the capacity to produce novel solutions to open-ended problems in daily life [65]. With reference to the cognitive perspective of creativity, divergent thinking allows an individual to create more alternative ideas [66], leading to a more diverse toolbox from which an individual can generate potential solutions [67,68], tying creativity to various adaptation processes [65,66]. As previously mentioned, any movement solution formed when an individual is exposed to a novel task would be the product of the characteristics of the individual, environment, and task [69], arising in temporal couplings between the three as the action unfolds. An individual capable of developing more movement solutions in response to a given situation is therefore termed more "flexible". Flexibility forms the basis of adaptability, as the latter is one's ability to respond effectively to a changing task, i.e., to achieve the outcome successfully (see Section 3.1). Creativity is therefore a form of flexibility when facing a situation for the first time.

Promoting a high level of creativity in the learning tasks, leading to high flexibility in the performers' behavior is a potential key factor for learning and training for extreme environment sports. For instance, Komar et al. [70] recently showed that when introducing uncertainty in climbing an unknown route (i.e., decreasing the amount of available information by making visible only a few coming holds), the key feature of expert climbers is not only the ability to make relevant decisions but rather to keep the maximum number of options open as long as possible until they can make their decision on where to go next. More specifically, experts were organizing their feet positions to be able to reach the potential next holds on both left and right paths, waiting for the information on where to go to appear. As far as possible, experts will continue to perceive and keep open multiple solutions until they choose one (earlier shown in tennis [71]). Specifically, this ability allowed those experts to avoid going backward (e.g., going back on lower holds) to re-adapt their route and continue moving upwards. In extreme environments, such as mountaineering when going a few steps backward is not always possible, anticipating the possible routes and always keeping open multiple options necessitates being creative and flexible in order to be adaptive. More than introducing variability in practice, training for extreme sports may benefit from the infusion of uncertainty in practice because uncertainty will push performers to constantly develop and maintain alternative solutions. Probably more than any regulated sport, an extreme environment requires performers to face uncertain, unexpected and potentially novel situations, and coping with those appears key for performing. In that sense, motor originality (i.e., a unique solution a performer can create) seems to be a predictor of persistent behavior [64], helping to face the unexpected. An interesting observation from Richard et al. [64] also highlights that more creative and flexible performers perceive the task as less difficult than less creative and flexible people. This is of major importance as learners are keener to explore or challenge themselves when the task reaches an optimal level of difficulty. Playing with the information–movement coupling in designing learning environments [13], specifically with how much information is available, can be a key pedagogical component to prepare learners for extreme environments.

4. Conclusions

In this narrative review, we conceptualized how, within the framework of the ecological dynamic, environments, conditions of practice and engagement would challenge the acquisition of perceptual-motor skills in extreme sports, such as climbing. In particular, skill acquisition should be investigated at the ecological scale, meaning that extreme sports practitioners should consider the coupling between performers and their environment (involving mutuality and reciprocity) in studying how they behave when facing a set of constraints in interaction. For this purpose, the eco-physical variable should be investigated and would allow tracking the behavioral dynamics to better understand emergent movement and performance variability as exploitation of degeneracy in the perceptual-motor system. We suggest that this behavioral variability could also be induced via manipulating

constraints so that multiple affordances can be functional. This allows the individual to explore available system degeneracy by harnessing self-organizing processes. The challenge for the extreme sports practitioner is how to set up variable practice and uncertainty for efficient exploration and creativity in a manner that avoids dangers and injuries. Representing or "*sampling*" uncertainty within the relative safety of indoor or dry-tooling settings may be one intervention for preparing climbers for performance in extreme environments, with respect to the constraints manipulation, the nature and level of uncertainty that they represent in the learning design. For instance, uncertainty could be promoted in teaching and induced by manipulating (i) visual information during training, such as preventing route preview or requesting climbers to switch from one route to another route, in order to find backup strategies, and (ii) haptic information during training on indoor routes, such as changing the shape, texture, size and distance between holds to hide relevant information in order to further develop perceptual attunement and calibration, i.e., to develop functional exploration and creativity.

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Article

Has Being Lost While High-Altitude Mountaineering Become Less Frequent? A Retrospective Analysis from the Swiss Alps

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Abstract: Background: High-altitude mountaineering is becoming more popular. Despite technical developments such as global positioning systems, mountaineers still lose their way. This study aimed to analyze characteristics of alpinists that lost their way while high-altitude mountaineering in Switzerland. Material and Methods: Data from the central registry of the Swiss Alpine Club between 2009 and 2020 were retrospectively analyzed. Changes in the number of cases and severity of injuries over time were examined using simple linear regression models. Descriptive analyses were performed for age, time of emergency occurrence, and factors associated with being lost. The Mann–Whitney U test assessed between-sex comparisons. Results: Of the 4596 emergency cases during the observation period, 275 cases (5.9%) were due to being lost (76.4% male). A mean of 22.9 ± 9.6 cases per year was detected. The number of cases did not change significantly over time. Similarly, this was the case for the NACA-Score (National Advisory Committee for Aeronautics Score) with the majority of mountaineers remaining uninjured (77.8%). The median age was 42 (35–54) years for the full sample and 45 (35–56) years and 40 (33–48) years for males and females, respectively. Fog or weather changes, exhaustion, and inadequate tour planning (time and darkness) were frequently documented by rescuers as perceived reasons for being lost. Regarding the time of emergency occurrence, three peaks were detected, around 10 am, 5 pm, and 8 pm. Conclusions: Our findings show that the number of emergencies due to being lost was stable during the 12-year period. Furthermore, we presented factors that might be associated with losing one's way during mountaineering. These results may form an important basis for future studies determining risk factors for being lost and the prevention of such emergencies.

Keywords: map reading; cognitive skills; alpine environment

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1. Introduction

Mountain sports activities have experienced increasing popularity, and increasing numbers of people are active in the mountains [1–3]. For high-altitude mountaineering, an annual number of 150,000 practitioners is estimated in Switzerland [4]. Apart from the well-known health benefits, the apparent risks for accidents and emergencies should not be neglected [1,2]. Falls, illnesses, lightning strikes, or becoming lost can potentially occur during these mountain sports activities [3–6].

Over the past decade, considerable progress has been made in the development of global positioning systems (GPSs), altimeters, and mobile reception. These allow the mountaineers to more easily locate their current position on the map and facilitate their arrival at a secure point, such as a cottage or a trail [7,8]. Mountaineering maps are constantly updated and of high quality, thus, facilitating tour planning. Recommendations by the Swiss Alpine Club (SAC) in combination with their maps and relatively easy adaptable concepts (performance km) allow for an adequate estimation of the duration and difficulty of a route [9–12].

Becoming lost during high-altitude mountaineering is an area of research that has received little attention. Data on the number of such emergencies over the last decade are of interest in terms of frequency and relevance. Furthermore, the characteristics of alpinists becoming lost are unknown. These data would, however, form an important basis to determine risk factors for this type of emergency. Characterizing victims of emergencies has proven to be valuable in other types of alpine emergencies, such as falls and cardiovascular events during mountain hiking as well as mountaineering [2,13–15].

Studies showed that sex might be associated with the occurrence of other types of mountain emergencies [2,13–15]. Moreover, there are indications for differences in safety behavior between men and women, with women being more risk averse than men [16]. For instance during mountain hiking, the sex ratio for non-fatal accidents was 55% female and 45% male; for fatal accidents, the female-to-male ratio was 28% and 72%, respectively [2,15]. Hence, whether sex also plays an role for being lost is of interest.

This study aimed to analyze whether the number of cases of being lost during high-altitude mountaineering has changed over the past 12 years in the Swiss Alps. Furthermore, we aimed to describe characteristics that may be associated with losing one's way.

2. Materials and Methods

2.1. Study Design

This was a 12-year retrospective study (2009–2020) based on data of the central registry of the SAC, focusing on emergencies caused by persons becoming lost during high-altitude mountaineering in the Swiss Alps. The Ethics Committee of North-western and Central Switzerland granted ethical approval for the secondary data analysis.

2.2. Population

All mountain emergencies in the Swiss Alps requiring official rescue organizations to be mobilized are documented in the central registry of the SAC. The registry contains data from the Swiss Air Rescue Service, Air Glaciers Lauterbrunnen, Air Glaciers Sanenland, Register SAC, Kantonale Walliser Rettungs organisation, Snow and Avalanche Research Institute Davos, and the cantonal police registers. A first classification according to the cause of the emergency was made by these services, which was later checked by the study authors during the analyses. Mountain emergency is a definition for all events in which mountaineers receive the help of mountain rescue services or are affected by mountain hazards [9,10,17]. This also applies to illnesses and evacuations of uninjured mountaineers. Each mountain emergency included the emergency number used to make the call, date, rescue organization, event, place, canton (federal state in Switzerland), activity, NACA-Score (National Advisory Committee for Aeronautics Score; see Table 1), nationality, date of birth, sex, place of residence, coordinates, and a short report [18,19]. The short report contained information about the circumstances and perceived reasons of the emergency from the rescuers' perspective. The term 'blocked' was defined as being no longer able to move forward or backward. Data were available for the period from 2009 to 2020. For the present study, all cases due to being lost were of interest.

Table 1. Description of NACA-Score (National Advisory Committee for Aeronautics Score) [18,19].

NACA 0	No injury or disease.
NACA I	Minor disturbance. No medical intervention is required (e.g., slight abrasion).
NACA II	Slight to moderate disturbance. Outpatient medical investigation but usually no emergency medical measures necessary (e.g., fracture of a finger bone, moderate cuts, dehydration).
NACA III	Moderate to severe but not life-threatening disorder. Stationary treatment required, often emergency medical measures on the site (e.g., femur fracture, milder stroke, smoke inhalation).
NACA IV	Serious incident where rapid development into a life-threatening condition cannot be excluded. In the majority of cases, emergency medical care is required (e.g., vertebral injury with neurological deficit, severe asthma attack, drug poisoning).

Table 1. *Cont.*

NACA V	Acute danger (e.g., third grade skull or brain trauma or severe heart attack).
NACA VI	Respiratory and or cardiac arrest.
NACA VII	Death.

2.3. Statistical Analyses

Data in text and tables are presented as median (IQR), mean ± SD, or absolute and relative frequencies. A normal distribution of the data was verified graphically using quantile–quantile plots. The direction of the alpinist at the time of the emergency was categorized as 'descent', 'ascent', or, if this information was not available from the short reports, as 'unknown'. Similarly, the consequences of being lost were categorized as 'blocked', 'losing general orientation', or 'unknown' if this information could not be extracted from the short reports. To analyze potential differences between sexes, the Mann–Whitney U test was used. Changes in the number of cases and NACA-Score over the observation period were examined using simple linear regression models. Statistical significance for the two-sided tests was set to 0.05. All statistical analyses were performed in R version 4.0.3 [20].

3. Results

Out of a total of 4687 cases of emergencies during the observational period, 275 cases (5.9%) of alpinists that were lost were identified, of which 210 (76.4%) were male. The median age of those that became lost was 42 (35–54) years. Male alpinists were significantly older than females (median [IQR]: 45 (35–56) years vs. 40 (33–48) years; $p < 0.01$). Ninety-two (33.5%) were from Switzerland, 41 from Germany (14.9%), 18 from Italy (6.5%), 18 from Austria (6.5%), and 15 from France (5.5%). Furthermore, 16 were from the Netherlands (5.8%), 15 from Great Britain (5.8%), 11 from Czech Republic (4%), 11 from Poland (4%), 10 from Spain (3.6%), and 8 cases from Belgium (2.9%). The remaining individuals were from Denmark, India, Slovakia, Canada, Portugal, Japan, Hungary, the Soviet Union, and the USA (7.2%).

Figure 1 shows the distribution of cases during the observational period stratified by month, with an apparent peak during the two summer months of July and August. This distribution was similar for males and females.

On average, 22.9 ± 9.6 cases per year were detected in the full sample. When stratified by sex, 17.5 ± 7.3 cases per year were documented in males and 5.4 ± 3.4 cases per year in females. A simple linear regression of the full sample showed no significant change of the number of cases over the observational period, estimate (SE) = 0.4 (0.8) injuries per year; $p = 0.652$. Likewise, this was the case when analyzing males and females separately, estimate (SE) = −0.03 (0.6); $p = 0.958$ and estimate (SE) = 0.4 (0.3); $p = 0.140$, respectively.

The median NACA-Score was 0 (0–0) in both males and females (full sample 0 (0–0)), not significantly differing between sexes ($p = 0.099$). No fatal injuries were identified among the 257 cases. See Table 2 for more details on the distribution of the severity of injuries. The mean NACA-Score did not change over the observational period, estimate (SE) = −0.01 (0.02); $p = 0.666$. This was also the case for males and females, with estimate (SE) = −0.03 (0.03), $p = 0.352$, and estimate (SE) = 0.04 (0.03), $p = 0.200$, respectively.

Table 2. Distribution of injury severity quantified by NACA-Score in the full sample and by sex.

NACA-Score	Total (n = 275)	Males (n = 210)	Females (n = 65)
0—no injury	214 (77.8)	165 (78.6)	49 (75.4)
I	47 (17.1)	35 (16.7)	12 (18.5)
II	8 (2.9)	5 (2.4)	3 (4.6)
III	5 (1.8)	4 (1.9)	1 (1.5)
IV	1 (0.4)	1 (0.5)	0 (0)
V to VII—death	0 (0)	0 (0)	0 (0)

Note: Data are presented as absolute frequencies with relative frequencies in brackets. A higher NACA-Score indicates a more severe injury. Abbreviations: NACA-Score. National Advisory Committee for Aeronautics Score.

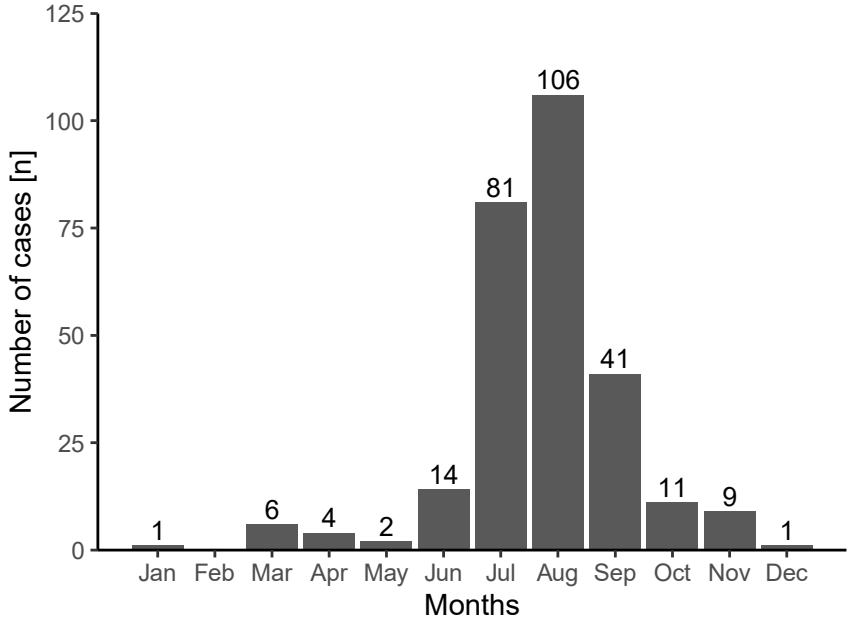

Figure 1. Number of cases due to being lost in the observational period (2009–2020) by month. Color coding: grey, male; black, female.

Figure 2 illustrates the group size at the time of the emergency. Of mountaineers who lost their way, there were a greater number in the category of couple compared to the category of individual or group.

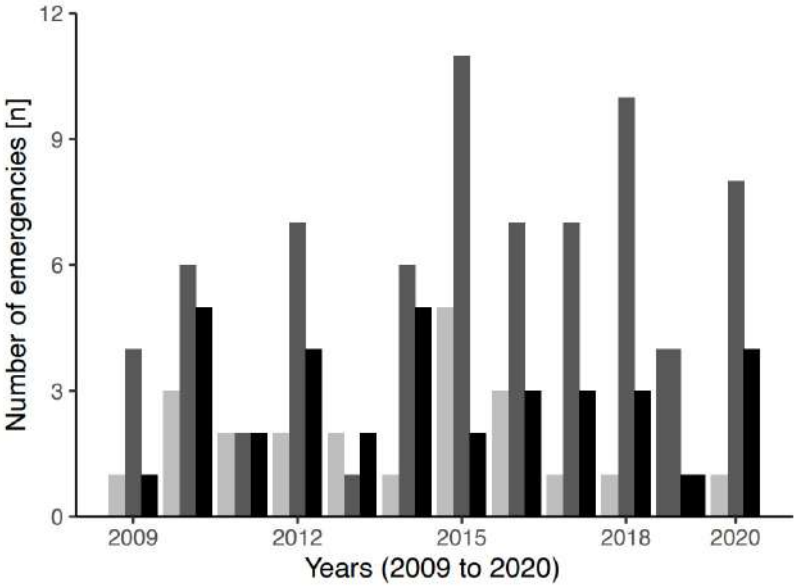

Figure 2. Number of emergencies due to alpinists being lost over the observational period (2009–2020) stratified by group size. Color coding: light grey, solo; grey, as a couple; black, in a group of three or more.

Perceived reasons by the rescuer for being lost are summarized in Table 3.

Table 3. Perceived reasons and associated factors with being lost that were extracted from emergency reports stratified by sex. The topic is in italic.

Variables	Total (n = 257)	Males (n = 195)	Females (n = 62)
Environmental factors †			
Fog	53 (20.6)	42 (21.5)	11 (17.7)
Weather change	47 (18.3)	38 (19.5)	9 (14.5)
Tour planning †			
Darkness	17 (6.6)	14 (7.2)	3 (4.8)
Time	23 (8.9)	17 (8.7)	6 (9.7)
Pathless terrain	17 (6.6)	11 (5.6)	6 (9.7)
Direction			
Descent	61 (23.7)	50 (25.6)	11 (11.7)
Ascent	25 (9.7)	18 (9.2)	7 (11.3)
Unknown	171 (66.5)	127 (65.1)	44 (71.0)
Subjective reasons †			
Exhaustion	22 (8.6)	18 (9.2)	4 (6.4)
Anxiety	2 (0.8)	2 (1.0)	0 (0.0)
Consequences			
Blocked	80 (31.1)	54 (27.7)	26 (41.9)
Loosing general orientation	110 (42.8)	88 (45.1)	22 (35.5)
Unknown	67 (26.1)	53 (27.2)	14 (22.6)

Note: Data are presented as absolute frequencies with relative frequencies in brackets. ǂ Multiple answers were possible. The term 'blocked' implies being no longer able to move forward or backward.

Finally, a distribution of the time of the emergency is displayed in Figure 3.

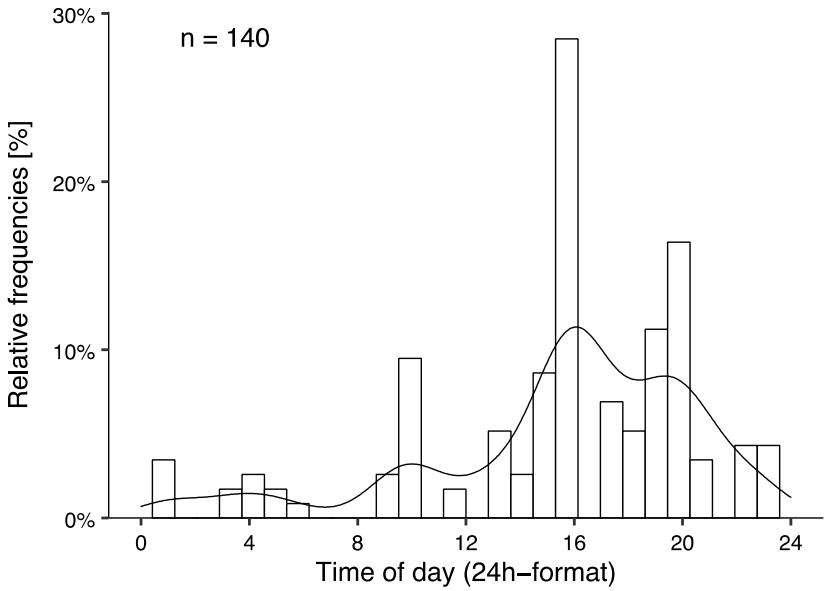

Figure 3. Histograms illustrating the time of the emergency.

4. Discussion

The major findings of the present study are that around two-thirds of the victims were from countries associated with the alpine region, the majority of alpinists that were lost were male (76.4%) and around 45 years of age, injuries were quite rare, and the number of cases was stable over the past 12 years, whereby environmental factors (i.e., fog and weather changes) and descending from the mountain seem to be associated with losing one's way. Furthermore, emergencies peaked in the morning, afternoon as well as in the evening (Figure 3). The proportion of emergencies due to being lost in the high mountains was relatively low, considering that they only accounted for 5.9% of all mountaineering emergencies in the observational period in Switzerland. Around 45% of all mountain

emergencies can be attributed to falls in the same data set (data not shown). Nevertheless, the objective should be to reduce the number of emergencies to a greater extent.

Considering that high-altitude mountaineering is mainly practiced in summer [21], it is not surprising that around two-thirds of all cases occurred in July and August (Figure 1) [21]. In addition to the high number of active alpinists in these months, meteorological aspects may play a role. Mean precipitation was previously shown to peak in July and August in the Swiss Alps [21,22]. This corresponds to the data from the emergency reports with 20.6% of the victims mentioning fog and 18.3% weather change. Thus, meteorological aspects may contribute to the majority of cases seen in summer and early autumn [22].

The number of alpinists that lost their way remained stable between 2009 and 2020. In addition, the number of SAC members during the respective time, which may be used as a proxy of mountaineering activity, increased by around 4% per year [3,4,6]. This indicates that the number of cases may have even decreased. A potential explanation could be the technological progress with global positioning systems, altimeters, meteorological services as well as cell phone reception which improve orientation on the mountains.

Likewise, the severity of injuries did not change over the observational period. The median NACA-Score was 0, indicating that cases of being lost are usually not accompanied by injuries. Accordingly, one could argue that such emergencies only yield a considerable economic burden. Searching for a missing person in the mountains can lead to rescue actions lasting for hours or even days, whereby rescue organizations need to rely on helicopters and actions can even be dangerous for the rescuers themselves. Thus, despite the low percentage of emergencies due to being lost, it seems important to minimize their occurrence.

Most alpinists who lost their way while mountaineering were a couple of two, followed by groups of three or more, and seldom a person mountaineering alone. Yet, it is not possible to imply causation from the available results. Nevertheless, the main causes of losing one's way may in the core is a lack of map-reading skills and simply failing to gather or interpret weather information [9,10,17,23–26]. Thus, being accompanied by at least one person with sufficient map reading skills would potentially be enough to prevent becoming lost. However, map reading is a special skill that needs to be constantly practiced in order to have a sufficient skill level [23–26]. Thus, being skilled at map reading may be more important than group size. A relevant factor that may have biased this finding is experience. Solo mountaineers could be generally more experienced than others [23–26].

Information on the circumstances of the emergencies could form a basis for the development of prevention strategies and act as a starting point for future research. Being blocked was more frequently reported in females (41.9% vs. 27.7%) and a general loss of orientation more often in males (45.1% vs. 35.5%). Both situations may be avoided primarily by adequate tour planning and map reading. Additionally, for being blocked, technical skills (i.e., climbing skills) may come into play.

Environmental factors (i.e., fog and weather change) seem to be central elements associated with being lost. Thus, we recommend inquiring about current weather information prior to every trip. Moreover, it is advisable to keep an eye on the weather during the tour and act in a timely manner.

The descent was more often identified as the situation in which alpinists lost their way than the ascent. In a study on fall-related emergencies in mountain hikers, Faulhaber et al. [15] suggested that general fatigue may be a contributing factor. This may also be the case for losing one's way, since 8.6% of cases reported exhaustion, even though the underlying mechanisms may differ. The close relationship between exhaustion/fatigue and cognition may affect map reading, predisposing alpinists to losing their way [23–26]. Nonetheless, this needs to be clarified in the future.

Chronometric data for this type of emergency during mountaineering are currently lacking. Studies on rock-climbing injuries reported that injuries most frequently occurred between noon and the early afternoon, i.e., 5 p.m. [27,28]. This is partly in line with the present data. Yet, there were additional peaks in cases in the morning around 10 a.m.

and in the evening around 8 p.m. Since exhaustion seems to be an unlikely explanation, environmental factors, especially fog, seem more reasonable. Furthermore, underestimating the planned tour in terms of duration and difficulty may play a role by leading to time pressure and increasing darkness. This is supported by the data of the emergency reports but needs to be confirmed by future research that directly surveys the victims.

This study had several limitations. Firstly, the total number of active mountaineers in the Swiss Alps is unknown and difficult to estimate. The number of emergencies can therefore only be provided in absolute values. Applicable estimates of the number of active mountaineers in Switzerland would be important for future research. Secondly, as previously mentioned, studies using data from official emergency registries usually do not include emergencies that do not involve professional rescue organizations [2]. Thus, the actual number of emergencies was likely underestimated. Thirdly, the emergency reports presented did not contain standardized information. The utility thus varies greatly between cases. We recommend extending the routinely collected data by information about mountaineering experience, physical fitness, and general health status. Surveying the victims that lost their way would further enhance the quality of data. Fourthly, the factor of 'experience' might be highly relevant in the context of being lost. Knowing the terrain, being skilled at map reading, and being aware of potential weather changes might be beneficial for preventing being lost.

5. Conclusions

Based on the present data, we conclude that being lost in the Swiss Alps is relatively rare compared to other causes of mountain emergencies. The number of emergencies due to being lost has remained low and stable within the past 12 years despite potentially more alpinists being active over the observational period. This might be due to the technological advancement of electronic devices making orienteering easier. Alpinists are most of the time uninjured, but being lost is nonetheless associated with potentially long and expensive rescue operations. In particular, meteorological aspects (i.e., fog and weather change) and inadequate tour planning might be associated with losing one's way. The findings of the present study may form an important basis for future studies determining risk factors for losing one's way and the prevention of such emergencies.

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Review

Feeling and Thinking about It Are Two Different Things: How to Capture Momentary Emotions of Extreme Sports in the Field

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Abstract: To learn about extreme sports and what motivates such activities, we need to understand the emotions embedded in the experience itself. However, how we go about assessing these emotions might provide us with very different answers. An experience is a fleeting and ever-changing phenomenon, rich in detail and filled with nuances. What we remember and, therefore, what we are able to report from our experience might, however, be strikingly different to what we experienced. Our memories are grained by time, impaired by arousal, and affected by context. Despite these limitations, the most common way to measure an experience is by self reporting. The current paper reviews some of the relevant theory on emotions and how this might impact different assessments. I also describe a new way of measuring momentary emotions in the field by use of video cameras and automatic coding of facially expressed emotions. Extreme sports may leave us with positive memories but may be anything but pleasant while in the midst of them. In the end, this paper may give some hints to why.

Keywords: emotions; facial recorded emotions; extreme sport; face reader; self-report

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1. Introduction

He is scared. Even the baggy clothes cannot hide his shivering while he takes the last microscopic step and places his toes on the very edge of the cliff. Between his toes and the bottom of the valley is a whole lot of nothing, 1003 meters of nothing, to be exact. The weather is perfect. No wind, just sun and an exceptionally pleasant temperature. We could have spent this perfect day relaxing on the beach. Instead, we are here, far from most of the stuff that matters in a normal life. "Are you ready to jump?" One of the experienced BASE jumpers looks at the owner of the toes, as unaffected as if he just asked him to step on board a bus. The owner nods. I look down into the viewfinder of my camera, making sure that I get everything on film. As the owner takes a last deep breath, one word keeps on bouncing around in my mind: why?

A range of studies describe a multitude of motives for taking part in extreme sport [1–8]. Some of the divergence may be due to the challenges of defining what extreme sport really is, and what types of activity sort under the extreme sport umbrella [9,10]. However, at its core, humans tend to repeat what makes them feel better and avoid what makes them feel worse [11]; in the midst of it, however, such experiences seem to be everything but pleasant [5,6,8]. What is it with these experiences that makes them so captivating that they lead people to repeat them over and over again? In an attempt to understand, we need to explore the emotional experience during such activities and track how these experiences are transformed into positive memories. In earlier studies on backcountry riders [6] and mountain bikers [8], we measured participants facially expressed emotions from moment-to-moment and compared the results to the participants' self-reported emotions. The results from these studies show that there is an apparent shift within the momentary measures between when the participants are in the midst of their activity and when they pause. There is also a major difference between moment-to-moment facially expressed emotions

and retrospective self-reported emotions obtained immediately after the activity is over. Given the variation within a single extreme sport episode such as a BASE jump, what you measure, how you measure and when you measure will provide different results.

In this paper, I will describe in more detail how facially expressed emotions can be used to measure momentary emotions in the lab and in the field. I will also address some challenges with this method and ordinary self reporting. Efforts to measure the emotional quality during and after the event might help explain how such intense experiences turn into pleasant memories that motivate the participants to repeat the endeavor. To understand this, we need to start with a short review of emotions, their functions and how they may change over the course of an extreme sport episode.

1.1. Emotion as a Motive for Taking Part in Extreme Sport

In the first half of the 1900s, voluntary risk-taking was seen as evidence of pathology [12,13]. Later, extreme sport athletes have been portrayed as egocentric risk-seeking individuals, and scholars have provided different theoretical explanations to the apparent abnormality in partaking in extreme sport, including: sensation seeking [14,15], psychoanalysis [16], type T personality [17], reversal theory [18], and edge work [19]. For a review, see Brymer and Mackenzie [20]. However, as noted by Milovanovic [21], many of the traditional explanations are simplistic and based on a naïve non-participant point of view.

The extreme sport participants themselves describe their effort to hone their skills and minimize risk [22]. Storry [23] noted that the focus on risk and thrill misses the point entirely.

Recent studies, in contrast, describe growth-oriented motives such as mastery, peak experiences, transcendence and flow, wherein the participants are able to acquire increasing levels of mastery and skills in activities that produce often otherwise-inaccessible feelings of joy and elation [1,4–6,8,24–27]. Such experiences do not exist in a vacuum but rather constitute a dynamic interplay between the athletes and the environment, their behavior and psychological expressions [28], and affected by their personal and social identities [29]. However, at its core is the emotional experience itself.

Measuring these emotions is not an easy task. There exists a wide range of measures, from simple self-reports, sampling immediate or reconstructed experiences, to complex physiological measures of bodily processes and behavior. These measures assess different components of an emotional experience at different times, and will therefore often produce different results. Before I describe some of these methods, we need to review some of the important facets of emotions.

1.2. What Is an Emotion?

Feelings and emotions are not the same. As reviewed in Vittersø [30], feelings are both broader and narrower than emotions. They are broader in the sense that as long as we are conscious, we always feel something. This general feeling state reflects what it is like to have a subjective experience, such as eating a banana or seeing a red tomato, but these feelings need not be emotional [31]. However, feelings are also narrower than emotions, because they are just one among several components of an emotion. In addition to subjective experience, emotions consist of components such as physiological processes, bodily expressions, and action readiness [32]. In this paper, I will use feelings as a description of the subjective experience of an emotion, while emotions will be used as a description of the coherent package of emotional components, where feelings are one component.

There are two major and competing classifications of emotions: the dimensional approach and the discrete or basic emotions approach [33,34]. From a dimensional point of view, a few broad dimensions such as pleasure and arousal are the fundamental building blocks of emotions. Emotions can further be comprised into two broad categories of positive and negative affect [35–37]. From a basic emotions point of view, there exists a handful of discrete emotions, which are fundamentally different from one another. These

are seen as innate and hard-wired and cannot be divided further into elements that are not emotions [38,39].

Emotions have functions, and according to Oatley [38], each of these basic emotions activates a predefined set of cognitive "checklists" and primes us for a set of actions. The feeling of fear, evoked from a threatening situation, will set up our cognitive system to confront the danger. As for the physiological component of emotions, our body will be set in a fight or flight mode with increasing heart rate and blood pressure. The behavioral expressive component will produce facial expressions of fear and our vocal pitch and body posture will change [40–42]. The action readiness component will terminate all ongoing activity, and we will focus solely on the source of danger, while we prepare for and execute appropriate counter action.

1.2.1. Two Levels of Emotional Experience

There are two types or levels of emotional experience: a continuous and sometimes unconscious stream of raw feelings (first level) and an accompanying reflective cognitive overlay (second level). The continuous flow of raw feelings typically includes feelings and desires, many of which include physiological components and felt action urges. The reflective cognitive overlay includes conscious thoughts, appraisals of emotional states, or the environment. Although raw feelings and reflective cognition might be identical, they often diverge. What determines the balance between them is, as Nilsen and Kaszniak [43] put it, how much one is "in the grip" of emotion.

Putting experiences into words demands a level of cognitive reflection [44]. If people are totally immersed, they will be unable to report their emotions. When they regain the ability to report, their self-reported emotions will, consequently, be a mix between raw feelings and reflective cognition, leaving the pure raw feelings beyond reach.

Such unconscious emotions can be powerful enough to affect behavior without people ever becoming consciously aware of it happening [45]. However, a lack of access to these first-level emotional experiences might lead people to infer what they feel based on self-observation, much like an outside observer [46]. Indeed, split-brain patients have reported second-order emotional awareness without any first-order emotional experiences ever occurring [47]. Wiens [48] proposes a hypothetical model wherein second-level awareness is based on either first-level emotional experiences or actual or illusory perceptions of physiological changes.

A slightly different view on the distinction between moment-to-moment and overall emotions is presented in the functional wellbeing approach (FWA [49,50]). The FWA argues that momentary emotions are generated by the step-by-step execution of small acts that lead towards the goal. As such, overall emotions arise as an evaluation of goal accomplishment for the whole event. If the goal is successfully reached, this will evoke emotions such as pleasure or satisfaction. If the goal is not achieved, this will lead to negative emotions such as sadness or anger. Therefore, when we assess people's emotions (e.g., during or after an activity) may fundamentally impact the result we receive. A difficult activity could, for example, be reported as interesting or even frustrating while in the midst of it, but if the task is successfully accomplished, happiness is likely reported in retrospect. Similar findings are also described in the field of exercise psychology, wherein pleasure declines during exercise followed by a positive rebound that exceeds the baseline after the activity is over [11]. This is in line with the results from several of our previous studies where we found that there is little correlation between the moment-to-moment measures of facially expressed emotions and the retrospective self-reported emotions [6,8]. We even find the same pattern within the activity itself where backcountry skiers [6] do not express any happiness while skiing but display increasing levels of happiness as soon as they start to slow down (as an example of this shift, see the film from the analysis of backcountry skiing participants [51].

In an ongoing mixed-method study of ski flyers, the participants describe the shift from being fully immersed and also experiencing high levels of fear at the start of their jump

to happiness towards the end of flight and after landing. We find the same pattern in a case study reported in this paper from one of the jumpers wearing a face-fronting camera [52]. The optimal or dysfunctional impact of such emotions on athletes' performance depends not only on the emotional content but also on their intensity [53]. This leads us to another set of inherent challenges in extreme sport, namely the high levels of high arousal and its impact on the ability to report one's emotions.

1.2.2. Arousal

The common understanding of high arousal is to be wide awake, excited, vigorous, and alert. To be unaroused means to be relaxed, sleepy or tired [54,55]. The level of arousal may be measured in a variety of ways, from cortical activity such as EEG measures to autonomic measures such as skin conductance (SC) and heart rate (HR) [55]. Although there is evidence that arousal consists of a range of separate arousal systems, McGaugh [56] has shown how separate arousal systems serve the same function, which is to moderate the resources available for information processing [54].

On the one hand, high arousal at encoding facilitates both detection and encoding for long-term retrieval. On the other hand, it may also lead to an inability to retrieve information for a short period of time, up to 30 min, after the original experience [54]. For example, in their well-known article, Kleinsmith and Kaplan [57] found that arousing words were better remembered after one week than they had been two minutes after learning. This is in line with research on stress hormones, in which high arousal has been shown to increase the ability to retrieve information in the long run [58].

High arousal has also been shown to cause an increasing number of false memories [59]. Given the effect arousal has on immediate retrieval, self-reported emotions may be severely biased if administered immediately after an extreme sport experience (for further arguments, see [59]. However, a delayed report of emotional states creates yet another set of problems, namely what we are able to remember.

1.2.3. Memory

Our memory is a far-from-perfect representation of the actual event, and this is also true for our remembered emotions. The more time between the experience and the report of it, the greater the chance for errors or biases. Robinson and Clore [60] argue that people prefer to use the most specific source of information when reporting their emotions. They suggest that people access at least four types of knowledge to assess their emotion. Ranging from most to least specific, they are: experiential knowledge, episodic memory, situation-specific belief, and identity-related belief.

Experiential knowledge is the direct access of current emotions. This information can neither be stored nor retrieved. However, through episodic memory, people can attempt to retrieve specific moments or contextual details from the past. Although past emotional experiences cannot be re-experienced, they can often be reconstructed, aided by such memory cues.

Situation-specific beliefs are people's belief that certain emotions are likely to be experienced in a particular type of situation. For instance, most of us believe that vacations are associated with happiness and the death of a loved one with sadness. Finally, identity-related beliefs are the beliefs people hold onto their emotional experiences in general, such as their emotional traits, but also normative social beliefs. One of the most prominent beliefs is a gender stereotype in which people believe that women are more emotional than men. Indeed, in retrospective reports, women report higher levels of emotion than men [61,62]. However, these differences seem to disappear when measured as the activity unfolds [60]. All of these four sources give potentially different information about the individual's emotional experiences. This shows how sensitive self-reports and questionnaires can be (see also [61]), depending on the kind of information being accessed.

2. Some Challenges with Measuring Emotional Experiences

2.1. Self-Reports

When I planned the study on BASE jumpers, I had no tool for measuring momentary emotions. I eventually ended up with a design inspired by experience sampling [62] and day reconstruction [63]. To sample the BASE jumpers' experiences, I asked the jumpers to fill out a questionnaire immediately after landing. However, high levels of arousal are shown to impair participants' reporting [54]. I therefore wanted to reconstruct the experience in a low-arousal setting. To aid their recall of the experience in a low-arousal setting, I showed them a film of their jump the following day, captured with their own helmet camera, before they filled out the same questionnaire. The analysis returned high correlations for emotions such as pleasure, engagement, and anger—but no correlation for fear. Interestingly, the participants reported low levels of fear immediately after the jump and also the day after—but their recorded heart rate told a different story. With almost no exceptions, the jumpers were close to their theoretical maximum heart rate before the jump. They had then been sitting still or performing only modest activity at the exit point for at least half an hour. One of the explanations for this lack of correlation may be found in the way we assess their emotional experiences.

Overall vs. Moment-to-Moment Self-Reports

Ordinary self-reporting measures are not designed to capture the intensity and variation experienced in activities such as BASE jumping. Our results show that standing on the top of the mountain before a jump is a highly unpleasant experience. During the jump, pleasure varies extensively, and after landing, the jumpers often report extreme levels of pleasure. Fear has a similar but inverse pattern. Therefore, asking the jumpers to rate the jump on a single-item Likert-like scale will only return a meaningless average for the duration of the experience. We found a similar pattern in a recent study of elite ski-jumpers [52]. To capture the experience of BASE jumping, we therefore tested out a new measure [5].

This instrument enables the participants to provide a retrospective moment-to-moment report from the episode. As shown in Figure 1, the *y*-axis shows the intensity of the emotions, and the *x*-axis is the timeline of the episode. The result is a schematic emotion report that gives the researcher the opportunity to make comparisons at different stages during the jump. We named it the Feelometer and extracted the following five measures: (1) height of starting point, (2) number of peaks, (3) height of end point, (4) height of highest point, and (5) height of lowest point.

Such a graphical representation of the emotional experience allows the participants almost unrestricted possibilities when reporting their emotions. Although this captures more of the variety in an emotional experience, it poses great challenges when it comes to operationalizing and analyzing such data. In a later study on backcountry skiers, we therefore transformed this measure into seven questions, asking them to report their level of happiness, interest, and fear at seven different stages of the descent, from the top until after they stopped [6]. For a review on the challenges and risk in backcountry skiing, see [64,65].

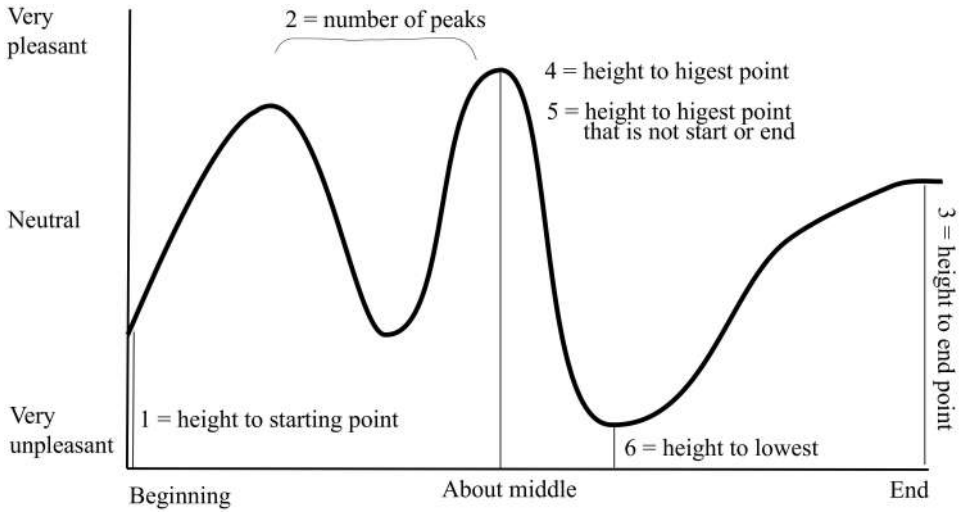

Figure 1. The Feelometer shows the six measuring points extracted in the study on BASE jumpers [5]. The *x*-axis represents the jump from before exit until after landing. The *y*-axis represents the magnitude of pleasure or interest, ranging from very unpleasant/uninteresting to very pleasant/interesting. Compressed example of the Feelometer used in the questionnaire, with the size of the *x*-axis being 11.5 cm and the size of the *y*-axis being 6.5 cm.

3. How to Capture Momentary Emotions

Despite this complexity, one of the most common ways to measure emotions is by use of ordinary self-reports, or random repeated measures such as the experience sampling method (ESM) wherein people are cued—at random times—to report a current experience. Although most researchers recognize that such reports are prone to error, the ease of administering such measures still makes them the most frequently used measure of emotions and mental states. In addition to the inherent errors of self reports, several studies have demonstrated that cognitively reflecting over an experience might change the way people feel about them altogether [46]. The effect is similar to what is called re-appraisal, which is a well-known tactic to improve people's experiences of negative events [66] but creates a challenge for researchers that aim to sample the emotional experience as it was experienced in the moment. Given these challenges, is there a way to tap into the flow of momentary and sometimes unconscious feelings without them being affected by the effort of measuring them?

Kahneman and Riis [67] have argued that, given that they are properly validated, physiological measures such as the EEG, heart rate, or skin conductance level would give an uninterrupted report of momentary emotions. However, at least in the case of action sport, which inherently involves physical activity, the activity itself will create a considerable amount of noise, rendering it impossible to disentangle the effect of psychological activity expressed physiologically from the mere physical activity itself. There are also issues of translating these measures into what they really mean in terms of experienced emotions, particularly in situations with ambiguity in bodily responses (e.g., misattribution of arousal, e.g., [68].

Functional MR studies are delivering exciting results, and they are able to pinpoint activity in brain areas associated with different emotional reactions. However, these measures are both costly, time-consuming and restricted to experiences that can be produced inside a three-foot-wide steel tube.

3.1. Facially-Expressed Emotions

Another way to measure momentary emotions is by observation and analyses of facial expressions. As the behavioral expressive component of emotions, facial expressions are (A) universal (however, there is evidence that suggests that people from East Asia express and interpret facial expression slightly differently compared to Western Caucasians, see, for

example [68], and reliable indicators of discrete emotions which (B) co-vary with subjective experiences and (C) are a part of a coherent package of emotional responses that includes appraisals, physiological reactions, and other nonverbal behaviors and subsequent actions [69]. There is solid support for at least six universal facial expressions communicating happiness, fear, sadness, disgust, anger, and surprise [41]. However, new studies suggest that as many as seven additional positive emotions are associated with distinctive expressive displays. These emotions are: happiness, amusement, awe, contentment, interest, joy, love, and pride [70,71].

To perform a reliable measure of facial expressions, Ekman and Friesen [72] developed the facial action coding system (FACS), which is a way of directly measuring movements of the facial muscles. FACS consists of 46 action units, each representing an independent motion of the face, which in turn is combined into different facial expressions. A smile, for example, is characterized by an upward turn of the corners of the lips, which is produced by contraction of the zygomaticus major muscle [72] and described in the FACS system as the activation of the cheek raiser with action unit six (AU6) and lip corner puller (AU12). Sadness, on the other hand, is characterized by raised inner brows (AU1), lowered brow (AU4) and depressed lip corners (AU15). Facially expressed interest is characterized by activation of AU1 (inner brow raiser) and AU4 (brow lowerer) and also partially AU24 (lip pressor). Interestingly, the facial expression of interest as described by [71] bears no resemblance with happiness but a strong similarity with facially expressed sadness. In the past, the analysis of facial expression had to be performed manually. However, with advances in technology, this analysis can now be carried out with the help of software.

Automatic Coding of Facial Expressions

Automatic facial coding (AFC) has several advantages and a few disadvantages compared to manual coding. First and foremost, automatic coding demands very little labor. Recent advances in automatic coding of facial expressions have made this method more reliable and ubiquitous [73]. The software Facereader produsedby Noldus, Wageningen, Netherlandes, used for AFC either applies a direct FACS coding of facial movement or categorizes them into emotions. One major question is, of course, the validity and reliability of such tools. In other words: how well does the software actually measure what it is intended to measure? Lewinski and his colleagues [74] describe the validity and reliability of AFC based on (1) principle of computer algorithms, (2) psychological theories and (3) recognition studies. In software designed for scientific investigation, AFC build on psychological theories of human facial expression of emotions. These computer algorithms code facial expression after a given set of rules, which is applied to every image of a facial expression. Given large datasets of facial expression across ages, gender and ethnicities, such algorithms do not have any personal biases about gender, culture, or age. These algorithms are not prone to confirmation biases and are thereby truly blind to the condition.

FaceReader, which is the AFC application applied in the studies described in this paper, builds on Ekman's [41] theory of universal facial expressions. FaceReader originally coded facial expression into categories of human emotion, but from version 6.0, FaceReader added functionality to code 24 different action units. In a reliability study, [74] tested FaceReader (version 6.0) against two publicly available and previously annotated datasets of human facial expressions: the Warsaw Set of Emotional Facial Expression (WSEFEP; 51) and the Amsterdam Dynamic Facial Expression Set (ADFES; 52).

For facial expressions, FaceReader recognized 88% of the target emotions. The human emotion recognition for the same datasets was 85%. In the FACS analysis, FaceReader labeled the correct action units at 69% of the analyzed images. To receive a FACS certificate, a human coder must reach an agreement on 70%. Previous reliability studies testing the recognition of facial expressions of FaceReader version 1.0 have reported an accuracy of 89%. Similar results have been reported in other studies [75,76].

On the downside, the methods for coding facial expression are still being developed and refined, particularly by distinguishing different displays of positive emotions (see, for

example, [71]). It takes time and effort before enough pre-coded material is available to update a computer model. In addition, humans are able to code head movements and body postures, which the software currently is unable to read. Therefore, happiness is still the only positive emotion included in the automatic analyses of facial expressions. In a study on mountain bikers, we tried to tease out facially expressed interest, but the results were inconclusive [8]. A major issue, though, is that the algorithms are trained on static images as also often applies for emotion recognition research in human participants, e.g., [32,75]. However, our emotions unfold over time [76].

Still, the advantages in most cases outweigh the cost, making this method increasingly popular, as seen in studies within the science of emotion [77,78], educational research [79,80], human–computer interaction [81], consumer behavior, user experience [82], clinical investigations of facial nerve grading in medicine [83], monitoring pain [81] and advertising and commercial films [84,85].

The rapid development of camera technology that has taken place in the past ten years is nothing less than a small revolution. These days, most of us is carrying a camera in our pocket with a quality that could produce a Hollywood movie [86]. Web cameras have improved in quality, and the development of small action cameras has made it possible to film from angles that were previously impossible—for example, capturing facially expressed emotions during an activity.

After testing the automatic facial coding technology in a study on tourists and their reaction to tourist commercial films, I realized that this might be the tool with which to capture emotions during a high-arousal activity [6]. Together with my colleagues, I developed a rig where we could mount a face-fronting action camera that could be carried during backcountry skiing.

However, mounting anything in front of the face in high-energy activities is dangerous, and the potential for serious harm to the participants should not be taken lightly. After months of testing, we eventually came up with the rig shown in Figure 2. Mounted this way, the camera will swing either up or sideways—away from the participant's face—in case of a fall. If the camera is forced down towards the face, it will detach and fall off. We also added another camera capturing the participant's point of view to be able to see the activity from their perspective. This made coding of the activity much easier. We have conducted several experiments with this rig, including a sample of backcountry skiers, mountain bikers, and ski jumpers [6,8,53].

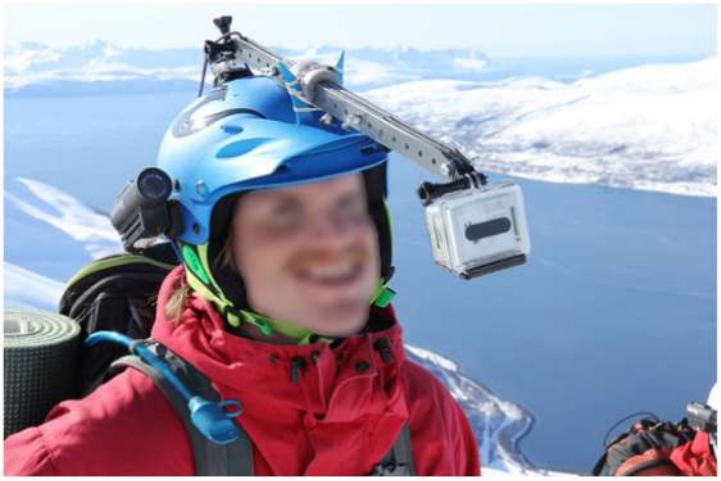

Figure 2. GoPro camera mounted on a ski helmet. This camera will capture the participant's facial expressions during the activity. Most participants reported that they quickly habituated and paid little attention to the camera while skiing. Written informed consent has been obtained from the participant for the publication of this image.

4. How Are Momentary Feelings Transformed into Pleasant Memories?

In his seminal book from 1879, An Introduction to the Principles of Morals and Legislation, Bentham [87] described a method for calculating the value of pleasure and pain. This has come to be known as the hedonimeter. Bentham further articulated the doctrine of ethical hedonism, which claims that pleasure is the only good and pain the only bad. Hence, human goodness is simply the accumulation of pleasant moments. Bentham further argued that the value of pleasure could potentially be measured according to its intensity and duration. This idea was further developed by Kahneman, who argued that this might be solved by the use of ecologically valid self-reports in combination with sophisticated methods such as the assessment of physiological indicators of hedonic states [88]. According to the logic of hedonism, this procedure offers data that are unaffected by memory and evaluation biases and should grant insights into the participants' momentary emotions, or what Kahnemann called "true" feelings, or objective happiness [88].

Although Kahneman supported the idea that feelings can be measured moment-by-moment, he never argued that adding these momentary feelings were equivalent to the mental image that we store in memory representing this experience. Rather, he introduced a distinction between momentary feelings (the experiencing self) and memories of that experience (the remembering self).

Two factors seem important when emotional episodes evolve from experiences to memories. The first is emotional states at key points such as the beginnings, endings, and during emotional peaks or troughs [67,76,89]. The second reflects the slope or emotional development over time—for example, if happiness is increasing or decreasing [90,91]—and the rate of change—how fast things are improving or deteriorating [92,93]. Features such as the duration of the experience have been found to have little or no impact on the retrospective evaluations [94]. Following this logic, the memory of an experience should be predicted on the basis of how it started and ended, as well as its peaks, troughs, and/or emotional trajectory during the experience.

Although numerous studies verify the impact of these key moments, some factors might moderate or eliminate the effect. First, people might have many similar experiences to the one studied, and thus have experienced more intense peaks in a time before the study or experience several peaks with nearly similar intensity within the study and, as such, render the measured peaks as less important [84,91]. Second, the extreme effect of peaks fades more rapidly over time, causing the peaks to be recalled less intensely [95] and thus flattening the emotional profile.

In addition, the study of how such defining features affect the overall evaluation of entire events has focused mainly on single episodes with a defined beginning and end. Ariely and Zauberman [96] have demonstrated that if a single episode is broken down into different subparts, the impact of improving trends, or slopes on overall evaluations, is significantly reduced.

Momentary: Facially-Recorded Emotions vs. Overall Self-Reported Emotions

In our studies on backcountry skiers and downhill bikers, we found a large discrepancy between momentary and retrospective emotional experiences [6,8]. In a recent mixed-model study on elite ski-jumpers [53], we found that the participants described a somewhat similar overall emotional profile in qualitative interviews and retrospective self reports. However, there is also a discrepancy between the qualitative interviews and quantitative measures and the self-reported emotions and moment-to-moment facially expressed emotions.

One difference between the self-reported and facially expressed emotions is the lack of happiness during the ski jump. The participant describes and reports feeling joy during flight, but facially expressed happiness only surfaces after landing. Interestingly, when we asked the participants to report their expected emotional experiences, they all—presumably based on experiences from the past—described that they expected the jump to be more joyful and less fearful than they reported the actual jump to be immediately after. It thus seems that the closer we get to the actual jump, the less happiness or joy we find.

In the early phases of the jump, the participants describe and report feeling a mix of fear, excitement, and being completely immersed. There is currently no facial expression for excitement or interest built into the FACS system, even though Campos and colleagues [71] have described it along with several other facially expressed positive emotions. Instead, the corresponding moment-to-moment measures returned large sections that the AFC labeled disgust, and also sadness, in addition to the expected fear. These readings might be explained by taking a closer look at the instrument itself and some inherent challenges in capturing facially expressed emotions in the field.

5. Limitations and Future Research

The method of filming and analyzing facially expressed emotions in the field described in this study opens up new possibilities for uninterrupted measures of emotions during experiences. However, the method is not without shortcomings. The technology was developed to work in a controlled laboratory setting and a shift in light conditions may impact the quality of the reading. To obtain a good reading of facially expressed emotions, the participants can not wear any eye protection. This might be a challenge in some activities such as backcountry skiing. The camera also needs to be mounted in the participant's field of vision. Even though the participants say they quickly habituated and did not pay much attention to the camera, great care needs to be taken in order to produce a setup in which the camera will not come lose and harm the participant. This should not be taken lightly.

Measuring emotions is a challenging task regardless of the method. According to Hannais and Ekkekakis [54], as much as 80–85% of the self-generated emotion labels are not included in the various standardized emotion scales. For automatic analysis of facially expressed emotions, the list of emotions to read is even shorter. In addition, there might be challenges in the coding of facial expressed emotions itself.

Potential Error in Coding of Facially Expressed Emotion

In the study of BASE jumpers, one of the interesting findings was that the participants reported no sadness at all [5]. However, when we recorded the facial expressed emotions to a sample of tourists while they watched tourist commercial films, they displayed more sadness than happiness [85]. Among backcountry skiers, we found sadness to be the second most prominent emotion after happiness.

A possible explanation may lie in the action units that are the building blocks in FACS. Interest and sadness share two action units; raised inner brows (AU1) and lowered brows (AU4). Interest also activates compressed lips (AU 24), whereas sadness is characterized further with depressed lip corners (AU15) instead of compressed lips.

In a physically strenuous activity such as backcountry skiing, the participants, more often than not, breathe through their mouth and not their nose. An open mouth is incompatible with compressed lips and maybe also with depressed lip corners. This leaves little difference between a sad and an interested facial expression. We therefore speculated that the relatively high levels of facially expressed sadness may partly be mislabeled interest. This would mirror the predictions from the Functional Wellbeing Approach. However, in a follow up study in which we applied the same method on a sample of mountain bikers, we did not find the same high levels of sadness [8].

So, why is interest not one of the basic emotions described by Ekman? The answer is coincidence more than anything else. In an interesting paper, Ellsworth [97], who, at the time of the development of the FACS system, worked alongside Ekman and Friisen, describes how they needed pre-coded pictures to develop the tools to test if facially expressed emotions were universal. They were working towards a deadline for the journey to New Guinea and the first of what should be followed by a large series of replication studies. They simply ran out of time and had to go with what they had. For some emotions, they were only an image short. Interest was definitely on the list, and Caroll Izard [98], who was carrying out cross-cultural studies at the time, found support for several additional emotions, including interest. So, an image short in the late 1960s, 60 years later, unfortu-

nately, leaves us shorthanded when it comes to capturing more of the moment-to-moment dynamics in intense emotional experiences in extreme sport.

Future research should validate the findings with low levels of happiness during intense activities such as extreme sport and also applying different methods for capturing and comparing emotions during and after an activity.

6. Conclusions

So, how was it? It much depends on when and how you ask. Intense experiences are probably not as pleasant or joyful in the midst of it as you remember. However, the memory of such events can be a shining beacon guiding our path into the future. To fully understand the experience, we need to know not just to know how it was, but how it is. The current paper discusses some challenges with measuring emotions in extreme sport in the field and also presents a recently developed method where the participants facially expressed emotions can be captured with a camera and analyzed in post. This method provides a glimpse into how extreme-sport activities are experienced in the midst of it. When compared to emotional assessments in post, this may be able to explain why many extreme-sport participants report happiness to be among the key motivations for taking part, even though they apparently do not express much happiness during the activity itself.

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Institutional Review Board Statement: In this paper, I refer to previous studies where I have used different methods to capture momentary emotions in different extreme-sport activities. All participants were adult and provided their informed consent. All the studies also had ethical approval from the Norwegian Centre for Research Data. Please refer to the individual studies for more detail.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the studies. Please refer to the published studies cited in this paper for more detail.

Data Availability Statement: This article elaborates on previous published studies. Please refer to the original studies.

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Article

Rescue Emergencies Due to High-Altitude Illnesses Are Rare in Switzerland

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Abstract: Background: Despite a potential high risk of acute mountain sickness (AMS) in the Swiss Alps, there is a lack of analyses concerning its relevance over longer periods. In consequence, the aim of this study is to analyze the prevalence of AMS in comparison to other causes of mountain emergencies in recent years in Switzerland. Material and Methods: Based on the central registry of mountain emergencies of the Swiss Alpine Club (SAC), all cases in the period between 2009 and 2020 were analyzed for AMS including the most severe forms of high-altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE). Emergencies were assessed for the severity of the event with a National Advisory Committee for Aeronautics (NACA) score. Results: From a total of 4596 high-altitude mountaineering emergencies identified in the observational period, a total number of 352 cases of illnesses were detected. Detailed analysis revealed 85 cases of AMS, 5 cases of HAPE, and 1 case of HACE. The average altitude was 3845 ± 540 m. Most cases were in the canton of Valais, especially in the Monte Rosa region and the mountains of the Mischabel group (Täschhorn, Dom, Südlenz, Nadelhorn, Hohberghorn). There were only three deaths related to high-altitude illnesses; all the other events could be identified as moderate to severe but not life-threatening. Discussion: An emergency due to AMS that requires rescue is unlikely in the Swiss Alps. This does not imply that AMS is not a concern. However, the facts that the maximal altitude is relatively low and that fast self-descents often seem possible probably minimize the likelihood that mountaineers with symptoms contact emergency services.

Keywords: high-altitude pulmonary edema (HAPE); high-altitude cerebral edema (HACE); high-altitude accidents

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1. Introduction

Switzerland is well known for its beautiful mountains. The high alps in the south-eastern and western parts reach up to 4500 m. The Mischabel and Monte Rosa areas are particularly well known for their high mountains. In addition to famous peaks such as Dufourspitze (4634 m), Täschhorn (4491 m), Dom (4545 m), and Matterhorn (4448 m), Switzerland has many smaller peaks with altitudes between 3000 and 4000 m. Switzerland also has many cabins located between 2500 and 3500 m [1,2]. Since an estimated 150,000 people are active in the Swiss Alps in high-altitude mountaineering each year, numerous alpinists there should be at risk of developing the severest forms of high-altitude sickness including high-altitude cerebral edema (HACE) and high-altitude pulmonary edema (HAPE) [1–5]. In principle, people who do not live at high altitude and rapidly ascend to altitudes above 2500 m may develop one or more unpleasant symptoms such as headache, anorexia, and insomnia [3,6]. If several of these symptoms, which may progressively include vomiting and severe headache, are present, the syndrome is defined as acute mountain sickness (AMS), and physical examination of these patients may also disclose tachypnoea, pulmonary rales, and periorbital or peripheral oedema [3]. Data on the incidence and prevalence of these syndromes have been reported for trekkers in

Nepal [7,8], Indian soldiers [9], and in places in North America [10–12]. Furthermore, an encompassing analysis exists of the prevalence of acute mountain sickness in the Eastern Alps, which detected an overall prevalence rate of 16.2% for AMS, while the prevalence of AMS increased significantly with altitude (2200 m: 6.9%; 2500 m: 9.1%; 2800 m: 17.4%; 3500 m: 38.0%) [13]. Maggiorini and colleagues directly questioned alpinists in SAC huts and examined them clinically [3]. Three of the four huts were in the Bernese Alps: the Konkordiahütte (at 2850 m), the Finsteraarhornhütte (at 3050 m) and the Mönchsjochhütte (at 3650 m). The hut at the highest altitude was the Capanna Margherita (at 4559 m) in the Monta Rosa area in the canton Valais [3]. The general prevalence of AMS was 9% at 2850 m, 13% at 3050 m, 34% at 3650 m, and 53% at 4560 m [3]. In principle, these rates seem valid based on general experience, and the clinical examinations were properly performed. Newer estimations find a normal incidence rate of 0.1 to 15% one to two days after arriving at high altitude depending on factors such as maximum altitude, ascent rate, physical exhaustion, individual susceptibility, and coexisting cardiopulmonary diseases [13–15]. Based on the potentially high prevalence, a lot of research has been conducted on pathophysiology in Switzerland, especially in the Monte Rosa region, and preventive measures were developed [16–19]. Although the Alps are visited each year by millions of tourists and there are approximately 350,000 overnight stays in the huts belonging to the SAC, the likelihood of developing AMS seems low compared to the likelihood of other mountain emergencies [1,2]. However, there is little available information about actual prevalence rates or how often emergency services must deal with AMS. This study aims to answer the following questions: What is the likelihood of requiring professional emergency services for high-altitude sickness in the Swiss Alps? How do the results compare to requiring professional emergency services for other mountain emergencies and how has this changed in recent years?

2. Material and Methods

2.1. Analyzed Population

All emergency cases related to high-altitude mountaineering in the SAC central registry from 2009 to 2021 were analyzed. The central registry contains data from the Swiss Air Rescue Service (REGA), Air Glaciers Lauterbrunnen, Air Glaciers Sanenland, the Register SAC, the Kantonale Walliser Rettungsorganisation (KWRO), the Snow and Avalanche Research Institute Davos, and the cantonal police registries. The term mountain emergency covers all events where mountaineers require the help of mountain rescue services or are affected by subjective and objective mountain hazards [20,21]. This also applies to illnesses and evacuations of uninjured mountaineers. Each mountain emergency includes the emergency number used, date, rescue organization, event, place, canton, activity, National Advisory Committee for Aeronautics (NACA) score (Table 1), nationality, birth date, sex, place of residence, coordinates, and a case report [22,23]. The case reports were analyzed to determine the occurrence of AMS, HAPE, and HACE. To help identify cases, the subjective version of the Lake Louise score was used (headache plus one additional symptom such as gastrointestinal symptoms, fatigue, weakness, dizziness, lightheadedness [6]). It has to be mentioned that, by definition, at least moderate headache and one of the additional symptoms are necessary to reach the score level of three necessary for diagnosis. However, a sort of uncertainty remains as sometimes only headache was reported but not the severity level. Study analyses were performed in line with the Declaration of Helsinki and its later amendments. Confirmation and a waiver concerning secondary data analysis were received from the local ethics commission.

Table 1. National Advisory Committee for Aeronautics (NACA) Score [24,25].

NACA 0	No injury or disease.
NACA I	Minor disturbance. No medical intervention is required. e.g., slight abrasion.
NACA II	Slight to moderate disturbance. Outpatient medical investigation, but usually no emergency medical measures necessary. e.g., fracture of a finger bone, moderate cuts, dehydration.
NACA III	Moderate to severe but not life-threatening disorder. Stationary treatment required, often emergency medical measures on the site. e.g., femur fracture, milder stroke, smoke inhalation.
NACA IV	Serious incident where rapid development into a life-threatening condition can not be excluded. In the majority of cases, emergency medical care is required. e.g., vertebral injury with neurological deficit, severe asthma attack; drug poisoning.
NACA V	Acute danger. e.g., third grade skull or brain trauma, severe heart attack.
NACA VI	Respiratory and or cardiac arrest
NACA VII	Death

2.2. Data Preparation

In a first step, the causes of mountain emergencies were classified into the following categories: falls, being stuck (unable to go further or back), illness, lightning, crevasse accidents, avalanches, stone falls, ice falls (serac), being lost, material failure, and other. This classification was originally developed by the SAC to enable comparisons of all the disciplines of mountaineering, such as hiking, backcountry skiing, climbing, and classic mountaineering. The classification scheme was unique, meaning that multiple classifications were not allowed. This was followed by a detailed data analysis for the missing entries. Since missing data for fewer than 5% of the entries hardly affected the validity of statements (for example, fewer than 5% of entries were missing values for age), an easily applicable substitution method (mean-value imputation) could be used for further statistical analyses [24,25].

2.3. Statistical Analyses

Descriptive statistics were calculated per calendar year for age and NACA scores for the subclass of illnesses. As the hypothesis of normal distributions of the two variables age and NACA score could not be rejected with the Jarque–Bera test, two-sided heteroscedastic t-tests were performed to detect potential sex differences [26,27]. To analyze changes over the observation period, linear regressions of the degree of determination (R^2) were calculated. Calculations were made with Microsoft Excel (Microsoft Inc., Redmond, WA, USA) and SPSS (Armonk, New York, NY, USA).

3. Results

First, a rough analyses revealed 4596 cases in the observational period of 2009–2020; 1028 (22.4%) were female and 3568 (77.6%) were male. There were 1951 (42.4%) cases of being stuck (not able to go further or back), 1348 (29.3%) cases of falls, 352 (7.7%) cases of illnesses, 275 cases of being lost (6%), 266 (5.8%) with stone falls, 162 (3.5%) cases involving crevasse accidents 162 (3.5%), 45 (1%) cases involving avalanches, and in 197 cases (4.3%), the cause was not defined or had an uncommon cause such as lightning or rope-related incidences. A slight increase in cases with time was identified (number of cases = 0.839 × time + 23.9, R^2 = 0.168). All cases of illnesses were then analyzed in detail. Analyses of the case reports were performed with the help of Lake Louise scores. This analysis showed that 92 of the 352 illness cases (26.6%) had AMS, HAPE, or HACE. Of these cases, 25 (27.1%) were female and 67 (72.8%) were male. Concerning the remaining approximately 260 cases with an illness, diverse reasons were identified, including eye problems due to sunlight (snow blindness), muscle cramps, allergic reactions, hypoglycemia

in persistent diabetes, abdominal cramps, asthma, circulatory problems, heart problems, discus hernias, syncope, food poisoning, dehydration, vomiting, and renal colic.

From the case reports, only five cases exhibited clear signs of HAPE, and only one showed clear signs of HACE. Overall, the average age of female alpinists with AMS, HAPE, or HACE was 44.2 ± 12.2 years, and that of male alpinists was 43.1 ± 12.9 years. No statistical difference was detected (p = 0.765). Thirty cases were individuals from Switzerland (2 with HAPE), 15 were from Germany (1 with HAPE, 1 with HACE), 9 from Italy, 7 from Great Britain (1 with HAPE), 6 from France, 4 from Slovakia, 2 from Poland, 2 from Austria, and one individual from each of the following countries: Ireland, Canada, Hungary, Russia, the Czech Republic, the Netherlands, Greece, Latvia, Spain, Slovenia, and China (1 with HAPE). The three fatal cases were from Switzerland, Latvia, and Slovakia.

The average altitude at which victims were rescued was 3845 ± 540 m, and the average NACA score was 1.82 ± 1.59 (Figure 1). For female alpinists, the average NACA score was 1.72 ± 1.25; for males, it was 1.86 ± 1.72. No significant difference was detected (p = 0.686). Concerning location, four main areas could be identified: Monte Rosa (Valais), Mischabel (Valais), Jungfrau (Bern), and Bernina (Grisons) (Figure 2).

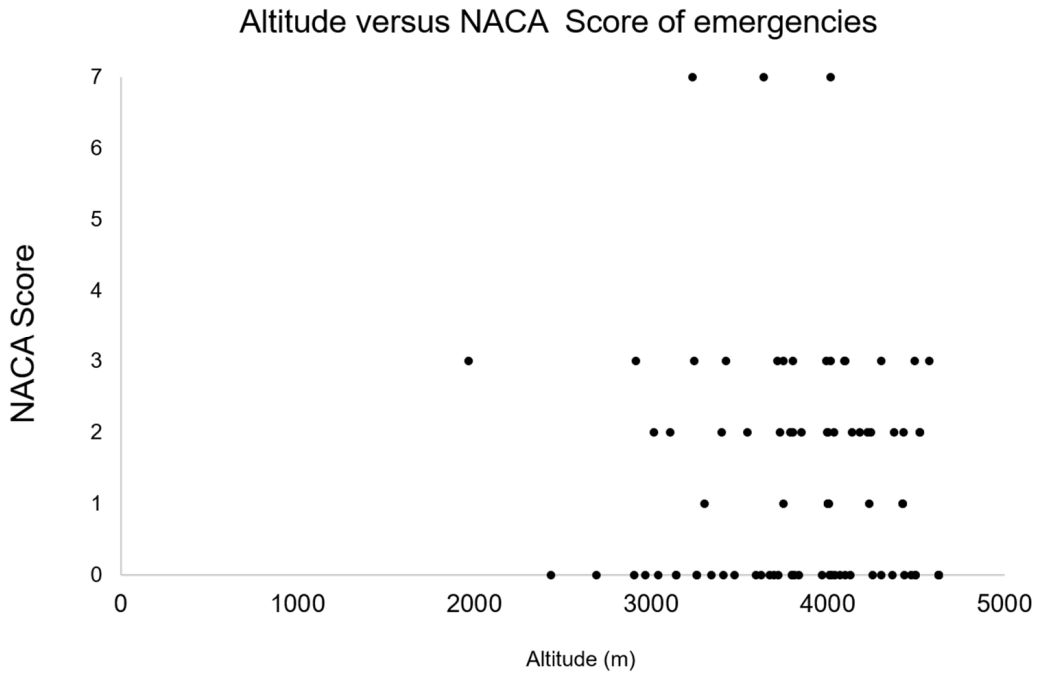

Figure 1. Distribution of altitudes of the events (x-axis) and NACA scores (y-axis). Mean NACA score was 1.82 ± 1.59, and mean altitude was 3845 ± 540 m. Only three deaths were found (NACA score = 7); for all other events, NACA score was 3 or less.

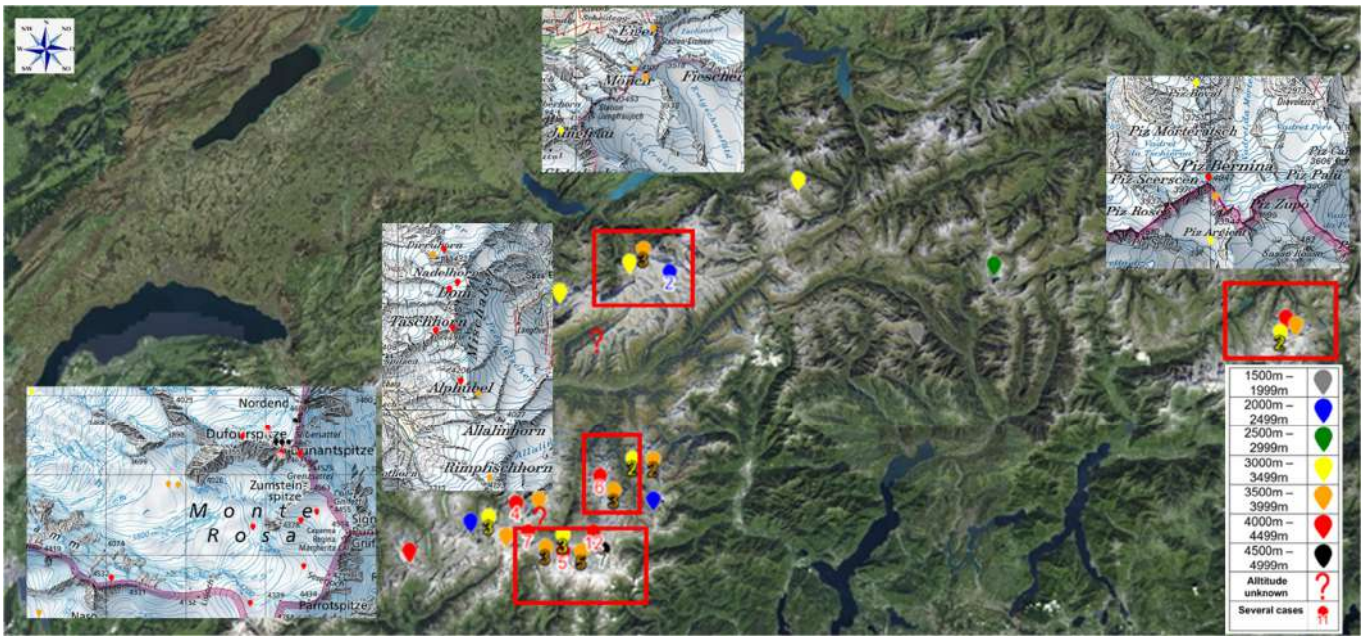

Figure 2. A map of Switzerland with locations of the cases (color-coded dots show the altitude of the event with the number of events if several). Four central regions could be identified: in the Bernese alps in the Jungfrau area, in the eastern part of the Bernina area, in the Mischabel area and in the Monte Rosa region.

4. Discussion

The aim of this study was to assess the prevalence of specific altitude illnesses in mountaineers rescued in the Swiss Alps. Some factors limit the probability of developing AMS in the Alps. First, the emergency system is well established and fast rescue is often possible. Second, alpinists usually do not develop severe forms of AMS and can go down by themselves to moderate altitudes since the distances are normally relatively short. Compared to the Himalayas and the Andes, it is often possible to return from high-altitude terrain very fast, maybe even with the help of a cable car. Third, the altitude is relatively low compared to the Himalayas or Andes, so in the highest areas, the partial oxygen pressure is still only reduced to approximately fifty percent compared to sea level [16–19,28,29]. Nevertheless, the SAC central registry was analyzed from 2009 to 2020. Illnesses were less common than other causes in the central registry, such as falls or being stuck. Approximately one-quarter of subjects affected by an illness had AMS, HAPE or HACE. This was approximately 2% of all registered cases in the sample. The mean NACA score was below 2, which indicates a moderate to severe but not life-threatening case. AMS was mainly found in the Valais mountains, especially in the Monte Rosa massif and the mountains of the Mischabel group (Täschhorn, Dom, Südlenz, Nadelhorn, Hohberghorn). In relation to the entire observational period (2009–2020), the mortality rate was low, with only 3 deaths in 12 years. In comparison, the mountain emergency statistics for the last 5 years show an average mortality rate of approximately 21.8 deaths per year while high-altitude mountaineering [30]. According to the report, they all had a severe form of AMS according to Lake Louise score. The low mortality rate would underpin the claim that AMS is a rare event in the Swiss Alps. Except for the three deaths, all the other cases had a NACA score of 3 or less (Figure 1). Focusing on further aspects, Maggiorini et al. (1990) and Hackett et al. (1976) found that AMS was evenly distributed among both sexes, which is in line with the findings here. More men (70.9%) were affected compared to woman. However, the share is more or less the same as from the total analysis (78.1%). A priori AMS seems a rare phenomenon in the Swiss Alps, especially when one considers the claim of the SAC that 150,000 alpinists are active each year in Switzerland at high altitude, which

yields a prevalence of only 0.048% (less than one case per 10,000) [2,30,31]. Several reasons for a low prevalence requiring emergency treatment can be identified. This analysis only included cases that resulted in a response by emergency services such as Air Glacier or REGA. Cases of self-assignment, for example, to an emergency department or a General Practitioner were thus not captured in the statistics. Additionally, many mountaineers affected with signs or symptoms of AMS probably simply started to descend on their own.

Although they were beginning to show signs of AMS, even some cases with signs of HAPE or HACE, they are not recorded in the statistics. Descents of this manner are often easily possible in the Swiss Alps, as the distances to moderate altitude are often short. In addition, there are often transport options such as cable cars for returning to lower altitude levels at a high speed. A further limitation was the accuracy of the case reports, since emergency services were probably happy to have successfully performed a rescue and were not focused on commenting on the cases in detail. To summarize, emergencies due to AMS, HACE or HAPE exist but are rare in the Swiss Alps.

5. Conclusions

Emergencies due to AMS, HACE or HAPE exist in the Swiss Alps, but they should be considered rare events. Most cases were detected in the Valais in the Monte Rosa region (Castor, Pollux, Lyskamm, Signalkuppe, Parrotspitze, Zumsteinspitze, and Dufourspitze) or in the Mischabel group (Täschhorn, Dom, Südlenz, Nadelhorn, and Hoberghorn). There are several reasons for the low prevalence requiring emergency treatment of AMS, such as the relatively low maximum height of the Alps (compared to the Himalayas or the Andes). Furthermore, it is often possible to reach high-altitude areas with the help of a cable car, for example, so quick descent is also possible, which is definitely less common in the Andes or the Himalayas. AMS can occur within 24 h of ascent, particularly with rapid ascent and/or exertion [6]. Lake Louise scoring criteria suggests 6 h as a minimum exposure duration before measurement but acknowledges that symptoms can occur prior to this [6]. Yet, most forms are mild, perhaps because many peaks are often quickly reached (within 24 h) and can be completed in one day, so a severe form of AMS cannot develop.

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Exploration of Psychological Resilience during a 25-Day Endurance Challenge in an Extreme Environment

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Abstract: Psychological resilience is the ability to use personal qualities to withstand pressure, consisting of the interaction between the individual and the environment over time. It is essential when operating in extreme environments which are typically characterised by a complex combination of stressors with increased elements of risk and adversity. Psychological resilience has never been investigated "live" (e.g., in the moment) throughout the duration of an extreme endurance challenge, despite anecdotal accounts of the need for resilience to successfully function in such environments. The aim of the study was to explore psychological resilience with challenge team members (n = 4, mean age = 46.0 years) involved in a 25-day extreme endurance challenge. The object of the challenge was to 'TAB' (Tactical Advance to Battle, fast marching with weighted packs) 100 peaks in the UK in 25 days and complete long-distance bike rides between base camps. A mixed-methods approach with a focus on qualitative methods was utilised. Specifically, individual reflective video diaries (n = 47) and focus groups (n = 4) were completed and analysed using interpretative phenomenological analysis (IPA). At the same time, the 10-item Connor Davidson Resilience Scale was employed to measure resilience, which highlighted the individualised and dynamic nature of resilience. Two superordinate themes were identified from the video diaries and focus groups, namely, the identification of the stressors within extreme environments and strategies to maintain functioning. Stressors were split into subordinate themes of significant and every day, and collectively, they created a cluster effect which contributed to pressure associated with operating in these environments. Challenge team members employed various strategies to maintain functioning, including using a challenge mindset to positively appraise pressure as a challenging learning experience. Further research should continue to develop an understanding of how participants completing challenges within extreme environments utilise and develop personal qualities to maintain functioning.

Keywords: endurance; extreme environments; mixed methods; resilience; stressors

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1. Introduction

The understanding of psychological resilience is inhibited due to theoretical and definitional difficulties [1] and remains an elusive concept in sport psychology [2]. Psychological resilience is complex [3], and conceptually, has been identified as a trait, process, or outcome to an adverse experience (for an in-depth review, see [4,5]). Historically, resilience has been defined as a trait which is a constellation of personal qualities that protect individuals from the potential negative effect of stressors [6]. These protective factors help individuals to withstand the pressure of the environments they are operating in [7]. However, this trait conceptualisation is outdated [5] because it does not take the environment, and how this interacts with the individual, into account [8], so scholars have suggested that resilience is a process [9] that is different within individuals and is more than just a fixed quality [10] and is, in fact, dynamic in nature [11]. Resilience has also been highlighted as context-specific [12], whereby individuals can show resilience in one environment but not

another [10], and resilience changes over time [13] where individuals can show resilience at certain times but not others [13]. Resilience can cascade through time and is influenced by multiple processes across different systems [12]. Therefore, this process can be viewed as a "resilience bandwidth" [14], where individuals develop resilience over time based on their personality, environment, and the interaction between the two. This combined trait and process conceptualisation of resilience makes resilience an interactive concept between the individual and environment over time [10,13]. In line with this perspective, psychological resilience is defined here as "the role of mental processes and behaviour in promoting personal assets and protecting an individual from the potential negative effect of stressors" [15] (p. 675).

A grounded theory of psychological resilience in sport [15] was devised by interviewing twelve Olympic champions from different sports. This theory highlights resilience as a process and how the qualities of the individual interact and operate within the environment they are in. This grounded theory proposed psychological factors (e.g., positive personality, motivation, focus, confidence, and perceived social support) that influence how athletes appraise stressors in the environment as a challenge to influence their meta-cognitions. This process protects against possible negative effect of stressors experienced in elite competition. This protection is a result of individuals attempting to maintain homeostatic balance with internal and external stressors causing disruption at different bifurcation points [16] with the resources at their disposal. At these points, there is disruption where the individual attempts to reintegrate and re-establish balance within their homeostatic comfort zone. Recent work has highlighted this individual approach in terms of psychological flexibility in the COVID-19 global pandemic [12,17] with [18] suggesting that flexibility is the cornerstone of resilience. This flexibility increases psychological resource and is a combination of personal skills and qualities, which leads to increased resilience. Therefore, resilience is an individualised process with different people being affected by these stressors at different intensities and for different durations [13].

Consequently, the environment plays a significant role in resilience [14] pointing to the Ecology of Human Development model [19] being a suitable theoretical structure to explore the complex dynamic individualised nature of resilience. This model posits that there is interaction and influence from elements (e.g., experiences and people) within the immediate environment, but that there are also influences from other connected environments. For example, an expedition leader in an extreme environment has to contend with stressors in the environment (e.g., weather and terrain) but also stressors from other environments they are involved in (e.g., family and career). All these contribute to influence how the expedition leader will demonstrate resilience to function in the immediate environment. Additionally, The Everyday Stress Resilience Hypothesis [20] considers resilience through a systems perspective supporting the dynamic context of resilience [21]. This postulates that resilience increases from consistently experiencing stressors in different intensities and situations over time, very similar to the hay fever sufferer who takes a daily teaspoon of local honey to build inoculation to the pollen. Resilience is a result of an individual's ability to manage stress and so their capacity to cope is increased. It has been suggested that resilience can initially protect individuals against adversity and then allow for positive adaptation to occur [4]. This indicates the interaction between the individual and the environment [8], whereby the individual has to appraise the adversity they face as a challenge [14]. This relates to the to the amount of challenge and support present in the environment, and for resilience to be demonstrated, there must be an element of adversity present which is typically present in an extreme environment [6]. This makes extreme environments the ideal setting to investigate psychological resilience.

Humans can operate in a wide range of environments and are capable of functioning within the extremes of these [3]. People will identify different environments as extreme due to their perceived individual capabilities to perform within them, so any environment that pushes an individual outside of their comfort zone can be considered extreme [22]. Examples of extreme environments are extensive with research being completed in space

flight [23], expeditions in the polar regions [24,25], mountaineering expeditions [26], ocean crossings [27], and adventure/outdoor education programmes [28,29]. Therefore, extreme environments have been defined as settings that possess extraordinary physical, psychological, and interpersonal demands that require significant human adaptation for survival and performance [30].

Extreme environments are very complex and characterised by a range of intense stimuli [31], which people react differently to [23]. Examples of stressors within extreme environments are isolation, danger, risk, fatigue, sensory and social deprivation, and uncertainty [31], and therefore, they can be considered complex. Indeed, this complexity in the extreme environment of counter-terrorism operations has been explored [31]. This complexity can lead to a perceived lack of control among those immersed in them [30]. This may be in part due to a cluster effect, whereby the combination of these stressors can have a greater negative effect on performance as opposed to if individuals were exposed to individual stressors [31]. A review of the literature on working in Antarctica was completed [32] highlighting the stressors of operating in an isolated and confined environment (ICE), the consequences of living in such an environment (including anxiety and heightened friction, hostility, and conflict) and the coping strategies employed (e.g., preservation of group harmony, maintain schedules, and preparation pre-expedition). Therefore, the psychological response to these extreme environments is often the most important [3].

The contents of adventure education programmes (which are often conducted in extreme environments) typically possess similarities seen in individuals who demonstrate resilience [28]. These included perseverance, self-awareness, social support, confidence, responsibility to others, and achievement. Extreme environments encompass some form of risk and adversity that participants within them need to attend to so that they can positively adapt and show resilience [33]. The consequences of not being able to positively adapt can lead to serious injury or even death. This points to the importance of resilience in these environments [3], and to function in these environments, individuals have to demonstrate resilience [31], with numerous anecdotal accounts of the importance of resilience within extreme environments and a linguistic analysis of an individual within an Artic environment indicated that resilience might be demonstrated [34]. Despite this, research within extreme environments has mainly focused on the role of personality [26,27] and group functioning [25].

Over the past decade, psychological resilience has been investigated in sport (for reviews see [5,35]), with extensive research on resilience in athletes [36], teams [37], and coaches [38], with the majority of the studies investigating resilience using retrospective research methods [28] and single interviews at one time point [14]. However, these methods may not provide the depth of data required to adequately draw conclusions regarding the complexity of resilience due to recall bias and decay [35]. Thus, it has been suggested that resilience researchers should employ prospective and longitudinal qualitative methods to explore the process of resilience over time [5].

Surprisingly, psychological resilience has never been specifically investigated within an extreme environment, despite anecdotal accounts of the need for resilience to successfully function in such environments. Furthermore, no study has attempted to explore resilience "live" (e.g., in the moment) over time throughout an endurance challenge. Therefore, the aim of the study was to explore resilience "live" and longitudinally throughout the course of a 25-day challenge undertaken in an extreme environment.

2. Method

2.1. Research Design and Philosophical Underpinnings

A relativist ontological position was adopted for this study, as people construct reality and give meaning of specific phenomena (i.e., psychological resilience) in different ways, interpreting experiences based on their beliefs and past experiences to form their own notion of reality [39]. From an epistemological perspective, a subjective and transactional

view of knowledge [40] was utilised due to the dynamic nature of the interactions over time between individuals and their environment, with the aim of the study to understand and interpret the world from the perspective of those involved (i.e., individuals completing a challenge in an extreme environment) [39], but also because of the complex [6] and individualised notion [10] of psychological resilience. This epistemological view makes the researcher an active member and inextricably linked with the challenge and the team members influencing the data collection and analysis [41]. This is known as the researcher as instrument, whereby the characteristics of the researcher may influence participants. The lead researcher of this paper visited the challenge four times, staying overnight in the base camp and completing tasks and interacting with both the challenge and support team to build a rapport [42]. However, by visiting the challenge, the researcher became connected to the challenge team members through their interactions, which may have influenced the research [41]. Hence, researchers must undertake self-reflexivity [41] and ensure methodological congruence [40], whereby all aspects of the methods are congruent with one's philosophical standpoint.

In the present study, our interpretivist paradigm is congruent with the principles of Interpretative Phenomenological Analysis (IPA), chosen as the analysis of the qualitative data because it shows how individuals interpret their experiences based on their sense of reality over the course of the challenge [43,44]. The longitudinal nature of the study also aligns with the philosophical assumptions of IPA [45]. Longitudinal IPA has typically been used in nursing and health research [46,47], and IPA has previously been utilised in a sporting context investigating decreases in performance [36] and adventure psychology [48]. A key tenet of IPA is for the researcher to get as close to the data as possible to access the personal world of the participant taking an active role in what is a dynamic process of analysis [49], which was achieved by the lead researcher's visits. This is because the interpretation process of IPA is double hermeneutic, whereby "participants are trying to make sense of their world; the researcher is trying to make sense of the participants trying to make sense of their world" [49] (p. 51). There also needs to be an understanding of the phenomenon in question (i.e., psychological resilience over time). Thus, for triangulation purposes, a quantitative resilience measure was utilised to track individual changes in resilience over time within the challenge team.

Researching in extreme environments presents unique practical challenges when completing research within them [3,50]. Specifically, there needs to be flexibility and simplicity in the research design to account for this complexity while maintaining quality data collection [50]. Therefore, creativity is needed when designing methods within extreme environments [3]. This creativity can be achieved by using mixed methods to provide better insights [51] and a holistic view of resilience [35] within extreme environments. Although research has typically tended to use a retrospective cross-sectional design, predominantly utilising quantitative methods, a mixed methods approach was employed to study resilience in an adventure education programme [28]. Incorporating qualitative methods into research completed in extreme environments can provide a significant contribution to the study of resilience by exploring the interaction of the individual within the complexity of an extreme environment [10] by producing a richer understanding of the subjective nature of psychological resilience [35,52]. This would elicit the depth needed to conceptualise and unpick the complexity and dynamic nature of psychological resilience live and longitudinally [5,52]. Indeed [34] also utilised a mixed method approach to provide insight into the psychological changes of participants before, during, and after an activity completed in an extreme environment, while [53] used mixed methods to explore stressors within a policing environment. Consequently, the current study employed a convergent mixed method research design [51,54] with an emphasis on qualitative methods. These qualitative methods explored the individual perceptions of the process of resilience within team members during the 25-day challenge. The quantitative methods allowed resilience to be tracked over time throughout the challenge to enhance the perceived individual changes identified in the qualitative methods.

2.2. Challenge Context

The challenge investigated in this study was the 100 Peaks Challenge [55] (Permission was granted by the organiser and 100 Peaks Challenge Team to name the challenge) completed for charity to create a legacy for the organiser's younger brother, who was killed in action. The aim was to TAB (Tactical Advance to Battle), an acronym used by the British Military [56], up 100 of the highest peaks in the UK in 25 days. This is essentially fast marching with a weighted pack comprising essential kit (up to 30 lbs), which was deemed an extreme environment due to the significant stressors involved in completing the challenge. TAB marches are an essential component of most military training, where recruits are required to complete numerous weighted marches over various distances to simulate the pressures associated with battle scenarios [57]. Accordingly, there is a significant psychological aspect to this training [58] that has not yet been explored within the research. Alongside the TAB elements of the challenge, when the challenge team transitioned between locations, they cycled to the next base camp location which were situated in remote locations of the UK (for example, Snowdonia and Lake District National Parks), where the challenge team lived in tents, apart from the last location, which was a hotel a short distance from the last peak. At each location, a long-distance bike ride was also completed. Due to the extreme weather conditions during the challenge, some elements were either modified (e.g., TAB and bike routes adapted) or cancelled completely (e.g., Kayak across the Irish Sea to a peak on the Isle of Man) to ensure the safety of the team. During the challenge, a team of volunteers supported the challenge also living in each base camp. Furthermore, there were male and female 'partials' who completed routes with the challenge team, staying in base camp from one to several days.

2.3. Participants

In line with IPA guidelines, purposive sampling was utilised [49] to recruit a homogenous sample of 100% of the full challenge team (n = 4 total, n = 3 male, n = 1 female, mean age = 46.0 years, SD = 3.4 years). All members volunteered and had no obligation to take part signing an informed consent form before commencing the study. Due to the small challenge team, specific participant biographies have not been added to protect anonymity. The challenge team members had an average of 5.5 years (SD = 5.2) experience of completing TAB events. None of the team had completed a challenge of this magnitude before, but one was an army reservist and one was a former international cyclist. One was the organiser of the challenge. To maintain anonymity, gender neutral pseudonyms have been assigned to each participant.

2.4. Data Collection Methods

To explore psychological resilience "live" and longitudinally, multiple methods were employed in a mixed method approach with a focus on qualitative methods.

2.4.1. Video Diaries

Video diary methods have been employed in outdoor adventure education settings [59] and extreme environments [34]. Due to the flexibility this method provides [60], video diaries allowed the complex individual narratives and experiences of psychological resilience during the challenge to be explored. Participants had autonomy with regards to content and duration of each video entry. Participants were given prompts attached to their video cameras to use as a guide if required (e.g., How has the day gone? What challenges have you dealt with today? How did you manage/deal with the challenges? What personal and/or collective qualities helped you to deal with the challenges?).

2.4.2. Focus Groups

To stimulate collective team discussion around shared experiences during the challenge and explore the complexity of psychological resilience, four focus groups were employed [61]. The focus groups were completed on location in the base camps of the

challenge (e.g., under a tarpaulin at the foot of Ben Nevis in Scotland). Focus groups have been employed as a method to investigate team resilience in a team setting to produce collective conversations and capture shared experiences [62]. Focus groups were chosen to explore the collective experiences of the challenge team.

2.4.3. The 10-Item Connor-Davidson Resilience Scale (CD-RISC10)

The CD-RISC10 [63] was employed at four timepoints throughout the challenge. Psychometric evidence for the use of the CD-RISC10 to measure resilience has been provided in long-distance running [64] and cricket [65]. Psychometric evidence has also been offered in military populations [9]. Furthermore, elements of this measure have been utilised in adventure-based experiences [28]. Finally, the conceptual foundation for the measure originated in Shackleton's experience of survival [66], making it a suitable measure to use in extreme environments. The CD-RISC10 is a 10-item measure with items such as "I am able to adapt when changes occur", "Having to cope with stress can make me stronger", and "I am not easily discouraged by failure". Responses to each item are on a five-point Likert-type scale (0 = "not at all true" to 4 = "true nearly all the time") [64]. The range of the total scale is 0 to 40, with higher totals indicating higher levels of resilience.

2.5. Procedure

Following institutional ethical approval, the lead researcher met the challenge team before the challenge started to complete the first baseline CD-RISC10. All subsequent data were collected on location while the participants were completing the challenge. Each participant was given an individual video camera and charger before the challenge started to record their video diaries. The cameras became their responsibility during the challenge. Participants were asked to find a quiet location to maximise confidentiality to complete their video diaries (e.g., participants tents, campsite bathrooms, and support vehicles used in the challenge). The completed recordings were collected by the researcher at the end of the challenge.

With regards to the lead researcher's visits to the challenge, the exact days and times of these visits were organised during the challenge to minimise the impact of the research on the challenge [3]. During these visits, the focus groups were completed. The first three focus groups were recorded with members of the support team present as they doubled up as the challenge daily briefings. Additionally, the CD-RISC10 was completed by challenge team members at the same time as the focus groups and collected by the end of the visit. Finally, after each visit, reflexive notes were completed, and social media posts from the challenge and challenge team members were tracked.

2.6. Data Analysis

A total of 47 video diary entries were analysed, with each team member completing a varied number of video diary entries (Blair n = 10, Charlie n = 8, Jordan n = 12, Kendall n = 17). A total of 375 min of video footage (max length = 20:38 min and seconds, min length = 3:38 min and seconds, average length = 8:33 min and seconds, SD = 5:18 min and seconds) were collected from the challenge team video diaries. With regards to the focus groups (n = 4), a total of 97 min of data (max length = 29:50 min and seconds, min length = 17:40 min and seconds, average length = 24:40 min and seconds, SD = 6:09 min and seconds) were collected. The recording for each of the video diaries and focus groups was initially watched in its entirety to allow immersion in the data [67] and embodied transcription [68,69] was then utilised to transcribe the data. Embodied transcription is the process where the researcher is able to gain greater insights into the lived experiences of participants by speaking the contents of the video diary from the perspective of the participants into voice recognition software [69]. This made transcription an integral part of the data analysis as opposed to an initial act before interpretation [68] enhancing the ideographic aspect of the IPA process. The focus groups were transcribed verbatim.

IPA was used, as it offers a flexible analysis to identify central themes within the data [70] and differences within experiences across participants and over time to be shown [39]. After transcription, each transcript was read to get a 'feel' for the contents [49] and maintain an inductive approach [45,46]. Identification of initial themes were noted in pencil on the transcripts. Following this, each transcript was taken in turn and reread with further interpretation of the data and expansion of the initial notes into emergent themes in red pen. This was then transferred by handwriting extracts from the text and accompanying notes into a table of three columns (themes, original transcript, and exploratory comments). This process allowed further immersion into the data. The scoring of the CD-RISC10 was completed to give a resilience score for each participant at each time point. Descriptive statistics were completed at each time point to support the qualitative data to show individual changes in resilience over time. These were then presented diagrammatically to visually represent the change of resilience over time.

2.7. Methodological Rigour

Rather than universally applying rigour criteria, it has been advocated to select the most appropriate criteria [71] proposed by scholars [42,72] to ensure rigorous data that are fit for purpose for the specific research question. Specifically, to ensure rigour, the current study demonstrated prolonged engagement, persistent observation, and thick, rich description [42] of a worthy topic [72]. Rich rigour [72] was also ensured by considering the practical lessons learnt from [50] (i.e., completing a detailed planning process to ensure that the design had balance between simplicity while safeguarding the theoretical rigour of the process), and discussing the process with critical friends [71]. To ensure that the IPA analysis was of the highest possible quality, IPA research markers highlighted by [73,74] were utilised. Namely, a compelling narrative of resilience over time within the 100 Peaks was provided to emphasise experiences and factors important to the participants pertinent to understanding resilience in an extreme environment. This was done by spending time to consider and interpret the choice of words used by participants, in line with the double hermeneutic interpretation of IPA. In line with recommendations by [71], member reflections were completed with two of the challenge team to ensure philosophical coherence and rigour of the research. There are often misunderstandings around the generalisability in qualitative research because the statistical processes to achieve generalisability in quantitative research are not applicable, so different criteria need to be used for qualitative research [75]. The current study utilises naturalistic generalisability whereby the research resonates with the reader's perceptions of expe-riences they have had, allowing them to reflect on the experiences of the challenge team and make connections with their own life experiences [75]. The epistemological assumption of the research also allows transferability, which is another criterion of generalisability [75]. As knowledge is constructed by the perceptions of the individual and is so subjective in nature, the reader can identify what is similar to their own experiences that can be generalised to other contexts. To achieve this, the research has utilised rich and detailed extracts from the challenge team and provided interpretative richness to assist the reader to think about the results and how they connect with their own experiences and transferred to other contexts. Reflexivity is an important feature of qualitative research [76] and IPA [77], since the researcher needs to understand their role in relation to others and to ensure rigour in the data collection process [78]. Therefore, the lead researcher went through a process of reflexivity to become aware of how they might have influenced the experiences of the challenge team during their visits. This was to increase awareness of potential subjective preconceptions derived from their identity as a neophyte PhD researcher invited to complete the research by the lead organiser of the challenge and background in sport psychology. This process also provided a valuable perspective of the individual and longitudinal nature of psychological resilience within an extreme environment.

3. Results and Discussion

The results of the current study highlight the individualised, complex, and dynamic nature of psychological resilience within extreme environments. Specifically, two superordinate themes were identified, the identification of the stressors within extreme environments by those operating within them and how these are perceived and influence an individual's ability to maintain functioning over the duration of an ultra-endurance challenge. Furthermore, challenge team members employed various strategies to maintain functioning within the extreme environment. Taking both of these superordinate themes into account, this section will begin with an overview of the stressors in the 100 Peaks Challenge because the relationship between the individual, their interaction, and the environment cannot be researched independently [14], as there is a need to identify and understand the unique stressors within the environment (e.g., when they appear, their duration, and their frequency) when resilience is being investigated. The context in which resilience is demonstrated is important [13] because the process has context sensitivity with strategies being employed varying across individuals and environments [79]. The results from the video diaries and focus groups highlighted that the 100 Peaks environment was complex and extreme with an array of stressors with six subordinates identified (see Table 1). These stressors were split into significant and every day, which created a cluster effect [31] that influenced an individual's ability to maintain functioning in these environments. Individual changes in resilience over time were identified by the results from the CD-RISC10 (see Figure 1), suggesting that the cluster effect influenced each individual differently at different times throughout the challenge, because there is individual variability in the appraisal of the stressors in the environment [13]. The reflective accounts of the challenge team highlighted this variability and also identified the significance of when the cluster effect started and how this subsequently cascaded through the reminder of the challenge. Following this identification of stressors, an exploration of how these stressors were perceived and influenced individuals' resilience throughout the course of the 100 Peaks Challenge will be presented focusing on how team members maintained their functioning (see Table 2); three subordinate themes were identified, namely using a challenge mindset, which included accepting the environment, putting one foot in front of the other, and the use of humour. The complexity of social support and how it was used as a strategy will also be discussed alongside the influence of interpersonal differences.

Table 1. A summary of qualitative results from the video diaries and focus groups (part 1).

Identification of Stressors	
Significant Stressors	Personal Administration Errors Unpredictable Disruptive Incidents
Everyday Stressors	
Cluster Effect	
The Start of the Cluster Effect	
Different Stages and Bifurcation Points	

Table 2. A summary of the qualitative results from the video diaries and focus groups (part 2).

Exploration of Resilience	
Challenge Mindset	Acceptance Putting One Foot in From of the Other Humour
The Complexity of Social Support	
Interpersonal Differences	

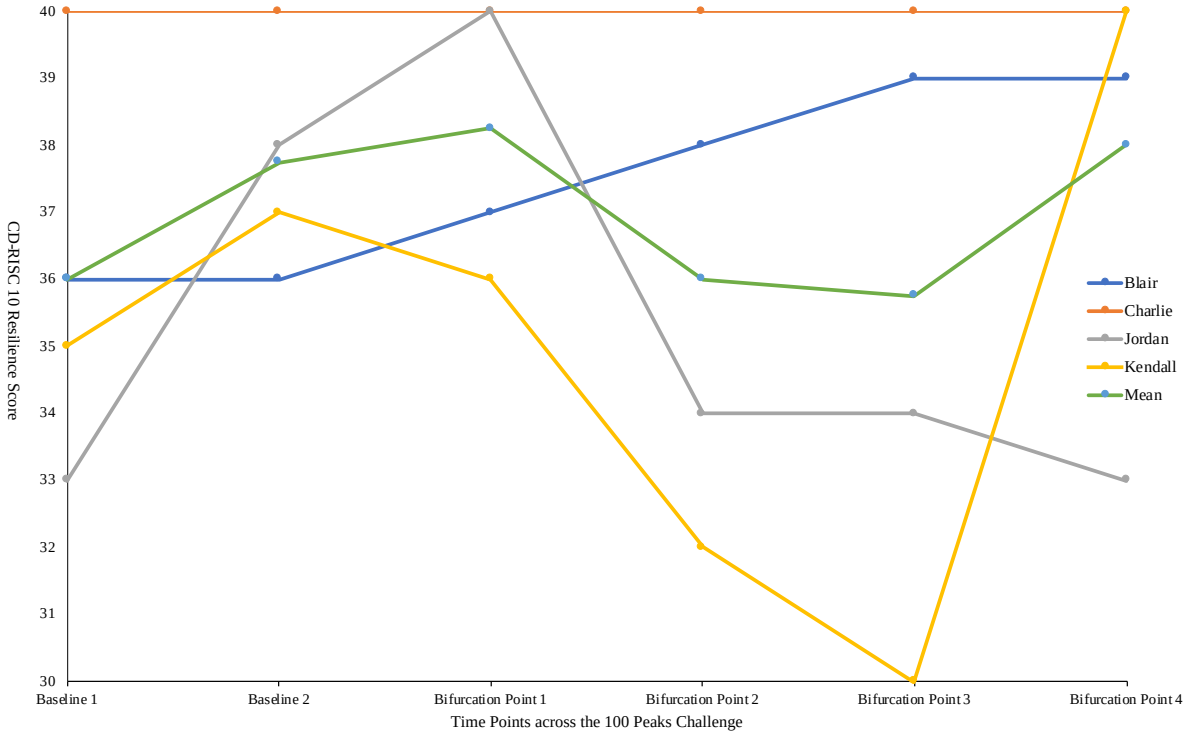

Figure 1. The individual CD-RISC10 scores of challenge team members across the time points of the 100 Peak Challenge. The time points of the challenge where the data were collected was determined by the Challenge Team, the Support Team, and the conditions at the base camps. Hence, they were not standardised. Below is some additional information to add context to these time points in the graph: Baseline 1—University in London, England. Completed 3 weeks before the challenge started. Baseline 2—Fort William, Scotland. Completed 24 h before the challenge started. Bifurcation Point 1—Fort William, Scotland. Completed on day 1 of the challenge. Bifurcation Point 2—Newton Stewart, Scotland. Completed on day 7 of the challenge. Bifurcation Point 3—Keswick, England. Completed on day 14 of the challenge. Bifurcation Point 4—Merthyr Tydfil, Wales. Completed on day 24 of the challenge.

3.1. Identification of Stressors during the Challenge

The 100 Peaks Challenge had numerous stressors and challenges that needed to be overcome. These changed depending on the location and time point within the challenge. For example, base camp 1 had high temperatures and high numbers of midges, where base camp 3 had high levels of wind and rain. Each stressor had to be perceived by the challenge team members individually [23] so that they could adapt to the stressor and maintain functioning. Therefore, the amount of time this took was different in all team members. This could account for the variation in the CD-RISC10 scores recorded during the challenge.

The stressors identified during the challenge were split into significant stressors and everyday stressors. Significant stressors were further split into personal administration errors (e.g., getting lost while on the mountain, wrong kit/nutrition strategies) and unpredictable disruptive incidents [15] (e.g., becoming ill, bike crashes, transition between base camps). Personal administration errors typically affected the participants more than unpredictable disruptive incidents, which were accepted as part of completing the challenge in an extreme environment. These stressors had serious consequences for the challenge team, as each member needed time to perceive and then comprehend each of these stressors to initiate appropriate strategies to maintain functioning. Unpredictable disruptive incidents were events that were out of the control of the challenge team. Furthermore, stressors either had a direct or indirect effect on challenge team members [80], as it became apparent that the interpretation of stressors by others and their subsequent response/actions to them had complex and varied consequences impacting the rest of the challenge team. During the challenge, this actually became another stressor affecting the day-to-day ability to complete

daily tasks. Although part of the challenge and predicted, transitions between base camps could be considered a significant stressor because these transitions had a disruptive effect and contributed to the cluster effect (see below).

Everyday stressors were more challenge- and environment-specific. These were generally more accepted as part of being in an extreme environment and completing such a challenge. These included weather, terrain, and other aspects within the environment. Being exposed to these stressors contributed to the challenge team members' overall comfort and strategies had to be employed to maintain functioning. For example, Blair and Kendall highlighted the extremely hot conditions early in the challenge by saying:

> "Some serious terrain challenges, makes you question the choices, choices you are making. Obviously, the heat today, apparently it was the hottest place in the UK today and we certainly felt it. So, obviously, that adds some real complexity to being out on the hills."

> "It was a very hot day and a very tough day . . . the first few hills going, I could feel my quads and my calves but I expected that so I went through and we just managed through the day."

3.1.1. Cluster Effect

The results of the current study suggest the presence of a cluster effect of stressors within the extreme environment. Challenge team members had to withstand the effect of a range of stressors to ensure the challenge objective was achieved [81] and it is the clustering effect of these stressors that may have caused reduced functioning [30]. Each individual stressor chipped away at the challenge team's capacity to function where their effect compounded as they clustered together. Blair summarised this by stating:

> "Today, it's just knowing what's required in these sorts of conditions to ensure you are safe, the group, the people you are with, the team are safe, are they doing the right things . . . with the cumulative effect of what we're doing."

This cluster effect has been evidenced in other research completed in extreme environments. Individual stressors can be tolerated, but when they cluster, the potential negative impact on performance can be increased [31]. This cluster effect can be thought of by considering the metaphor used by Jordan, who suggested the extreme environment was "a bit of a pressure cooker environment; you're spending a lot of time with people that you don't know particularly well, some you know better than others" when thinking about the effect different stressors have and how they interact as well as how people perceive and deal with these. The cluster effect works by inhibiting the individual's ability to recover from stressors, which subsequently could cause acute stressors to develop into chronic stressors. For example, Blair provided evidence of the complexity and the individual nature of perceiving the cluster effect in relation to personal administration errors and unpredictable disruptive incidents focusing on the social dynamic (see below) within the challenge during the third focus group.

> "But I think obviously we've had it difficult, the support team have had it difficult because it's been there are challenges within the challenge no one anticipated that we would have to deal with the midge infestation that we had or well just the biblical efforts of the weather. And of course that puts a strain on things. It's natural you're isolated because you can't actually sit and be a complete community cause the only shelter is a piece of polythene. We're in each other's pockets 24 h a day, 7 days a week with people that you've not lived with spent time with and we've all got our own idiosyncrasies. We've all got our own ways of doing things and at time yeah you do lose it. You don't lose your temper or you get moody or whatever and take yourself away from it but then in the end you've just gotta come back and carry on."

3.1.2. Different Stages and Bifurcation Points

Each extreme environment has a unique variety and combination of stages [80] that individuals must work through. Within the resilience literature, [15] coined the notion of bifurcation points to discuss resilience within a life span perspective. Bifurcation points can be applied to an extreme environment as the ability to survive, function, and perform within these requires adaptation over time to deal with the array of stressors present in the environment before moving onto the next bifurcation point. However, this is not always possible, causing a cascade effect during the challenge. This indicates that if the stressors cascade, so does resilience, as this process buffers against the impact of these stressors [12]. With regards to the 100 Peaks Challenge, the four time points or bifurcation points in this research represent four different base camps and the transition between them. Consequently, each contained different combinations of stressors in different sequences than other timepoints for each challenge team member to deal with and process.

Stressors ranged in number and severity depending on the bifurcation point that the individual was in, and how they perceived these stressors. These stressors can build up creating a cluster effect if a longer time to adapt is needed to overcome them. Hence, stressors can build up within and between bifurcation points, producing a more intense cluster effect, as individuals have to attend to existing stressors (from previous bifurcation points) as well as adapting to a new combination of stressors in the subsequent bifurcation point. This is emphasised by Kendall during the last focus group the night before the final day:

> "It is an unusual environment to be in and you all get tired you all have good days and bad days and you get through that. There's not a lot of choice you just focus on the next day but there's always something coming next or you have to get ready or there's like people asking questions or prepare for the next day it's all go, go, go. And I think it's for everyone it's for the support team it's also for us the same . . . Yeah so we didn't really have a lot of time to actually chill and relax and let things sink in because we had long days and we had to get ready for the next one and think about the next day so we didn't have a lot of like downtime just to chill and just sit as a team. And also because of the midges and the weather we kinda stuck in our tents sometimes so yeah."

3.1.3. Start of the Cluster Effect

The transitions were planned and an integral part of the challenge but became unpredictable disruptive incidents, as they were not expected to have the effects they had on the challenge team. This first transition from base camp 1 to base camp 2, where challenge team members moved from bifurcation point one to bifurcation point two (see Figure 1 for challenge team members' individual CD-RISC10 scores) within the challenge, was a highly significant time point, as it created a unique combination of stressors that allowed the cluster effect to be observed for the first time. This is because the full impact of moving the kit, the logistics of changing location, and the subsequent knock-on effects of this process to challenge team members were not foreseen. Additionally, transitions presented an increased risk due to the challenge team cycling between base camps often in extreme weather conditions as well as the support team moving all the kits.

The context of this transition is important as it became a critical point of the challenge for all participants. The team experienced some significant stressors (both personal administration errors and unpredictable disruptive incidents, see Table 1 and identification of stressors section) at base camp 1 and there was an expectation that things would improve with regards to these. The lead researcher witnessed the team arrive from a long cycle 107 miles in high spirits, but this quickly dissipated with the realisation that the transition from a logistics perspective had been delayed and the camp was still being constructed. The lead researcher arrived at the base camp location before the support team, as they were delayed in traffic. When the support team arrived, the lead researcher assisted in constructing the base camp and completed the second focus group a couple of hours after

the challenge team's return. Additionally, there were a large number of midges present at base camp 1 and there was hope that moving south would see the number of these decrease. However, the reverse was true, and the number of midges actually increased. This increase in midges, base camp 2 not being ready clustered with other stressors such as fatigue, and differing levels of fitness at this bifurcation point made the transition to base camp 2 very difficult for the challenge team. Kendall attempted to articulate this difficulty in relation to the cluster effect:

> "Sure like it's if you go to find the cycling and the climbing the peaks like Jordan has said as well and the weather and the midges and just everything else even like transition day packing up and things like that those are challenges on their own apart from the cycling and you've got challenges also getting along with the team and making sure everything work well the support team those are separate challenges on top of what we do already so and yeah."

And Charlie articulated the experience:

> "The day went pretty well. Coming back to base camp, talking to the [support team] they have had a nightmare setting up the base camp. The midges here at the moment are absolute hell. That is, one of the hardest challenges is dealing with the midges."

Additionally, stressors from pre-challenge bifurcation points may not have been dealt with by challenge team members and came to the fore as stressors clustered together. This was particularly evident for Blair, who struggled with the reasons some of the challenge team members were completing the challenge:

> "I've found some situations difficult to deal with purely because I don't understand the mentality of certain individuals that they make, and, because of the nature of this challenge. Because of the nature of the physicality of it and everyone is getting tired the demands are great and conditions aren't ideal. Small things become big things."

The appearance of the cluster effect at this point was significant as the challenge team members never really seemed to recover from the stressors from this transition, which compounded further stressors, as they were dealing with stressors from this transition as well as those present in subsequent bifurcation points. This could be due to physiological stressors (e.g., fatigue and muscle soreness) having psychological manifestations that add to the burden of individuals [82]. Jordan talked about the particular transition and the impact it had on time, causing a video diary to be missed, which was caught up with the following day:

> "And because we had the transition before. It was a late start which wasn't ideal but it is what it is so we cracked on with the TAB and immediately found that the ground was quite tough."

This was also the case with Blair, "It's just been a little mad with the transition and the last couple of days". It could be described as the tipping/breaking point within the challenge with regard to interpersonal differences (see subsection below).

3.2. Exploration of Resilience

To make sense of the 'lived experience' of the challenge team [44] and to understand the meaning they prescribed to these experiences [49] from a resilience perspective, key themes from the participant's narrative were identified with similarities and differences between them highlighted in each theme [39]. Each individual perceived their experiences in a different way, evidenced in the variability in the CD-RISC10 scores between participants at each bifurcation points, and the nuances of these differences were exhibited in their respective narratives in the video diaries. Within the focus groups, these differences were less pronounced. This suggested the individualised and dynamic nature of psychological resilience throughout the challenge, supporting the notion that resilience is a process [9]

with interaction between the individual and their environment [13]. The individual CD–RISC10 scores depicted each member of the challenge team demonstrated a different pattern of their resilience scores across the bifurcation points, indicating that an individual's resilience is context-specific within the different stages of a challenge [12]. The CD-RISC10 scores also indicate that challenge team members had different levels of resilience entering the challenge, and the trajectory of each team member was different during the challenge, indicating that resilience is an individualised process that changes over time. Charlie scored full points across every time point demonstrating they had high levels of resilience. This was reinforced during their video diaries and their comments in the focus groups, suggesting they had the necessary resources to deal with the environment. This also highlights the importance of using mixed methods to explore complex phenomena such as resilience, as this may have been missed using only one method. Jordan had their highest score at the first bifurcation point, then showed a sharp decrease near the end of the challenge, indicating that they were still contending with the cascade of the cluster effect through the challenge. Kendall showed decreases in psychological resilience throughout the first three bifurcation points before experiencing a large increase at the final time point. This could demonstrate that the challenge had a positive effect on their resilience, and they had worked through the cluster effect and developed the necessary resources to cope. It could also indicate that the end of the challenge was a key focus. Finally, Blair showed a steady increase in their resilience during the challenge, showing that their trajectory throughout the challenge was positive and that they were able to deal with the cluster effect and developed the strategies to effectively function. These individual changes in psychological resilience will now be explored through the strategies used by the challenge participants to highlight the complexity and dynamic nature of resilience over time.

Challenge Mindset

Appraising experiences and stressors as a challenge rather than a threat is known as a challenge mindset [14] and was used throughout the challenge by all the participants. Individuals evaluate and appraise the stressors in the environment against the resources they have at their disposal seeing difficult experiences as an opportunity for growth [15]. This challenge mindset can be split into three further subordinate themes of acceptance, putting one foot in front of the other, and humour. Each is used to reappraise stressors into a challenge; each sub-theme will now be discussed.

Acceptance. Acceptance of the conditions within the extreme environment was used consistently by all participants throughout the challenge and could be seen as challenge appraisal [14]. This was seen in the interpretation of some of the language used within the video diaries, a way to achieve excellence in IPA [73]. Words such as "Brutal", "Tough", and "Ridiculous" were often employed to describe the weather conditions and terrain. For example, Charlie stated, " ... I mean every single mountain we're going up it's ridiculous, the incline of it and everything, it's just". These words were often used while highlighting that the experience was enjoyable and fun suggesting this form of acceptance had a masochistic element. They all seemed to enjoy this aspect of the challenge and had accepted this as part and parcel of completing the challenge.

This was evident for Charlie, who enjoyed the challenge of being in the mountains. They were less favourable about the cycling elements of the challenge but accepted them as part of the challenge and as something to get through so they could get back in the mountains.

> "It was a big challenge for me yesterday. I haven't covered anywhere near that distance ... another challenging day, but the hills are why I am here. The cycling isn't my thing. It's something I'm just doing [to get back in the hills]."

This acceptance was also shown in how team members sometimes showed an inability to articulate verbally their perceptions of the cluster effect and its impact. This difficulty to articulate may be a demonstration of acceptance of the situation, simplifying the experience

to just putting one foot in front of the other (see below) to get the job done while appraising the situation as a challenge. Jordan highlighted this difficulty in one of their video diaries:

> "The main challenge was the terrain for us from that point of view, absolutely horrendous again. It is so hard to explain what you have to go through to get to the top of the mountains."

Achieving a complete reflection of the cluster effect may take time, as individuals are first concerned with getting the job done, and then must reflect and appraise later as they digest what has happened. For example, Blair found it difficult to articulate the stressors within the environment. They also found it difficult to do this with the qualities and strategies they exhibited during the challenge to demonstrate resilience. Additionally, as Blair progressed through the challenge, their appraisal of their experiences showed they began to accept the cluster effect, which increased their resilience over the duration of the challenge, as evidenced by their CD-RISC10 scores. This could show that challenge appraisal is an ongoing process and the experiences within the challenge allowed them to find meaning from having to deal with the cluster effect as well as with the personal circumstances that brought them to the challenge. The reasons why they were completing the challenge carried more significance than short-term discomfort of the stressors from the extreme environment. As Nietzsche highlighted "He who has a why to live for can bear with almost any how", and this was seen with Blair as they accepted their circumstances to find meaning:

> "In comparison to what this time of year means to me, this challenge isn't anywhere near as tough as what this period of time means. So again, being away from home, maybe that's more of a challenge than this is."

This ability to find meaning through the acceptance of their circumstance allowed individuals to transcend beyond the stressors they have deal with [83] to complete the daily challenges they were faced with and get something out of the experience.

Putting one foot in front of the other. To combat the cluster effect all participants spoke about "putting one foot in front of the other" to reduce the impact of the stressors in the cluster effect. This allowed participants to break down and concentrate on relevant stressors to maintain functioning to achieve daily objectives. Perseverance was identified as a key element [28], which could be considered similar to putting one foot in front of the other. By focusing on the next step, team members maintained the challenge mindset to combat stress while persevering with the objective of completing the challenge. This is highlighted by Blair in one of their video diaries:

> "The terrain, its actually very very difficult to make people understand unless you're doing these routes how demanding actually those trails are. So, that's a challenge and the only way you can deal with that challenge is putting one foot in front of the other . . . I don't stop. I keep going. I keep focused on what we are trying to achieved."

And Jordan also highlighted this notion of focusing on the next step, "you keep going keep focused you don't really think ahead a lot other than the next step you have to make or the next . . . ".

All participants highlighted how tough the conditions were but there was a need to get the job done and to keep moving by putting one foot in front of the other. This could be considered a challenge mindset, which [14] have highlighted as a major feature of resilience, whereby individuals positively perceive the stressors they face and the resources they have at their disposal as positive. It allowed challenge team members to develop acceptance, allowing them to accept the tough conditions (e.g., everyday stressors such as the weather and terrain) as part of completing a challenge in an extreme environment. However, personal administration errors of challenge team members were harder to accept. This could be due to the potential consequences of these for individuals and the wider challenge. During the challenge, these administration errors could not be dealt with, and

they contributed to heightened levels of stress in base camp. It has been highlighted that distancing and removing yourself from a situation is a useful resilience strategy [16], but this could not be done during the challenge due to the base camp environment being an isolated and confined environment [30].

This challenge appraisal allowed challenge team members to employ specific short-term targets to focus on (e.g., putting one foot in front of the other to get to the top of the mountain etc). This kept them in the present and allowed them to keep moving without becoming overawed by the magnitude of the challenge and the cluster effect of stressors within it. Charlie encapsulated this by saying:

> "Mentally its draining purely because every single step we're taking, especially on the ridges, every single step you're taking you're having to constantly watch your footing and that is taxing."

By completing these short-term targets, it brought the long-term objective closer to being achieved and gave them some semblance of order and control over a complex and uncontrollable environment, allowing the extent of the challenge to be cognitively reappraised. The ability to reappraise and show psychological flexibility adjusted the behaviour of individuals so that the long-term goal could be achieved [18].

Despite this short-term focus, challenge team members were also acutely aware of the long-term objective of completing the challenge and getting the job done. This was very business-like, with an external focus strategy utilised especially in the early stages of the challenge. Their focus was on the support team as opposed to using an individually and internally focused strategy. Charlie and Jordan bestowed praise on the work the support team were undertaking. This stopped as the cluster effect cascaded through the bifurcation points of the challenge and participants reverted to "putting one foot in front of the other".

This challenge appraisal also allowed them to maximise safety and appraise risk correctly on the mountain while still balancing the requirements of achieving the objectives of the challenge ensuring the safety of everyone involved. This was because they were not taking up resources trying to deal with stressors presented in the environment. This risk appraisal was important so that undue risk was not taken at the expense of increasing the probability of an injury just to complete the challenge, while in the mountains, the challenge team had a responsibility to each other to ensure safety and this kept them going, supporting the work of [28]. This was a fine balancing act that required the situation to be constantly appraised while objectively taking into account the resources available to team members. This was done with honest objective communication in the form a 'Chinese Parliament' (a term used by the challenge team to describe a completely open and honest forum which is used in the British Military), where an appropriate decision could be made around the risk posed. Jordan summarised this by saying:

> "We decided to take a vote on it and initially 3 people wanted to go forward and along the ridge and 2 decided it was, probably too risky and I was one who said that is wasn't as bad as it looked, there was a safe way off . . . So, I think we made the right call."

This strategy was employed throughout the challenge while on the mountain to mitigate the risk. Indeed, [27] highlighted the importance of effective communication to maximise team effectiveness and minimise risk within a polar environment. It was also attempted early on in the challenge within the basecamp setting, but as the cluster effect developed and cascaded, it was not fully adhered to, causing a subsequent stressor of social support and individual differences.

Humour. In terms of apprising the environment as a challenge, participants emphasised the importance of humour, which was used throughout the challenge. Blair summarised the use of humour during focus group 2:

> "I think we just sort of bounce off each other a bit, don't we? And, you know, try and have a bit of a laugh, if you see someone down, just try and pick them up a bit, you know, sort of we're always having a laugh and a joke and, you know,

> it seems to keep everyone's morale up . . . it probably releases . . . tension is not the right word, but I think it just, a little bit of humour goes a long, long way. I think when you're faced with the challenges that we're obviously faced with day in, day out, irrespective of the challenge itself. Obviously in addition to all the personal challenges that people are facing, it just sort of, it's a smile, a bit of humour can make the day a lot, lot brighter. And obviously it needs to because the days are long and they're only going to get longer, and the challenges are only going to get more and more arduous as we go on."

Humour has been well-documented as a coping strategy [84–86] and contributes to resilience, enabling individuals to cope with extreme environments [3]. It is emotion-focused and looks to cognitively reframe stressors by reducing the severity of them to buffer their impact [3,84]. This was seen on several occasions; for example, during focus group 3, Charlie highlighted an experience while on the mountain:

> "Just having that focus to get up each one and again it was just . . . and yeah we have a right laugh when we're out it's a bit ridiculous really some of the things that we've done. Look at me. And looking across, I mean, we were on . . . We were going up one mountain it was the worst one we've been and I looked across to Blair and I mean it was literally like that [makes hand gesture about the slope] but it was all just loose stone and shingle and slate and everything else so every time you moved the whole mountain just moved and I've look across to them and we were just laughing at each other and I think if you haven't got that sense of humour you'd kind of knock it on the head."

Early on in the challenge, Charlie thought humour was important: "A good sense of humour. The team seems to have a good sense of humour. We're having, although it is brutal, you know, we're having good fun, good banter". Kendall also suggested humour was important towards the end of the challenge:

> "We actually had a bit of a laugh, just I didn't really chip in much, but, you know, we all had a laugh . . . There was a bit of a challenge yesterday and the way I kind of deal with it is to just laugh about it."

It has been highlighted that humour is a diverse construct with individual differences to how humour is used [86], and that it is not always a positive strategy to use if the humour is misinterpreted [84]. This may have been present during the challenge, whereby the use of humour could have been misinterpreted and perceived differently, leading to increased stress and further complexity of the social support within the challenge and interpersonal differences. This, in turn, increased the strain on the social dynamic within the team, which developed into an additional stressor that needed to be attended to. This misinterpretation may have started before the challenge started where comments made could have been misconstrued. This suggests that members of a team entering an extreme environment should attempt to do so with a metaphorical clean slate in relation to the different personalities and potential social interactions between them. Moreover, highlighting that the preparation phase of any challenge team entering an extreme environment is an important bifurcation point where it is imperative that team members become aware of each other's personalities and potential strategies they may employ during stressful periods.

The Complexity of Social Support. This study demonstrates the complexity of social support within an extreme environment with challenge team members drawing upon a unique mix of perceived and actual received support. The importance of resilience for coping with social stressors and dealing with physiological stressors such as fatigue has been outlined [82]. Therefore, social support is important in extreme environments. Within the 100 Peaks, this support came from different social agents, which was dependent on whether they were out on the mountain, on the bikes, or back in base camp. For example, Charlie bestowed a high level of praise on the support team during the early stages of the challenge:

> "All of us really is I would say sorting the base camp out. Within a couple of days they got it running like clockwork for us . . . So really the support team, at the moment the support team are what's making this happen for us. I mean we . . . well, for me, we've got the easy job, we're sort of doing what we love doing . . . it's such a hard physical challenge, it is easy for us because we're not having to come home and cook our tea, wash our clothes, get everything ready, these guys are doing it all for us. So, although the days are long and that, it's brilliant, it really is."

During focus group 3, they again highlighted their appreciation for the support team, and that they would rather be on the mountain than deal with the stressors at base camp:

> "They've been around, they've been terrible the midges. If it's not pissing down with rain and freezing cold then the midges are out but it's like I've said for us we're up in the mountains or on our bikes so we do get away from it for a long period of time these guys they're never away from it. The weather's either shit for 'em or they're getting bit too . . . We come back here and they've got nets over their faces and they're still cooking and getting stuff ready, washing, drying it can't be easy and like I say it's not a job . . . I'd much rather be climbing mountains all day than doing all that."

These social agents were supportive in some instances and perceived as a stressor in others, indicating that different contexts required different forms of support for different people. Social support is an important to buffer to the stressors in the environment, which influence an individual's ability to perform and maintain functioning and well-being. However, when social interactions are considered a stressor, they will inhibit an individual's functioning by contributing to the cluster effect of stressors in the environment (see the interpersonal differences section below). For example, the incorporation of partials into the challenge team for some of the days had both a positive and negative effect. For example, during focus group 2, Blair highlighted the morale boosting effect of being surprised by a respected member of the TABing community, who was named Partial here:

> "And on the top of the mountain we had [Partial] sitting there waiting for us with a carrier bag full of snow, stuffed with Trooper [bottled beer] in it. And the bloke had driven 500 miles just to be there and come and TAB with us, which is massive."

This experience was also alluded to by Kendall during their video diary on the morale boosting effect this had on the whole team, but they also highlighted the potential negative impact:

> "[Partial] wasn't as fit as I was, kind of, left with them, and I encouraged them. I looked after them and I looked after them and the [other challenge team members] went off. So, I that made me pretty pissed off to be honest."

Furthermore, it was the small gestures that had the most significant impact on the participant's ability to maintain functioning by boosting morale. Again, during focus group 2, there was a discussion between Charlie and Blair around the actions of one of the support team:

> "I mean a prime example was like yesterday, we was in the mountains for a good while. And the conditions were rubbish, you know, rain, wind, couldn't really see a lot in front of you. And we was up there like yesterday, what, eight/nine hours. You know, and then we come back down and [Support Team Member] is there with a hot chocolate.
>
> He offered us chocolate bars.
>
> Just that, it's a real sort of morale lifter.
>
> Just, that it's simple things like that, it really is simple things. When you've had a hard day, the thought of actually coming back and seeing that you've got something hot and steaming and sweet."

These small gestures of support appeared to buffer the impact of the cluster effect of the stressors within the environment, and these not only came from physical interactions, but also from messages of support through social media platforms.

Interpersonal Differences. The extreme environment intensified the relationships and differences between individuals in the challenge. Hence, a significant everyday stressor were interpersonal differences between individuals, which increased through the challenge contributing to challenge team members ability to function, perform, and maintain well-being. These differences contributed to the complexity of social support identified in the previous section, potentially preventing social support being used a strategy to buffer the cluster effect. Interpersonal differences are an inevitable aspect of operating in extreme environments [81], with many contributing factors including a culmination of fatigue during the challenge and existing pre-challenge differences. It has been highlighted that when working in an isolated and confined environments (e.g., Antarctica in their review), there is heightened friction, hostility, and conflict [32]. It was clear that there was a clash of personalities between the members of the challenge and support team. This evolved into a major contributing stressor to the cluster effect [31]. It affected team members' enjoyment, motivation, and energy and centred around pacing on the mountain, being in base camp, and interactions between the challenge and support team. As [23] stated, an individual's psychological reaction to operating within an isolated and confined environments can be affected by interpersonal factors. For example, during the last focus group, Blair tried to describe these differences without specifically mentioning them:

> "Everybody's physically tired, mentally tired and I mean we had a lot of days where you're not so much the stuff that we was doing was possibly physically demanding but it was mentally demanding."

Personality differences were difficult to deal with, and Blair took time to comprehend personality conflicts and dwelled on these over several days, culminating in their polite articulation of these differences, as seen in the quote above. This cascade over a number of days contributed to the cluster effect, as they had to contend with other stressors that were presented each day, further contributing to the complexity of the situation. These personality differences were present in all the participants' video diaries, with clashes between different members of the support team, challenge team, and visitors. For example, Charlie found that they held back on occasion from voicing differences, supporting the need for tolerance and flexibility [27].

As some of the relationships between individuals were new and/or developing, it took time for everyone to work each other out. This was highlighted by Kendall during the second focus group:

> "You do face challenges like every day actually. When you come onto the hills, you've got mud, slime and yeah, like with communication as well. At first you need to, you know, get used to the people. See how they, you know, work and things like that. And the longer the challenge goes on, you know, the better it gets, you get to know each other better. But to pick out a specific challenge, it's quite hard, because every day, you know, every mile is a challenge, you know, sometimes you've got sore legs on the bike. Well, you just have to push through and, you know, work together and help each other."

And during the third focus group Jordan said:

> "You've got to accept at the end of the day individuals have different personality traits and it's trying to get used to how people operate. You've gotta then learn how to try and instil the best behaviour part of everybody to ensure that you get where you need to be. And I think with a challenge like this it's probably very difficult because although it's a seemingly long period of time it's not really in the grand scheme of things. 25 days isn't long to spend with people that you've probably never spent 25 days with before to completely understand them as

> individuals and obviously that takes a long time to work out the kinks but it's the getting there slowly but surely."

An aspect of operating in extreme environments is that personal space and privacy is limited [81]. Base camps offered limited personal private space, and thus, tensions were heightened due to the conditions, but also because there was limited free time to employ coping strategies such as past times [32], as time in base camp was needed for vital admin duties (e.g., eating, sleeping, cleaning, and preparing kit). This is shown in a quote from Jordan during the final focus group:

> "Probably not spent that amount of time in close proximity with these people before and there's always gonna be the odd tension that's gonna spring up from time to time it's just a case of if that arises putting the team first and thinking "I've gotta work with all these people" and getting on with it for the sake of the main goal."

These interpersonal differences had to be put to aside for the sake of the challenge. This proved difficult due to the cluster effect. This also increased perceptions of isolation [31,87] for some participants. This, alongside unfavourable conditions in base camp (e.g., poor weather), contributed to reduced social interaction between the team and support team, as there was a preconceived notion of what the challenge was going to be like at the end of each day (e.g., sitting around a campfire). If this notion had manifested itself, informal reflections/conversations could have occurred, which may have allowed any differences in opinions to be aired and ironed out.

The results of the present study highlighted the individualised dynamic and temporal nature of psychological resilience within an extreme environment. This was influenced by the unique combinations of stressors within the challenge, which affected the team's ability to function. These stressors produced a cluster effect that team members had to contend with. This cluster effect then cascaded throughout the challenge, forcing a range of strategies that were used to ensure the challenge was completed.

4. General Discussion

The findings of this study extend our understanding of the temporal and dynamic nature of resilience, emphasising the complexity and individualised notion of the phenomena. To our knowledge, this is the first study to explore resilience over time within an extreme environment and the strategies to maintain functioning of individuals operating in them providing an original contribution to the understanding of resilience as an interactive process between the individual and environment. It also advances our understanding of the complexity of social support and how it is used as a strategy to buffer the cluster effect of the unique combination of stressors within the environment. Finally, it has advanced our understanding of how a challenge mindset can be used in an extreme environment by those operating in them. This study has offered an original contribution by extending our understanding of resilience, which was achieved by using novel methods of data collection (e.g., video diaries) within a mixed method approach. These methods allowed resilience to be individually tracked over time using quantitative measures, while acquiring depth and perspective through qualitative exploration while individuals are within an extreme environment.

The current research supports the grounded theory developed by [15]. Namely, that psychological resilience should be considered in relation to the specific environment and is dynamic in nature [21]. This is so that the distinct stressors in terms of quantity, duration, and intensity can be identified and to understand how they cluster together [3]. The exposure to these stressors needs to be buffered and inhibited by appropriate strategies and the use of personal qualities to maintain functioning [14]. Two of the psychological factors proposed by the Grounded Theory of Resilience [15] were specifically identified in the results. These included perceived social support and focus (within a challenge mindset [14]) on small manageable objectives to keep moving towards the long-term

objective of the challenge. Social support in the challenge was complex, and when utilised by team members, it had a buffering effect against the cluster effect of stressors. When social support was perceived to be negative, it became a stressor and contributed to the cluster effect. The ability to focus on avoiding distractions on the mountain mitigated risks by focusing on the process rather than the outcome [15], giving the challenge team an element of control.

The results support The Everyday Stress Resilience Hypothesis [20] and the individualised and dynamic context of resilience [21]. An appropriate analogy to use here for the Everyday Stress Resilience Hypothesis is the running of a marathon [20]. A runner would not just go out a run a marathon, but would slowly increase the distance until they could successfully achieve the marathon, while taking into consideration the aspects that could affect their ability to run the 26.2-mile distance (e.g., nutrition, injury management, and logistics to find time to train while balancing other commitments). This is also the case with the challenge team; they had to slowly build up their training to allow them to successfully complete the challenge. This slow inoculation must be typical and not chronic in nature, as this would provide setbacks to the person to allow the building blocks to be established, similar to the marathon runner example.

The relationship between how the individual interacts with the environment they are in with continual exposure to those stressors causes the individual to adapt and become inoculated to buffer their impact [88]. However, the interaction is not just dyadic; there is also influence between others in the environment and across different environments in which the individual resides (as seen in the complexity of social support and interpersonal sections, see above). This points to a systems theoretical perspective to be adopted. One such perspective is the Ecology of Human Development model [19] that could be used to explore the interaction of the individual in a complex dynamic environment and how their resilience changes over time and throughout different contexts. Therefore, resilience is the process not only of the dyadic interaction between the individual and their immediate environment, but of the interaction with other environmental stressors within connected environments. These combine to produce a cluster effect that needs to be effectively buffered using appropriate protective factors at the individual's disposal (e.g., psychological qualities and/or social support). This is because resilience develops in individuals due to intermittent and frequent experiences of different stressors at different times to varying degrees in a complex and ever-changing environment. This is how the individual perceives the stressors in the environment and how they regulate this stress, which demonstrates resilience; it is the interaction between the individual and the environment [16]. Therefore, people positively adapt to the stressors, with resilience emerging, because this adaptation provides an increased capacity to cope when future stress is experienced [20]. This posits that a lifespan longitudinal research methodology should be applied to future research projects.

4.1. Strengths and Limitations

The current research design provides an innovative and flexible method of data collection that allows the exploration of psychological resilience longitudinally and 'live' within extreme environments, with the use of video diaries offering a viable method of exploring complex phenomena such as resilience. As suggested in other contexts, the use of video diaries should be used in conjunction with other methods to provide a deeper understanding of the complexity of functioning in extreme environments. This supports another strength of the current study; the use of mixed methods to explore resilience over time. The quantitative measures allowed individual differences to be tracked over time, while the qualitative methods allowed individual perspectives of resilience and how functioning was maintained during the challenge to be explored in depth. For example, the focus groups allowed greater depth to be gathered around the collective experiences of the challenge team, highlighting the complexity. They also acted as an opportunity for the researcher to become more immersed into the challenge, which is a key tenant of IPA [44].

However, the video diaries themselves could have served as a resilience strategy to maintaining functioning by merely allowing challenge team members to reflect and verbalise their experiences [16]. Nevertheless, despite the study's success in exploring resilience over time, there were still some concerns about whether the video diaries captured resilience live, as they were completed as close to the event as possible. As a result, there could still be elements of recall bias, as the participants were reflecting on the event after it had occurred. Due to the time constraints of the challenge, the video diaries were often completed as close to the event as possible, and not always at the end of each day. This could be interpreted as a demonstration of the cluster effect, as challenge team members were required to attend to relevant stimuli needed to maintain functioning. This was due to the vital tasks that needed to be completed, and it was often the video diaries that were the first to be dropped from daily task lists, as they were considered non-vital.

Due to the social dynamics within the challenge team members, they may not have given their honest opinion and might have held back some of their comments during the focus groups, preventing depth to be achieved. Moreover, they could have been giving responses they thought the researcher wanted to hear. Finally, the focus groups were largely completed in remote and unfamiliar locations, so the challenge team may not have been physically comfortable as well as having other tasks to complete around base camp. This may have caused them to be distracted and uncomfortable, which caused them to give shorter/incomplete answers, so they could attend to other essential administration duties that they were required to do. With regards to the CD-RISC10, one of the participants, Charlie, scored full points across every time point. This could have been due to them having just ticked the questionnaire without consideration, or it could be that Charlie simply demonstrated high levels of resilience. The CD-RISC10 has previously been used in sport [64,65], but not specifically in its entirety in an extreme environment. Consequently, this measure could have a ceiling effect that does not have measurement sensitivity to effectively distinguish between an individual's level of resilience in extreme environments. Despite an attempt to not interfere and limit the impact of the research within the challenge, the fact that the lead researcher attended different base camps to complete the focus groups as well as staying in base camp may have affected the team members, and thus, influenced the content they provided in both the video diaries and focus groups.

4.2. Future Research

In terms of future research, the current research points towards exploring resilience in other extreme environments due to the unique combination of stressors within each environment. Additionally, the research has highlighted the need to explore resilience over time using a lifespan perspective. Future studies should endeavour to utilise a lifespan perspective to develop an understanding of participants background in relation to past experiences (significant life events and experiences within extreme environments), as these can shape and dictate how resilience may present itself when confronted with the complex array of stressors in a specific extreme environment and subsequent transfer to other life contexts [16].

When exploring resilience methods that incorporate both live and retrospective data, different collection methods should be utilised. This could be achieved by using mixed methods at all stages of data collection. Quantitative measures could track changes in resilience and qualitive methods could explore these individual changes over time. To do this effectively, future research designs need to allow a period of reflection to allow participants to attempt and make sense of what has happened. This is because time (and resilience) is individually perceived, so any changes may occur post challenge and, thus, not captured live within the extreme environment. Any adaptation may occur after the challenge has completed. To do this, there needs to be a push to be creative and innovative in devising ways to do this not only in extreme environments but also other contexts.

4.3. Practical Implications

The results from this study have application to those working in and preparing for entering an extreme environment. Awareness should be given to the cluster effect and the strategies used to buffer its potential impact. People entering extreme environments should become as aware as possible of the possible stressors, how they might cluster, and the severity of them. This points to preparing correctly in every possible aspect of the environment (for example, this may be physical, psychological, and social). Despite this, nothing can substitute gaining experience of the actual environment in which an individual will be operating. This should be initially done in small doses to allow those operating in them to become accustomed to the stressors and how they might cluster. There also has to be an emphasis on highlighting the potential for the unique combinations of the stressors in the cluster effect in terms of frequency, duration, and order. The results demonstrate the importance of every member of a team operating in an extreme environment to commit to the long-term objective to enhance the challenge mindset of individuals. Whilst an awareness of the long-term objective is imperative, individuals should break down this objective down into smaller specific and manageable objectives to allow progress to be made toward this long-term objective, so that individuals can put "one foot in front of the other". The results of this study can also be applied to other contexts. Despite being completed in an extreme environment, the results can be applied to contexts that are less extreme, as every environment will have stressors that have the potential to cluster together. If individuals are not aware of these stressors and how they might cluster together, then functioning and performance could be impaired. The notion of preparation and gaining experience of stressors within the environments that individuals operate in is universal, whether that be in elite sport, health professions, or business. The notion of committing to a long-term goal and then breaking these in short-term targets such as those used by the challenge team also has universal application.

5. Conclusions

The current study is significant since it enhances our understanding of psychological resilience within extreme environments. Specifically, it adds to our understanding of resilience as a process, as it emphasises the complex, dynamic, and individualised nature of resilience and how individuals maintain functioning while operating within extreme environments. Specifically, a challenge mindset and social support were employed, but these were used to differing levels and at different times by team members. It has highlighted the importance of being aware of the potential stressors and how they might cluster together. The study is original since it has explored resilience over time within an extreme environment. Methodologically, this study offers a creative and original way to explore psychological resilience "live" and over time to unpick the complex interactions between individuals and the environment from a resilience perspective.

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Review

Learning and Expertise in Mineral Exploration Decision-Making: An Ecological Dynamics Perspective

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Abstract: The declining discovery rate of world-class ore deposits represents a significant obstacle to future global metal supply. To counter this trend, there is a requirement for mineral exploration to be conducted in increasingly challenging, uncertain, and remote environments. Faced with such increases in task and environmental complexity, an important concern in exploratory activities are the behavioural challenges of information perception, interpretation and decision-making by geoscientists tasked with discovering the next generation of deposits. Here, we outline the Dynamics model, as a diagnostic tool for situational analysis and a guiding framework for designing working and training environments to maximise exploration performance. The Dynamics model is based on an Ecological Dynamics framework, combining Newell's Constraints model, Self Determination Theory, and including feedback loops to define an autopoietic system. By implication of the Dynamics model, several areas are highlighted as being important for improving the quality of exploration. These include: (a) provision of needs-supportive working environments that promote appropriate degrees of effort, autonomy, creativity and technical risk-taking; (b) an understanding of the wider motivational context, particularly the influence of tradition, culture and other 'forms of life' that constrain behaviour; (c) relevant goal-setting in the design of corporate strategies to direct exploration activities; and (d) development of practical, representative scenario-based training interventions, providing effective learning environments, with digital media and technologies presenting decision-outcome feedback, to assist in the development of expertise in mineral exploration targeting.

Keywords: mineral exploration; ecological dynamics; expertise; needs-supportive environment; representative learning design

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1. Introduction

Despite increased expenditure, global greenfield discovery rates have stalled for over a decade (Figure 1 [1]). Reversal of the current trend is deemed critical for the desired global transition to renewable energy sources, particularly wind and solar, as well as the evolution of currently energy intensive industries, such as the automotive industry moving from fossil fuels to predominantly battery-driven vehicles [2]. Without access to raw materials, especially those defined as critical metals, society is unlikely to realise long-term goals towards achieving sustainability [3–5]. Additionally, well-targeted exploration will help reduce the environmental footprint of conducting exploration activities by decreasing the average number of holes drilled to make each discovery.

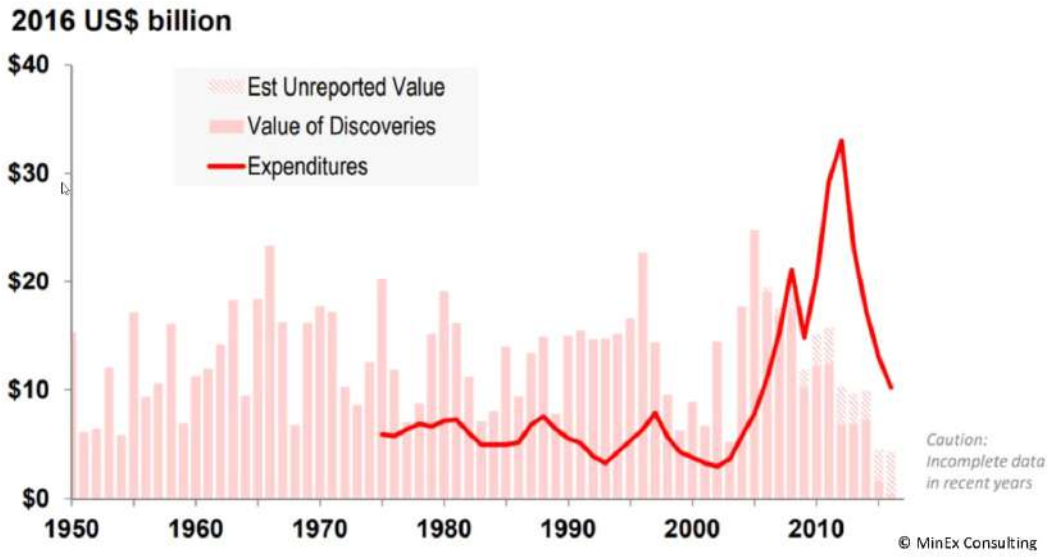

Figure 1. Declining rate of exploration success during last decade, despite increased exploration expenditure since mid-2000's. Adapted with permission from Schodde, R.C [1].

Traditionally, mineral exploration has followed a predominantly empirical approach, which initially entails searching for evidence of mineralisation upon the surface of the planet, then, with consideration of known deposit types, targeting drilling to define the extent of an ore body below the surface [6]. As outcropping deposits in well-explored areas are progressively depleted, there is a need for exploration to extend to less well-explored search spaces, typically in more remote locations, and for undefined deposit types to be considered [7]. These points suggest that exploration needs to include regions where surficial evidence for deposits is absent or unclear, requiring a conceptual approach to targeting, guided by an understanding of underlying mineralising processes shared across multiple deposit types (Mineral Systems Concept [8]). As the industry experiences this transition, Davies and Davies [9] argue that creativity in the application of the Mineral Systems Concept is key to realising long-term exploration success.

This paper presents the Dynamics model [9], incorporating the Dynamics challenge-performance curve [10] as a principled framework for understanding and supporting creativity and the development of expertise in predictive exploration targeting. These models provide guidance to the minerals industry in identifying and realising current decision constraints and adapting learning and working environments to promote greater degrees of creativity and on-going development of exploration targeting expertise.

1.1. Exploration Targeting

Exploration targeting involves defining and exploring areas that have potential to host economic mineralisation. This process, outlined in Figure 2, is recognised as a series of decisions [11–13]. In this decision-making process, both explicit and tacit (or implicit) knowledge is employed to assess the validity of various options available to the decision-maker [14]. At the time of the decision, the outcome of each option cannot be known for certain but is inferred through assessment of the information available [15]. To improve the quality of an assessment, and therefore the likelihood of a positive decision-outcome, an individual or team is required to call upon relevant experience from a host of disciplines. Specifically, exploration decision-making encompasses a range of geoscience-related disciplines [16], as well as general disciplines such as economics, business strategy, management and socio-political implications that may influence license to operate [17]. Exploration targeting thus represents a highly complex and dynamic task.

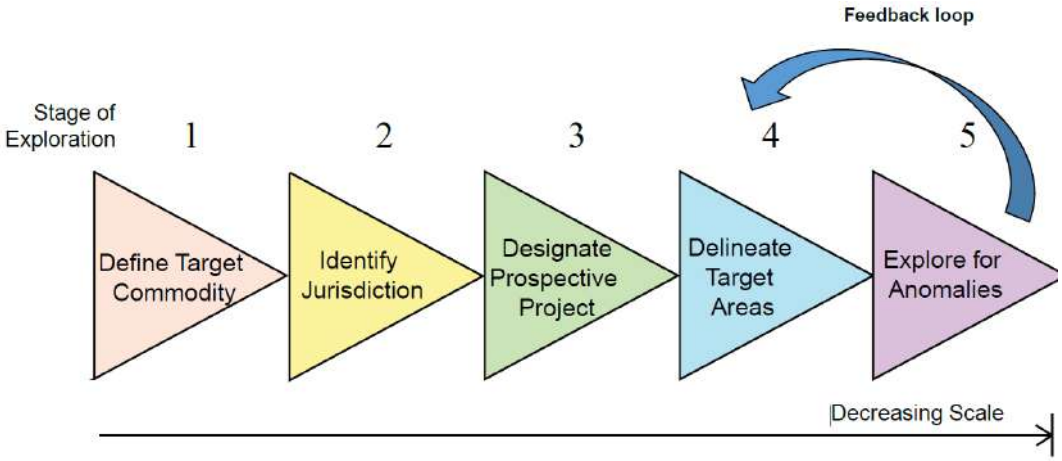

Figure 2. The stages of exploration targeting. Within each stage there is a period of data collection, integration, and analysis. Moving between stages requires a reduction in real options, such that a decision is made to focus on a specific area, decreasing the overall exploration search space. Although a single feedback loop is presented, it is noted that the true process of exploration is far less rigid. Feedback occurs at all stages, potentially leading to a reverse step in the process. For example, newly acquired data may present a case for defining a different, or second, target commodity within a project area.

1.2. The Exploration Search Space

Mining activities constitute sampling without replacement, from a fixed but unknown number of deposits, within any given search space [16]. Once resources are extracted from a location, they are permanently depleted. Ongoing exploration of locations containing high data density, significant known mineralisation and previous mining activities thus presents a long-term declining rate of return [18,19].

The current decline in exploration success is likely due to known search spaces reaching maturity [20,21]. In order to reverse the declining rate in exploration success, there is a need for sustained greenfield exploration in immature or newly discovered search spaces, often in remote or extreme environments [22]. For this to occur, explorers must move away from locations of high data density to areas of greater uncertainty with limited information, but also greater opportunity for significant new mineral discoveries [23]. This approach to the process of exploration targeting carries inherent risks and challenges.

One popular new frontier is exploration for buried deposits beneath transported, post-mineral cover. When buried under recently transported material, mineralisation is often impossible to detect by surficial exploration methods. Exploration for deposits in areas with considerable cover, including much of Australia, requires a conceptual targeting approach. Conceptual targeting requires exploration geologists to utilise available information so as to predict the likelihood that an economic ore body exists within a given search space. Rather than looking for empirical evidence of mineralisation, such an approach is underpinned by a detailed understanding of the processes leading to ore deposit formation and associated physical and chemical footprints [8]. In conducting conceptual targeting, the exploration geologist requires datasets that map mineralising processes and knowledge of a wide range of related deposit types [24].

1.3. The Mineral Systems Concept

Ore deposit formation is recognised to be a focused mineralisation event. These events represent "self-organising" critical systems and are underpinned by the interaction of complex, non-linear deposit forming processes [25]. Based on an understanding of these processes, the Mineral Systems Concept provides a framework for conceptual exploration targeting [26]. However, the application of an improved understanding of mineralisation systems is yet to provide a new wave of exploration discoveries [11].

Application of the Mineral Systems Concept to define new search spaces or predict new deposit types is conceptually challenging. This approach requires the development

and testing of hypotheses, based on an understanding of mineralisation processes, to predict the potential for existing and/or undefined deposit types to exist within a search space [17]. For cases where exploration is conducted in newly defined search spaces, there are often limited geoscientific datasets, creating a significant barrier to entry in that new data acquisition is an obstacle. Where data representative of system elements are available, it is difficult to integrate multiple geoscientific datasets and model complex interactions between mineralisation processes. Most importantly, the development of predictive targeting hypotheses requires significant creative input, based on a rich and diverse background of knowledge and understanding. Due to the risks and low success rates associated with these search challenges, there is a heuristic tendency for explorers to be biased towards preferential focus on advanced, data-dense 'brownfields' projects, over conceptual early stage 'greenfields' projects.

1.4. Technology as a Solution

Hronsky and Groves [26] recognise the propensity for mineral discoveries to follow the emergence of new concepts or technologies. As such, technological development has been proposed as part of the solution to the current decline in exploration success [27]. Mineral exploration is becoming increasingly data rich and knowledge poor, such that advanced algorithms and increasing computational power may provide opportunity to recognise patterns in larger, more complex datasets [27]. However, a critique of solely technology-orientated solutions is that they may fail to resolve scenario or context-related issues that need to be considered in the search process [14]. For example, although development of new geophysical survey methods may present improved mapping of components of mineral system processes [28], this fails to provide optimal survey locations, prior to data collection commencing, or methods for integrating newly acquired data into the broader, highly complex exploration decision-making process.

Greenfield exploration requires explorers to operate in data-poor environments [23]. They are required to fill significant gaps in existing geoscientific datasets, to predict potential decision outcomes and integrate with ongoing exploration activities [29]. By relying solely on technological development, we may fail to consider the requirement for human innovation and creative problem-solving in the generation and critique of multiple predictions, based on disparate datasets. Techniques such as 'deep learning' have provided significant progress in the ability of Artificial Intelligence (AI) to begin exploring a creative frontier [30]. Unfortunately, this creativity has been critiqued as merely mimicking existing data rather than producing genuinely novel outcomes, especially for challenging, high-dimensional problems [31]. With regard to the critique of predicted hypotheses, current AI is limited in its ability to interrogate correlations and avoid biases since current deep learning methods are poorly correlated with prior knowledge [31,32].

By providing comprehensive training data, AI appears capable of predicting locations of well-understood deposits in data-rich environments [33]. Nevertheless, AI remains far from being able to generate new conceptual deposit types or search spaces, based on a holistic understanding of Earth sciences. In an article on the subject of learning, Gopnik [34] states that "Despite enormous strides in machine intelligence, even the most powerful computers still cannot learn as well as a five-year-old does." She identifies the care, nurturing and support provided to a child as key ingredient in learning and creativity. In summary, mineral exploration is recognised as a complex, non-linear process [26] and although advances in AI and technology present significant opportunities to improve the quality of exploration targeting, the combination of technology and human creativity are considered key to realising long-term, recurring success [10].

1.5. Creative Problem Solving

Creative thinking is key to the development of novel solutions to overcome complex, high-dimensional problems. Within mineral exploration, previous explorers conducted targeting to test specific hypotheses. Since mining activities involve sampling without re-

placement, economic discoveries realised by previous explorers no longer remain within the search space. As such, it is important that future exploration efforts test newly developed hypotheses regarding new search spaces and subtly different deposit types.

Through consideration of underlying system processes, often shared between multiple deposit types, the Mineral Systems Concept presents a robust, scientific framework for creative problem solving. By reviewing existing empirical information, it is possible to separate features that are likely to be representative of key ore forming processes that define a mineral system, from those that are only locally relevant to a deposit [24]. Primed with this knowledge, an explorer can generate innovative, science-based hypotheses regarding new search spaces in which the same mineralisation processes have occurred or differing local features that may result in new deposit types. This approach allows the explorer to recognise fundamental patterns across geological settings and styles of mineralisation, thus generating hypotheses to test new exploration targets. However, creative problem solving and innovation are not simply academic endeavours. They require a high level of individual confidence and a perceived supportive environment [35].

1.6. Subjectivity in Geoscience

Subjectivity is the norm; a surprisingly small number of geoscience-specific studies have delved into the process of predictive decision-making and subjective assessment. Polson and Curtis [36] and Bond, Lunn, Shipton and Lunn [37] discuss the role of heuristics in generating geological hypotheses, or interpretations, based on uncertain data. They highlighted the potential for experts to reach contradictory conclusions when analysing the same data, advising that group workshops can help to reduce bias through sharing of knowledge and expertise [38]. Although these papers provide important insights into the elicitation process and adequacy of group assessment workflows, they fail to discuss the importance of developing expertise and the role it has in influencing the quality of interpretations. This omission is possibly due to an assumption that participants were already experts. Only Bond et al. [37] make comment that having a Masters or Ph.D. qualification significantly improved expert performance in interpreting a seismic dataset. Davies et al. [39] conducted a group workshop to evaluate the orogenic gold endowment of a greenstone belt in Western Australia, noting a significant degree of variation in expert estimates, but failing to find a relationship between estimates and participant experience. This issue presents an important question regarding the role of training and expertise in generating accurate or realistic hypotheses during creative problem-solving tasks.

1.7. Ecological Dynamics

Future exploration success relies on relevant skills of structured and creative perception, decision-making, and the planning of exploration targeting activities in challenging, uncertain and often remote environments. Targeting new conceptual deposit types or search spaces, based on a holistic understanding of Earth sciences, requires an explorer to acquire relevant knowledge and perceptual skills to undertake creative problem solving and decision making. For this to be successful, an explorer must develop new hypotheses to underpin novel exploration actions. This presents an important question, regarding the role of both domain-based and broader expertise in enabling individual capacity for creative thinking, problem solving, decision making, and hypothesis generation. To gain insights into this issue, it is worthwhile examining the contemporary literature on expertise and skill acquisition.

Contemporary perspectives on skill acquisition, heavily influenced by the conceptualisation of Ecological Dynamics (ED), have resulted in the development of an understanding of expertise in decision-making at the person–environment scale of analysis [40–43]. Ecological dynamics is a multi-dimensional framework shaped by several scientific disciplines, integrated to explain human behaviours such as performance, learning and expertise, in diverse and challenging performance environments such as sport, education, and work. Major theoretical influences are provided by key concepts from ecological psychology [44],

nonlinear dynamics [45] and the complexity sciences approach in neurobiology [46]. In ecological psychology, it is recognised that human behaviour is continuously regulated by information, shaping performance during activities such as the exploration of an environment [44]. Information use is based upon individual perception of affordances, which are opportunities or invitations acting to solicit or constrain behaviours within a specific performance environment [44]. The ecological approach has been enriched through the integration of tools and concepts from nonlinear dynamics, explaining how information is related to the dynamics of tasks and individuals within the performance environment. Dynamical systems theorising on human behaviour [45] propose the emergence of behavioural tendencies in perceptual, cognitive, and action sub-systems. Ecological dynamics emphasises the performer-task-environment system as the appropriate scale of analysis to explain behaviours, eschewing cognitive- or environment-biased conceptualisations of skill and expertise [47].

Much existing ED-related research has focused on developing an understanding of expertise, talent, and skill acquisition in sport, described by some as the most appropriate context for studying expert decision-making [48]. Ecological Dynamics takes into account the multiple dimensions of skill performance and learning, including perceptual, psychological, emotional, social, and physical aspects of the individual performer, while interacting with a specific task and environmental constraints [49]. These ideas signify the importance of the person–environment interactions at the heart of skilled behaviours, founded on the deeply integrated relationship between perception, cognitions, and actions of a performer. Based on these fundamental ideas of Ecological Dynamics, it is suggested that creative behaviours and solutions emerge during performance from continuous interactions with the environment [50,51]. This key idea implies that the emergence of creative behaviours and performance solutions is not solely a re-call of existing internalised representations or models but requires adaptation and iteration through continuous interactions with the environment, during processes of searching, exploration and discovery.

1.8. Perception-Action Coupling

Goal directed behaviours, such as creative problem solving, are viewed as functional coordination patterns, emerging under interacting personal, task and environmental constraints, which result in actions becoming tightly coupled to perceptual information, shaping intrinsic self-organisation tendencies in people [52,53]. Expressions of skill and expertise are continuously regulated by information. Learning is defined as the process of gradual attunement to real-time information that is meaningful, affords or supports goal-directed behavioural outcomes, and harnesses inherent system degeneracy (i.e., the same task outcomes can be achieved with different system components) [54]. Constraints, recognised as boundaries influencing behaviour, are classified into three broad categories related to the organism (the individual), task and environment [49].

Examples of mineral exploration constraints are presented in Table 1. Task constraints are aspects related to a particular goal or challenge. Although not an exhaustive list, in mineral exploration these include activity and specific goal parameters, corporate and exploration strategy statements, Key Performance Indicators (KPIs), finances and equipment. Individual constraints include the experience, attitudes and skill of individual people or teams. For example, education, values, beliefs, confidence, motivation, and risk-aversion. Environmental constraints are both physical and socio-cultural. Physical environmental constraints in mineral exploration include geology, mineralisation processes and accessibility of search areas. Company and national culture, management, reward and punishment systems, infrastructure, social networks, values, and social licence represent socio-cultural constraints that may impact the quality of decision-making. The values, attitudes and beliefs that give rise to organisation and industry culture are defined as a 'form of life' [55] and can significantly influence the behaviours of individuals within a system.

Table 1. Examples of constraints in mineral exploration targeting.

Group	Constraint	Description
Environmental	Geology	Geology of an exploration project (much of this remains unknown, as only the geoscientific datasets outlined under task constraints are available to the explorer)
	Company/culture	Organisational structure, explicit and implicit rules or values
	Management/leadership	Methods and styles applied to guiding individuals and teams within an organisation
	Government/mining law	Political landscape and specific laws governing mineral exploration/extraction
	Social perception	Social landscape and social licence to operate
	Land access	Access to exploration ground, defined by stakeholders, law and availability
	Market	Factors influencing commodity price and availability of investment funding
	Academia	Academic institutions conducting research and training students
	Economic geology theory	Current level of geoscientific theory and knowledge relevant to mineral exploration
	Exploration and mineral processing technology	Current technology available to the minerals industry
Individual/team	Individual attributes/skills	Knowledge and expertise of individual geoscientist
	Individual attitudes/motivation	Individual psychology, including motivation, attitude, values
	Team structure	Selection of individuals with complementary skills, working in a collaborative manner
	Team capabilities	Capabilities of team due to individual skills, psychology, teamwork, and corporate resources
Task	Geoscientific datasets	Geoscientific datasets that relate to the location of undiscovered ore deposits (geological, geochemical, geophysical, geochronological, etc.)
	Corporate/exploration strategy	High-level strategic plan and goals (company vision)
	Key Performance Indicators (KPIs)	Measurable performance outcome specific to a particular activity
	Finances	Availability of finances to conduct exploration activities
	Service providers/equipment	Consultants, research institutes, technology providers, and in-house company equipment
	Training/CPD	Training and professional development

Those highlighted in grey are typically recognised as key constraints in mineral exploration, although the remaining constraints outlined here also play a significant role in influencing decision-making.

Within a sporting context, an example of emergent and creative decision-making might be a mid-field soccer player identifying an opportunity (affordance) to make a pass, such that an attacking player can move into a position to potentially score. Here, the mid-field player perceives unfolding opportunities to exploit space, time, and movement (constraints) as a result of representative practice experience. During mineral exploration, geoscientists are similarly required to become attuned to meaningful specifying information, as outlined in Table 1 (constraints), to predict the likely location of an undiscovered economic ore deposit that can be subjected to exploration activities (affordances) such as drill-testing or additional data collection. Hypotheses regarding the location and quality of undiscovered ore deposits are generated, tested, and adapted based on perceived affordances available to an individual, within the constraints of a specific time and situation [56]. Differences in individual knowledge, perception, motivation, and meaning shape the influence of constraints and account for diversity of perceived affordances and resultant decisions, even when identical constraints are presented to separate explorers [54]. Finally, the results of

hypothesis-testing actions are observed, and the perception of constraints and affordances are subsequently adapted, both explicitly and implicitly [57]. The learning outcome is influenced by perception of action outcomes, meaning that the provision of objective and subjective feedback plays a significant role in the learning process and on-going development of expertise.

1.9. Learning and Expertise

Critical to improving exploration decision-making is understanding the differences between novice and expert explorers, and how one might transition from one to the other. Expertise can be loosely defined as being more attuned to specifying information, along with the creativity to recognise appropriate affordances for actions that lead to the discovery of new ore deposits. This requires the explorer to be perceptive of the constraints, including those outlined in Table 1, and able to recognise geoscientific patterns and features representative of key ore-forming processes and other specifying information within any set of dynamic and complex constraints. To do this, the explorer needs to gain experience that is representative, valid, and diverse.

For learning to be effective, it must take place in an authentic environment, containing perceptual information and affordances that are representative of the environments into which the skill will later be transferred [58,59]. If affordances are representative, then the learner can develop accurate declarative and tacit knowledge and an attunement to key information in the environment. With a broad base of relevant experiences, the learner has the opportunity to develop attunement to perceptual information in varied contexts, allowing them to recognise invariant cues and distinguish them from incidental information. This supports learners in the transfer and adaption of expertise into contexts containing novel constraints. Exploration targeting represents a complex domain, in which professionals are regularly presented with situations and tasks that are novel, requiring utilisation of a broad base of knowledge, sometimes developed for other purposes. A risk faced by mineral explorers is that their skill sets are too narrow, often focused on a single discipline (e.g., core logging, structural geology, geochemistry or geophysics), or a single deposit style or jurisdiction (e.g., orogenic gold in Western Australia, or sediment-hosted copper in the Central African Copperbelt). This represents fractionated expertise, meaning explorers are therefore not able to apply the Mineral Systems Concept to varying contexts or environments, such as the transition to new search spaces or different styles of mineralisation.

2. The Dynamics Model

Ericsson et al. [47] proposed that variations in individual expertise are predominantly a result of experience (e.g., "The best geologist is he [sic] who has seen the most rocks:" [60]), as opposed to factors such as innate talent. However, there are examples of experts reaching similar levels of ability within considerably different timeframes (e.g., Chess master level status reached in both 3200 and 23,000 hours of practice [61]), raising an important question regarding the influence that quality of experience has on developing expertise.

Ecological Dynamics and other non-linear pedagogy-based research has resulted in a growing number of studies examining key factors that influence the rate at which expertise is achieved: (a) autonomy-supportive learning environments [62–64]; (b) motivation [65,66]; (c) effect of anxiety on performance [67]; (d) perception-action coupling [68]; (e) embodied cognition [69]; (f) affective learning design [58]; (g) development of coordinative structures [70]; (h) judgment and decision making [71], (i) the need for adaptive expertise [72]; and (j) that expertise is only gained from experience in an environment with valid cues and opportunity for feedback [73].

Based on this research, Davies and Davies [9,10] presented the Dynamics model of decision-making and learning, shown in Figure 3, to more clearly define the influence that human psychological needs and experiences have on the development of adaptive expertise. The Dynamics model is based on an Ecological Dynamics framework, specifically

Newell's [49] constraints model. The 'energetic' organismic (individual) constraints are separate in the Dynamics model, to highlight their importance in the design and management of learning environments. The energetic constraints combine motivation, using Self Determination Theory (SDT [34]), arousal and focus of attention. The model also includes iterative feedback loops to the energetic and more stable individual constraints, to define an autopoietic (i.e., self-organising and self-regulating) system. Key elements recognised in the model are that learning is a non-linear process [74] (Ennis, 1992) and that motivation, intention, effort and focus of attention are the initial start points, defining the quality of individual input into learning and decision-making [10,75]. Focus shifts from acquiring specific knowledge or skills toward learning-to-learn and creatively solve problems.

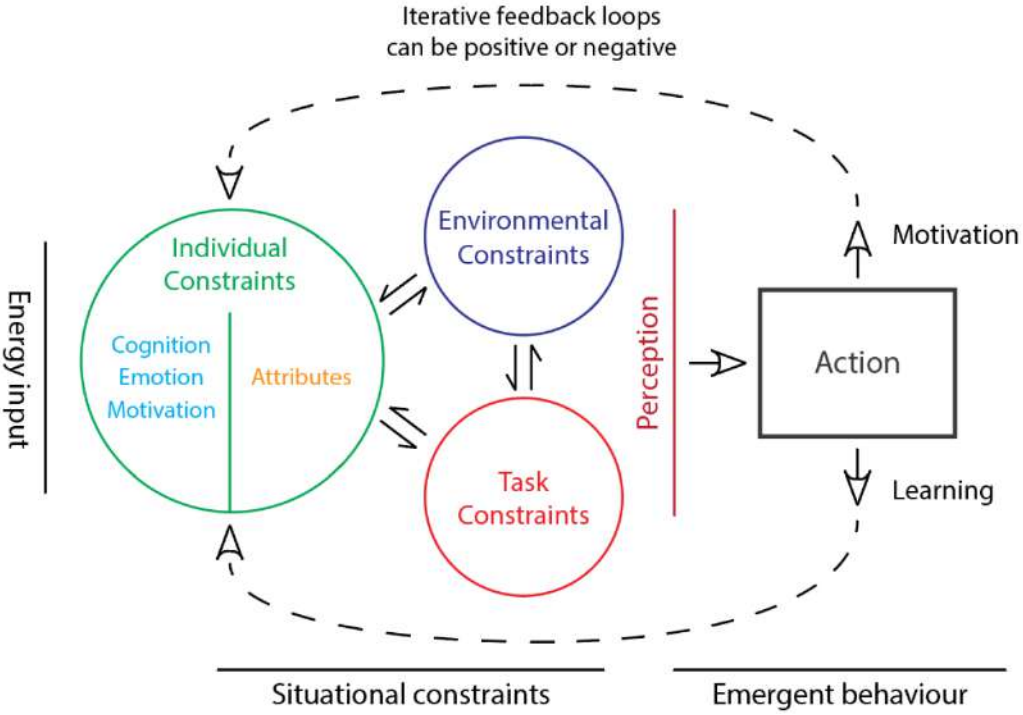

Figure 3. Dynamics model for decision-making and learning, adapted with permission from Davies, M.J. and Davies, R.S. [9]. Motivation is the initial start point, defining the quality of individual input into learning and decision-making tasks. Decision-making behaviours are shaped by intentions and perception of available affordances, within situational constraints. These constraints are broadly categorised into individual, environment, and task. Differences in individual perception, motivation and meaning shape the influence of constraints and account for diversity of decisions. Within mineral exploration, these decisions can include activities such as collecting additional geoscientific data (e.g., airborne geophysical surveys, surficial geochemical sampling), direct drill-testing of targets, or even choosing to relinquish ground. The results of hypothesis-testing actions are observed, changes in perception and decision-making may be implicit or explicit making them more difficult to identify, the influence of constraints may be redefined, and hypotheses subsequently adapted. This process of active learning results in perception-action coupling, where feedback or results have an impact on individual learning and motivation, through a learning feedback loop, defining an autopoietic (i.e., self-organising and self-regulating) system.

The model guides investigation of constraints and their complex inter-relationships. Over time, different constraints will have a greater or lesser influence in defining affordances. For example, changes in commodity prices will have a greater or lesser impact when combined with other constraints such as changes in technology, social perception, or legislation. From a skill development, creativity and risk-taking perspective, changes in constraints such as management culture, power relationships, training programs, and reward systems are all likely to have mutable and complex influences.

Dynamics Challenge-Performance Curve

The Dynamics challenge-performance curve, shown in Figure 4, presents the complex relationship between demands or variability of a task and expected performance output, where individual, task and environmental demands, contained in the Dynamics model, are combined to represent overall challenge [76]. An important feature in the Dynamics curve is the 'ugly-zone' (a term coined by Alred [77]), defining the region beyond current ability in which stable performance begins to deteriorate, converging on a transition or bifurcation point. Within this zone, the learner explores solutions related to new implicit and explicit problems, providing opportunity for generation of innovative ideas, coping strategies, and step changes in understanding as new affordances. Here, the learner has an opportunity to acquire a broad and diverse range of experience, thus increasing their relative level of expertise. However, operating in the 'ugly-zone' requires confidence and resilience and can feel awkward or regressive. An integral risk of learning in the ugly-zone, is the potential for a collapse in performance, arising from the learner becoming overwhelmed or over-challenged. For this reason, it is important to recognise that, during the development of expertise, failure will likely be the *status quo*. The ugly-zone must be perceived as a place of opportunity to vary search and exploration strategies, rather than an area of risk, or failure. As such, self-determination and energetic constraints are highlighted as fundamental to creativity, problem-solving, and the development of expertise. The incorporation of 'safe-uncertainty' into practice environments and activities is a key environmental enabling constraint for success.

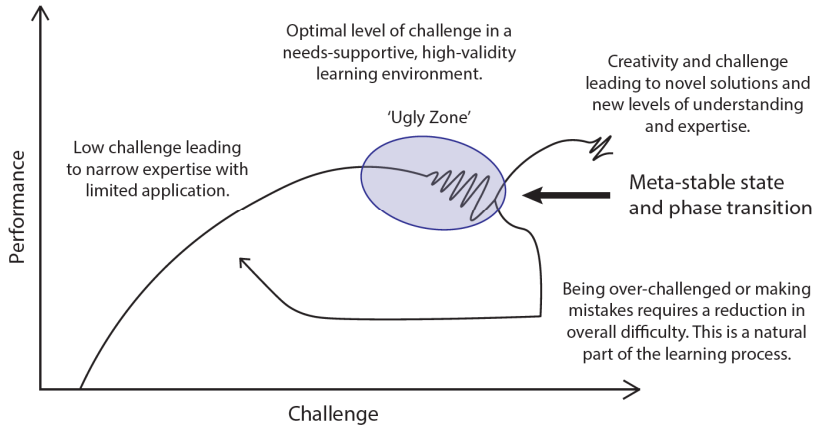

Figure 4. Dynamics challenge-performance curve, adapted with permission from Davies, M.J. and Davies, R.S. [10]. The complex relationship between demands of a task and expected performance output are represented by a performance curve, where individual, task, and environmental demands are combined to represent overall challenge. Limited overall demands result in a performer remaining under-challenged, lacking the opportunity to expand their expertise. With increasing difficulty, performance trends upwards towards the ugly-zone; a point of optimal challenge, where the opportunity to develop expertise is maximised, as new implicit and explicit affordances become available through interaction with dynamic constraints in real-time. Within the ugly-zone, performance becomes unstable, converging on a bifurcation point and presenting the risk of errors being made, or a drop in performance arising from the learner becoming overwhelmed or over-challenged. The curve shows that to get back to the optimal performance, overall challenge needs to be reduced significantly to allow reflection and learning (hysteresis). Despite this risk, it is important that the ugly-zone be perceived as a place of opportunity for learning and development of expertise within a well-managed, needs-supportive learning and performance environment.

The Dynamics curve and the Dynamics model, used together, can support the development of expertise in exploration decision making. The Dynamics model supports the identification of influencing constraints, thus providing guidance to inform the manipulation of constraints to create optimal learning experiences. Skilfully manipulating

constraints will promote learners to become attentive and attuned to specifying information at appropriate levels of challenge, within representative learning environments.

3. Discussion

The Dynamics model and learning curve support the development of management practices and training interventions, by providing a framework for understanding and, where possible, influencing the complex interactive and adaptive constraints that shape exploration decision-making. It is evident that the complex nature of human behaviour and decision-making must be considered within the wider individual-task-environment system. This includes the impact of goal directed behaviour, carried out in a landscape of perceived affordances, within the constraints of a particular system. Training interventions that focus solely on intellectual decision-making, or the role and influence of the individual, will fail to be effective where motivational, company structure, task, socio-cultural or other limiting factors significantly shape current behaviour.

3.1. Constraints Shaping Exploration Decision-Making

3.1.1. Goal-Directed Behaviour and Task Constraints

Goal setting is important when producing corporate and exploration strategy statements, as well as defining Key Performance Indicators (KPI's) as guiding intentions. Strategy statements outline business-wide long-term aspirations and goals and KPI's guide the focus of attention and the affordances perceived by employees as they work towards these goals. Well-defined goals provide clear task-related constraints for employees and teams in decision-making positions, helping to mitigate against excessive degrees of autonomy or risk-taking behaviour. Without this guidance, employees may struggle to effectively orientate their actions within an organisation, leading to splintering and 'siloing' of teams. Process goals are preferred over outcome goals, as they promote greater degrees of uptake and motivation [78]. Process goals define expected quality of an activity and, given the decision-maker typically has limited control over final outcomes in mineral exploration, presents an achievable objective. Realistic goals should guide, but not overly constrain, autonomous, creative decision-making within an organisation, through the provision of well-defined strategy statements and KPI's.

The provision of strategy statements and KPIs within mineral exploration should be treated with care. Given the predominant industry focus on mineral extraction, there is a risk that those in senior management positions of a non-technical background lack a detailed understanding of the exploration process, which more closely resembles research and development activities than the mining extraction process. The degree of uncertainty associated with exploration activities often leads outcome orientated KPIs to promote non-beneficial behaviours. A simple example is the introduction of a KPI that requires an exploration team to review a large number of projects per year, leading to limited resources being stretched across those projects, thus reducing the quality of each individual review.

3.1.2. Company Culture, Leadership, and Other Environmental Constraints

Several efforts have been made to define key aspects of company culture that influence exploration success. Towards developing a philosophy of oil exploration, Wallace Pratt [79] commented that "oil is first found ... in the minds of men," recognising the value of vision and creative thinking in exploration. Masters [80] suggested that adopting the characteristics of a small company was vital to success in oil exploration, trading control and routine for innovation, motivation, and speed, passing power down and providing employees with the freedom to both grow and fail.

Most notable within the minerals industry are the writings and interviews of Roy Woodall [6], widely recognised as playing a significant role in the success of Western Mining Corporation (WMC). Interviewed by Stanton [81], Roy Woodall stated that building a successful exploration company starts with the people, and that he conducted recruitment personally. The successful WMC team was brimming with creative intellectual energy

but could be a tough group of individuals to manage. In their report on the successful management of minerals exploration, McKinsey Company [82] stated that management and leadership play an important role in exploration success, and that "good explorers can be made as well as born." In an SEG Newsletter, Dan Wood [83] considered that exploration is "an art informed by science." Amongst other things, Wood suggested that risk-taking, creativity and a 'discovery culture' are critical areas that govern exploration success, sometimes preferring low-tech solutions that focus creative thinking over the latest computational or statistical methods. Wood and Hedenquist [84] suggest that improvements to business models and the predictive way geologists think when exploring are key to improving exploration success rates, with technological developments playing only a supporting role.

Although many companies within the minerals industry aspire to creating learning organisations, there is a persistent culture of error and risk aversion, lack of feedback, unfilled 'near-miss' books, and of rewarding 'safe' decision-making. Decision-makers must develop the ability to conduct appropriate risk-benefit analyses, where risks are identified up-front and considered against their potential exploitation, rather than simple elimination or justification [71]. Company reward and punishment systems [85], as well as an ego element of not being seen to make mistakes [72], further constrains creative decision-making and learning within mineral exploration. Critical to improving culture within the minerals industry is the degree of autonomy provided to each exploration geologist and an acceptance of the uncertainty and technical risk associated with conducting exploration and learning within the ugly-zone. However, providing autonomy, as part of a needs-supportive environment, should not lead to abdication of responsibility by management.

3.1.3. Motivation, Autonomy, and Risk-Taking

In his 2012 paper, Andrew Curtis [86] stated that "scientists should . . . not be ashamed of subjectivity, but should strive to . . . reduce its effects." This statement stands contrary to most research conducted into human intuition and decision-making, where decisions are made within a set of highly complex constraints, with incomplete knowledge of a context and expected outcome. Decisions, such as choice of research questions, methodologies, and interpretation of results, are fundamental to the scientific method, but are rarely measurable or quantifiable prior to their completion. As such, it is advised that exploration geologists embrace subjectivity in decision-making, with recognition of the importance of experience and creativity in making successful subjective estimates and interpretations, especially in conducting predictive exploration targeting.

As outlined by the Dynamics challenge-performance curve (Figure 4), the ugly-zone should be perceived as a place of opportunity. By increasing variability, there is opportunity to become attuned to new affordances, ultimately driving effective learning and the development of more adaptive expertise. Many of the constraints presented within mineral exploration are project-specific, meaning the exploration geoscientists operating 'on the ground' have access to the most detailed and up-to-date information. As such, the responsibility for decision-making will typically be in collaboration with more junior employees. To support these decision-makers, management must clearly articulate corporate strategy, goals, and broad environmental constraints.

Additionally, attaining a culture of creativity and adaptive expertise requires the motivational climate of a company to support the psychological needs of the employees, providing an appropriate degree of autonomy to take risks, without undermining their ability to learn or perform. In any context, humans are inherently driven towards personal development and satisfaction of three basic psychological needs: autonomy, competence, and relatedness [87]. If psychological needs are met, humans tend to possess greater motivation and feelings of competence [88], actively seeking out meaning and cues to support autonomous decision-making [34]. In contrast, when tired, under pressure, or emotionally challenged, humans are susceptible to heuristic biases, substitution, and risk-aversion [89].

3.1.4. Practical Training Interventions

Given shareholder capital is generally used to conduct exploration activities, there is a requirement for exploration companies to mitigate against excessive risk-taking. In this instance, the operating constraints within the industry reduce the potential of the learner to develop adaptive expertise, by limiting their ability to test and adapt innovative hypotheses or attune to affordances by exposing themselves to challenging decision constraints. Davies et al. [39] also recognised that certain aspects of exploration targeting are likely to have low-validity [89], where noisy or highly complex situations present a lack of decision-feedback, rendering genuine expertise unachievable through typical work-related experience and learning. This is compounded by the limited number of projects upon which an exploration geologist is likely to have worked during their career.

Although several studies have highlighted the ability of algorithms to outperform professionals in low-validity environments [90], these studies found that forecasts made by algorithms were generally incorrect, albeit less often than in human predictions. The superior performance of algorithms in low-validity environments is attributed to consistency [91], an undesirable trait in mineral exploration, where targeting activities are in competition with previous explorers, signifying that consistent or repeated activities are more likely to result in failure after an initial effort (sampling without replacement). To mitigate against these limitations, a number of on-the-job training methods have been proposed, including: observation of experts, professional discussion in communities of practice, experimentation with differing strategies, engagement in after-action reviews, and coaching from others with wider experience [92]. However, since certain aspects of exploration targeting are recognised as challenging and potentially low-validity, it is unlikely that sufficient expertise exists within industry to conduct wide-spread, on-the-job training [39].

Hogarth and Soyer [93] and Singer [94] suggest that simulated experiences can be provided to promote the development of expert intuition. As such, it is advised that practical scenario-based exploration targeting training courses should be developed, perhaps using virtual or augmented reality environments, based on real scenarios to ensure that contextual information is relevant and valid. Using these technologies, training environments can be designed appropriately for each individual learner, providing a representative learning environment within which decision constraints are carefully selected to promote positive exploration behaviours, as well as the recognition and understanding of key explicit and implicit information in a realistic exploration environment. This is achieved through highlighting key information sources, providing appropriate feedback, and promoting development of perception-action coupling, expertise, and resilience within a needs-supportive learning environment.

Such training interventions could involve presenting the learner with information (constraints) relating to the location of economic ore bodies. Using this information, the learner would present their hypotheses regarding the location of ore bodies and propose exploration programs (based on perceived affordances) to test these hypotheses. The complexity of decision constraints would be adapted based on the level of expertise of each participant. The design of these courses would utilize simulation programs, presenting the learner with realistic scenarios containing real exploration data to match future performance environments [10,46] and include sources of both implicit and explicit knowledge [57]. To achieve this, participants would be provided with comprehensive geoscientific datasets, but characteristics and locations of known deposits would be withheld. Each individual participant would work through the exercise to produce predictions for the size, quality, and locations of undiscovered deposits within the study area, and devise an appropriate exploration program with which to test these hypotheses. The training course methodology would outline a broad framework, but still allow a high degree of individual flexibility. This allows each participant to adapt individual strategy to gain maximum benefit from their personal background and expertise, as well as devise novel affordances for testing varied hypotheses. Although initial predictions would be conducted in isolation,

to promote engagement and divergent thinking [78], the exploration team could then come together to discuss individual predictions and reasoning, allowing for discussion and a group consensus to develop. Finally, upon completion of the exercise for a given study area, known deposit information would be presented to the participants to simulate the results of a comprehensive exploration program. This provides immediate feedback to the participants, allowing them to compare their predictions with the real-world deposit information. Opportunities for feedback, comparison and reflective learning might also be improved through guidance from qualified trainers. By conducting such training exercises, for a suite of study areas covering different geological environments, deposit styles, and jurisdictions, it would be possible for an exploration team to acquire experience, typically gained over decades in an exploration career, in a matter of days or weeks. Most importantly, this experience would be acquired in a safe environment, without risk to either career progression or shareholder capital.

4. Conclusions

It is proposed that an increase in creative and challenging problem-solving exercises, during application of the Mineral Systems Concept, has the potential to result in the development of widespread search expertise and improved long-term exploration outcomes. Through application of the Dynamics model, influential constraints can be identified and leveraged. Constraints that are limiting creative problem solving, for example traditional risk-adverse company culture, can be reduced, while enabling constraints can be amplified. In combination with the Dynamics challenge-performance curve, several areas are recognised as having significant influence over the quality and creative aspect of exploration decision-making. Explorers require a degree of autonomy to be confident enough to enter the ugly zone, take risks, and test novel search ideas. Clear goal-oriented strategies provide a focus of attention to relevant information, and management can provide a framework to mitigate and challenge excessive risk-taking and minimise consequences of inevitable failures. Finally, development of appropriate scenario-based training courses is identified as a critical suggestion, providing an opportunity for explorers to develop an accurate perception of situational constraints, and conceive affordances for testing novel exploration targeting hypotheses, thus significantly improving the quality of decision-making and learning outcomes throughout the exploration industry. Since energetic individual constraints define the quality of individual input into learning and decision-making tasks, each of the above suggestions must be provided within needs-supportive learning and working environments so as to maintain motivation, effort, and focus of attention throughout the exploration process.

Adoption of these concepts is required by the industry to present working environments that allow for effective application, and further development, of creative exploration targeting expertise. Further research is suggested, regarding each sub-discipline and their application to mineral exploration, as well as other industries and research organisations.

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Powder Fever and Its Impact on Decision-Making in Avalanche Terrain

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Abstract: We examined the effect of emotions, associated with "powder fever", on decision-making in avalanche terrain. Background: Skiing in avalanche terrain is a voluntary activity that exposes the participant to potentially fatal risk. Impaired decision-making in this context can therefore have devastating results, often with limited prior corrective feedback and learning opportunities. Previous research has suggested that arousal caused by emotions affects risk assessment and intentions to engage in risky behavior. We propose that powder fever may induce similar responses. Methods: We used the following two experimental methods: laboratory studies with visual visceral stimuli (ski movies) and a field study with real stimuli (skiing exciting terrain). We evaluated the effect of emotions on attention, risk assessment, and willingness to expose oneself and others to risk. Results: Both the laboratory studies and the field study showed that skiing-related stimuli had a relatively strong effect on reported emotions. However, we found very few significant effects on decision-making or assessment of risk. Conclusions: Skiing activities make people happier. However, despite the clear parallels to sexual arousal, powder fever does not appear to significantly impair decision-making in our study. More research on the effects of powder fewer on milder forms of risk-taking behavior is needed.

Keywords: affect; arousal; decision-making; risk assessment; risk-taking

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1. Introduction

Backcountry skiing, known as off-piste in Europe, is a rapidly growing leisure activity [1,2]. People who engage in backcountry skiing either ride in potential avalanche terrain that is in near proximity to ski areas but not controlled by the ski patrol [3,4], or in remote mountainous areas. Like many other outdoor sports, backcountry skiing is associated with risks. In the backcountry, riders face the risk of avalanches in addition to other risks, e.g., injuries caused by a fall or by severe weather. Each year, an average of 100 people in the European Alps, and 40 people in North America die in avalanche accidents [5–7]. This does not include near miss accidents where injury rather than death was the result. In 90% of all fatal avalanche accidents, the victim or a member of the victim's group is the triggering mechanism for an avalanche [8]; therefore, the decisions made by an individual or group play a crucial role in safe ski touring practice.

Research has demonstrated that people experiencing strong emotions (a so-called hot state), such as sexual arousal [9] or anger [10], express higher risk-taking propensity than people in a neutral state. Ariely and Lowenstein [9] showed that sexual arousal had a strong impact on judgment and decision making related to sex. Rydell et al. [10] examined intergroup anger and found that anger reduced the systematic processing of persuasive

messages and, when compared to intergroup fear, increased risk taking. These two studies suggest that hot states may impair judgments and decision-making.

In this paper, we tested if emotions associated with "powder fever" affect skiers' attention to danger signs, risk perception, and willingness to expose themselves and others to risk. Powder fever is a concept used by riders (skiers, snowmobilers, etc.) to describe the euphoric feeling and excitement, or anticipation that arises when they either ride or anticipate riding fresh snow or "powder". Given the impact that sexual arousal and arousal invoked from anger have been demonstrated to have on decision making, it seems plausible that powder fever may also influence decision making in this specific setting. A better understanding of the link between the emotions associated with powder fever and decisions in avalanche terrain hold potential to improve our understanding of avalanche accidents and lower the costs of poor decisions. The reduction in avalanche accidents and injury has clear benefits to the immediate skiing community but also for others who may be endangered by the unsafe practices of others (i.e., causing an avalanche to release on a skier's downslope), causing search and rescue resources to be deployed, and endangering others in an avalanche rescue scenario [11]. In addition, knowledge on the link between emotions and risk assessment in the backcountry could improve our understanding of excessive risk taking in other leisure activities. This is especially important during pandemic conditions when medical resources are stretched thin and volunteer responders are potentially exposed to COVID-19.

1.1. Emotions

Emotions influence literally all aspects of human functioning such as attention, inference, learning, memory, physiology, self-concept, goal choice, perception, and decision making [12,13]. The very function of our emotions is to assist us in adapting to the environment by guiding our attention and prepares us to act according to a goal. However, since emotions focus our attention on one goal, they can detract from competing goal pursuits [14,15]. Although our emotional reactions depend on both dispositional and situational factors, many theorists claim that the emotional system can be organized into two distinct motivational subsystems; pleasant affect and unpleasant affect [16–19]. Several studies report that experiencing positive emotions is among the key motivational factors for taking part in backcountry skiing, or other challenging activities [20–22].

Different emotions activate a predefined set of cognitive "checklists" and primes us for a set of actions [14]. Emotions thus save cognitive processing by triggering what Levenson [23] calls time-tested responses to universal experiences such as loss, sexual attraction, or a threat. In the case of a threat, the feeling of fear sets up our cognitive and endocrine systems to confront the danger and puts our body in a fight or flight mode. When we experience fear, we produce adrenaline, our heart rate and blood pressure increase, and our facial expression, vocal pitch, and body posture change [24–28]. In terms of action readiness, all ongoing activity terminates, and our focus is solely directed to the source of danger, preparing us to execute appropriate counter actions. On the positive side, happiness is a reward for reaching a goal or making progress on a plan [14].

1.1.1. Hedonic and Eudaimonic Emotions

The distinction between making progress and reaching a goal is significant. Several scholars make a distinction between hedonic emotions such as pleasure, satisfaction, and happiness and eudaimonic emotions such as interest, enthusiasm, and engagement [29,30]. From a physiological point of view, the function of hedonic emotions such as pleasure is to signal to the body that a return to a homeostatic set point has been achieved, such as eating when hungry or becoming warm after being cold [30]. From a psychological point of view, the function of hedonic emotions is to signal that a goal has successfully been reached [31]. Eudaimonic emotions such as interest, enthusiasm, and engagement, in contrast, serve as motivational signals that propel one toward a goal. This is elegantly summarized in a paper from Barbano and Cador [32] titled: "Opioids for hedonic experiences and dopamine

to get ready for it". The authors claim that dopamine seems more important in approach or "wanting" behavior, whereas hedonic emotions seem regulated by other brain systems responsible for reward, tied to endogenous opioids. Even though the two kinds of positive emotions serve different functions, they are both positive [31]. Powder fever likely has elements of anticipation and reward, we therefore include both classes of positive emotions in our study.

Emotions also guide the magnitude and direction of our depth of thought or deliberate reasoning. In general, a negative situation will lead to the deployment of more deliberate resources while a positive situation needs fewer deliberate resources. However, there are differences between the two classes of positive emotions. Eudaimonic emotions like interest motivates focused attention over time [33] whereas happiness leads to a broadening of attention [34]. Decision-heuristics are simple rules of thumb, which reduces the effort of making a decision to arrive at satisfactory outcomes/solutions [35]. The use of heuristics does not necessarily lead to poor decisions. Numerous studies have shown that simple heuristics match or even outperform more complex decision algorithms in several fields such as medicine, finance, management, and law [36–39]. However, heuristics necessarily trade off some accuracy for less effort [35]. Emotions affect our tendency to rely on heuristics when we make decisions [36,37]. For example, happy people appear to be more prone to use heuristics than fearful people [13]. Angry individuals perceive negative events to be under human control, and brought about by others, whereas people that are afraid perceive the negative events to be unpredictable and under situational control. Hence, emotions that signal high control, such as anger or happiness, will result in substantially lower risk perception compared to emotions that signal lower levels of control such as fear [38].

1.1.2. The Link between Emotions and Risk-Taking in Sporting Activities

Engagement in sporting activities give rise to a range of emotions that hold power to affect risk estimates, judgements, and ultimately decisions to take risks. Several mechanisms create these links.

First, when we engage in sport, we often compete either with others, or with ourselves. Competition gives rise to the fear of losing and has been shown to increase willingness to take risks [39,40]. Second, physical activity gives rise to arousal, e.g., via an increase in the heart rate. Previous research has shown that activity-induced arousal reduces risk estimates and risk judgments [39,40], and can increase risk-taking [41]. Black et al. [41] demonstrated that people who first engaged in a competitive exercise (playing tennis), took more risk in an unrelated task immediately following the exercise.

Black et al. [41] proposed the following two explanations for their findings: (1) the increase in the level of dopamine from the intense exercise leads to a search for further stimulation through risk-taking, and (2) the tiredness from the intensive exercise induces performance errors. The second explanation has been supported by research, which showed that the tiredness resulting from physical activity limits cognitive abilities [39,42].

Third, endorphins released during physical exercise affects emotions (primarily a reduction in anxiety) and mood states [43]. A mood state is a psychological condition that is typically of longer duration, more general, and less intense than an emotional state. Mood states directly influence risk perception and risk-taking behavior. Negative mood states are associated with increased risk-taking tendencies, whereas positive mood states are associated with lower risk taking [44–46].

Fourth, challenging physical activities can produce a pleasant state known as "flow". The sense of "flow" may occur when the challenge match or slightly exceed our level of skill [47,48] i.e., when we are just barely in control. Feelings of control reduce the perceived risk [37,38]. Delle Fave et al. [46] noted that the opportunity to experience "flow" acted as a motivating factor for high altitude climbers to take part in risky expeditions. Similarly, Raue et al. [40] found that the combination of physical activity and feelings of control

distorted the risk perception of indoor climbers. By contrast, fear is related to a lack of control and, therefore, increases the perceived risk [38].

1.1.3. Emotions and Risk Exposure in Avalanche Terrain

Skiing in avalanche terrain is a complex, and physically and emotionally rewarding activity with the potential for high levels of excitement [20]. In avalanche terrain, people with bounded knowledge and information need to make complex decisions about terrain, snowpack, and group dynamics, often under time and weather constraints. They further must balance the risk of being caught in an avalanche to the reward of skiing powder in potentially dangerous terrain.

Other than the most obvious signs of instability, a mountainous snowpack is relatively opaque, and highly variable with respect to avalanche hazard. Furthermore, the snowpack also provides poor decision feedback; that is, we may not always receive immediate or accurate feedback to our decisions to ski selected terrain, and the absence of corrective feedback (i.e., an avalanche or other signs of instability) empowers continued, potentially incorrect decisions. This is often referred to as a "wicked" decision environment [49]. The "wickedness" of the learning environment adds to the complexity of the decision space. Decision making in this setting is more complicated than kind learning environments.

The most effective way to avoid avalanches is to avoid avalanche terrain altogether. From a recreational skiing perspective, however, avoidance is typically not realistic for most users because the more favorable ski terrain is often also potential avalanche terrain. Skiers have therefore adopted a set of behaviors to mitigate hazardous terrain. A typical backcountry ski tour would consist of a small group of enthusiasts traveling to a ski tour destination (e.g., a specific trailhead/parking area), after acquiring the detailed avalanche forecast (if available) from an avalanche forecast center in their region. They would then assess their tour plan and make their way to the ski destination—typically a snowfield or alpine summit from which they would determine a descent route based on snowpack stability. The route both up and down would be contingent on a complex skill set that includes an ability and willingness to hold an ongoing group discussion of weather, time, and distance constraints; risk assessment of terrain and snowpack; as well as an assessment of group expertise and level of risk aversion. In addition, all the members of the group would carry tools that aid in locating a buried avalanche victim. These include an avalanche transceiver, probe, and a shovel for extrication. The combination of planning and communication coupled with rescue equipment are minimal expectations of behavior among skiers, and the absence of these would be considered to increase the risk to an unacceptable level in most groups. Other high-risk factors include skiing alone in risky terrain under elevated hazard conditions or skiing very exposed terrain with severe consequences when the avalanche hazard is high.

In response to the relatively high number of fatalities caused by human decision errors, there has been an increased emphasis on understanding the role of decision making in avalanche terrain in recent years [2,11,50–56]. In the avalanche community, decision making, and the factors that influence these processes in avalanche terrain has broadly been termed the "human factor" [57]. The awareness of these human factors was greatly increased by the pivotal work by McCammon [58,59] where he attributed decision failures to social dynamics (i.e., gender mix, leadership, the presence of others) but did not specifically consider either the role of physical activity or emotional state on the decision-making process. His use of a post-mortem approach to fatal accident analysis could not determine the emotional state of skiers at the time of the accident. Understanding how emotions affect judgement and decision-making in complex environments, such as avalanche terrain, is important. If emotions have an effect, and if people fail to recognize this, they are likely to be caught by surprise both by their own and others' behavior [9]. In a series of studies aimed at assessing the affective state of skiers with respect to risk, Stephensen and Matiny [60] presented backcountry skiers with a range of terrain scenarios and asked them to rate how much they liked it, and then how risky they found the descent. Across all the

studies, backcountry skiers judged the scenarios they liked to be less risky. Tiedens and Linton [61] demonstrated that high certainty emotions such as happiness and anger lead to less deliberate thinking. Low certainty emotions such as sadness and fear lead to higher levels of deliberate reasoning.

1.2. Aims of the Study

This research has expanded the notion of human factors in avalanche accidents by employing methods from Ariely and Lowenstein [9] to understand how emotions, associated with powder fever, may or may not alter skier decision making in potentially dangerous backcountry circumstances. The aim of this paper was to answer the research question: "Do emotions, linked to powder fever in the backcountry, affect the assessment of, and the willingness to expose oneself or others to, take risks?"

Our theoretical framework is summarized in Figure 1, below.

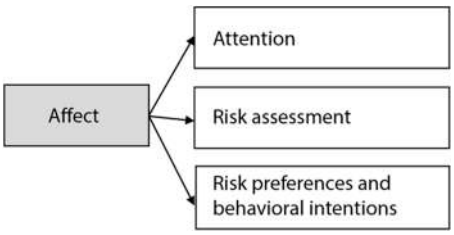

Figure 1. Theoretical framework.

Our work pursued two complementary lines of inquiry to evaluate how emotions affect risk perception, judgment, and behavior. One method used movies to induce positive and negative emotional states, and the other approach used the in-person experience of skiing powder. Our first two studies attempted to test the effect of emotions on attention to danger signs and risk judgements with visual visceral powder stimuli (ski movies). Specifically, we tested the role of media viewing on risk perception using both a positive and negative viewing experience. We tested for changes to both risk evaluation and personal risk perception resulting from respondents' viewing experience.

In the third study, we emulated prior work by Ariely and Lowenstein [9] examining decision-making under sexual arousal, but rather than sexual arousal, we examined the effect of powder fever by means of real powder stimuli (skiing exciting terrain in good snow). Specifically, we wanted to examine if powder fever affects intentions to engage in risky behaviors in the specific setting of avalanche terrain. Across all three studies, we also wanted to examine and compare if the method of invoking the stimuli affects the magnitude and direction of the measured response.

2. Study 1

2.1. Materials and Method

2.1.1. Hypotheses

Hypotheses 1 (H1). *Participants judge risk to be lower after seeing a positive ski film compared to participants seeing a negative ski movie.*

Hypotheses 2 (H2). *Attention to signs of danger (avalanche clues) is lower (higher) after seeing a positive (negative) ski movie.*

2.1.2. Participants

We posted an invitation to participate in an experiment in Tromsø, Norway, on the CARE Facebook page (@careuit). Participants were told that they would see a movie and answer a short questionnaire, and that pizza would be served. Fifty-four subjects (16 female, 38 male) aged 20 to 48 years (M = 27.54, SD = 5.71) participated in the experiment on two separate evenings. Of these, 44 provided complete answers to all questions.

2.1.3. Procedure

The experiment had the following three parts: A pre-survey, a movie treatment, and a post-survey. We sent out the pre-survey via email to all participants who signed up for the experiment. The pre-survey contained questions about backcountry skiing experience and skills, avalanche education, and risk preferences. The participants indicated their informed consent on the first page of the questionnaire. Only participants who filled out the pre-survey were invited to the movie experiment.

The movie experiment took place on two evenings, one to two days after the pre-survey. We screened a movie with positive emotional content on the first movie night, and a movie with negative emotional content on the second night. Both movies were approximately 15 min long. We allowed participants to choose which night to participate in the experiment. Participants knew that the movies would be about skiing but were unaware of the screening order.

During the movie experiment, participants were instructed to open, but not start the second survey (post-test) on their mobile phone before the movie started. They then watched the movie for 15 min. Immediately after the screening, participants were asked to advance to the first page of the survey, where they answered questions about their emotional response to the movie. The second section of the survey assessed participants' ability to identify relevant informational cues. We sequentially showed a set of 12 photos (3 s each), and thereafter asked participants to identify which cues had and had not been shown. The method to ask participants to rate or evaluate photos of avalanche prone descents has been used in previous studies [56,60]. The last section of the survey focused on risk assessment. Participants sequentially saw 15 different pictures (7 s each) of backcountry ski runs. After a run was displayed, the participants were asked to evaluate how risky it would be for them to ride the run under similar conditions. The experiment ended when all 15 runs had been displayed and evaluated. The photos and risk scenarios were shown on a large screen placed in front of the participants in an auditorium (same as the ski movie). Consequently, the order of presentation was the same for all participants. The experiment was reviewed and approved by the Norwegian Center for Research Data prior to data collection (NSD 56569).

2.1.4. Materials

The movie experiment had the following two treatments: positive and negative affect. We induced positive affect via a movie showing skiers successfully riding steep terrain in good snow, and negative affect via a movie showing skiers being involved in an avalanche accident (links to films and images used in this study are available through osf: https://osf.io/36dhf (accessed on 7 August 2021)). We chose to use ski films, since movies have been found to induce stronger arousal than pictures do [62].

We measured participants' emotional reactions to the movie stimuli with two questions: (1) "We would like to reflect on your current feelings and answer what type of feelings this movie elicited" (scale: 1 "very negative emotions", 4 "neither positive nor negative emotions", 7 "very positive emotions"), and (2) "How much would you say you liked the movie?" (scale: 1 "not at all" to 7 "Very much").

To evaluate if the movie stimuli influenced attention and information seeking, we used a series of 12 photos taken on backcountry trips. The pictures contained both relevant avalanche danger signs (e.g., fresh avalanches, wind-loaded snow) and irrelevant information (e.g., a snowboard, a helmet camera, see the Appendix A). Participants indicated what they had seen in the pictures on a list containing 8 relevant avalanche danger signs and 7 irrelevant information clues. We used the number of correctly identified danger signs as a measure of attention. We used the following two trait measures to evaluate potential differences in risk preferences between the two treatment groups: the "Brief Sensation-Seeking Scale" (BSSS) [63], and the "Stimulating-Instrumental Risk Index" (SIRI) [64].

The BSSS consists of the following four subscales: (1) experience seeking, (2) boredom susceptibility, (3) thrill and adventure seeking, and (4) disinhibition. Each subscale contains

two statements, for a sum of eight statements in total. Examples include "I would like to explore strange places" (experience seeking), "I prefer friends who are excitingly unpredictable" (boredom susceptibility), "I like to do frightening things" (thrill and adventure seeking), and "I like wild parties" (disinhibition). The participants answered on a five-point Likert-like scale ranging from 1 "strongly disagree" to 5 "strongly agree". The BSSS scale as a whole had a sufficiently high interim correlation (Cronbach's $\alpha = 0.80$) in our study. However, the items in the individual subscales displayed relatively low scale reliability coefficients (experience seeking: $\alpha = 0.45$, boredom susceptibility: $\alpha = 0.55$, thrill seeking: $\alpha = 0.62$, disinhibition: $\alpha = 0.79$). We, therefore, collapsed BSSS into one measure. SIRI consists of the following two subscales: (1) Stimulating risk taking (four statements), and (2) Instrumental risk taking (three statements). Example statements include "When I pursue my passions, I like the moments of balancing on the edge of risk" (stimulating risk-taking), and "I take the risk only when it is necessary to reach my goal" (instrumental risk-taking). All questions were measured on the same scale as the BSSS. The SIRI scale did not have a sufficiently high interim correlation in our study (Full scale: $\alpha = 0.55$, Stimulating risk-taking: $\alpha = 0.52$, Instrumental risk-taking: $\alpha = 0.49$). We, therefore, refrained from using this measure.

Experience with backcountry skiing was measured with the following two questions: "During the past 5 riding seasons, how many days per season did you on average ride back/sidecountry?"; and "During how many seasons in total have you been an active (at least one trip per year) back/sidecountry rider?". We measured riding skills with the question; "What is your level of skills would you say you have as a skier?" (scale: 1 "beginner" to 7 "Expert"). Finally, we asked participants to rate their avalanche training on a scale from 1 "No training" to 7 "Expert". All survey questions are available in Table S1 in the supplementary material.

2.2. Results

Forty-four participants signed up for the experiment and filled out the pre-survey. Of these, 21 saw a movie with negative emotional content (Group 1), and 23 saw a movie with positive emotional content (Group 2). Seventeen of the 21 participants in group one were male, while the corresponding number for group two was 15. We present descriptive statistics and tests for differences between the two samples in Table 1. The Shapiro–Wilk test suggested that some of our variables were non-normally distributed. We used Mann–Whitney U-tests to evaluate differences in means for these variables.

Table 1. Descriptive statistics.

	Group 1: Negative Affect		**Group 2: Positive Affect**				
	M	**S.D.**	**M**	**S.D.**	**Diff**	**Test-Statistic**	***p*-Value**
Age	26.81	6.52	27.52	5.88	−0.71	−0.897 [a]	0.370
Percentage of males	0.81	0.40	0.65	0.49	0.16	1.370 [b]	0.242
Ski days per season	24.14	16.41	17.35	17.85	6.80	1.746 [a]	0.081
Years BC experience	7.76	7.80	6.87	5.86	0.89	0.154 [a]	0.878
Avalanche training	3.14	1.28	3.09	1.76	0.06	0.120 [c]	0.905
BC riding skills	4.52	1.40	4.48	1.44	0.05	0.106 [c]	0.916
BSSS	3.63	0.71	3.16	0.78	0.47	2.080 [c]	0.044
N obs	21		23				

[a] Mann–Whitney U test. [b] Chi-square test. [c] Student *t*-test.

As can be seen in the last panel of Table 1, the differences in backcountry experience avalanche knowledge, or age between the two samples were not significant at the five percent level. However, the subjects in group one were significantly more sensation-seeking (BSSS) than the subjects in group two ($t = 2.080$, $p = 0.044$). This difference was not explained

by the uneven gender balance in the two groups. When we ran a regression where we controlled for treatment and gender, we found that the treatment had a significant effect, while gender did not. When we included an interaction between the treatment and gender, all coefficients dropped below 5 percent significance.

We present the results from the movie experiment in Table 2. The first two rows in Table 2 show the treatment effect on the reported emotions. Low numbers (1 to 3) represent negative emotions, while high numbers (5 to 7) represent positive emotions. Four represents neutral emotions. The participants in group one (negative affect), on average, reported mildly negative emotions, while the participants in group two (positive affect), on average, reported positive emotions. A *t*-test showed that the difference in reported emotions between the two groups was significant below the one percent level (t = −6.066, $p < 0.001$).

Table 2. Mean responses and bivariate tests of differences between negative and positive affect.

	Group 1: Negative Affect		**Group 2: Positive Affect**				
	M	**S.D.**	**M**	**S.D.**	**Diff**	**Test-Statistic**	***p*-Value**
Affect							
Emotion	3.40	1.45	5.65	1.19	−2.41	−6.066	<0.001
Like	5.57	1.03	5.35	0.98	0.22	0.738	0.232
Risk assessment							
Scene 1	2.76	1.09	2.61	1.16	0.15	0.655	0.327
Scene 2	5.48	0.68	5.78	1.04	−0.31	−1.143	0.327
Scene 3	2.62	1.20	2.61	1.37	0.01	0.027	0.130
Scene 4	5.10	1.04	4.65	1.11	0.44	1.359	0.490
Scene 5	2.57	1.03	2.78	1.51	−0.21	−0.230 [a]	0.818
Scene 6	5.05	1.12	5.17	1.27	−0.13	−0.349	0.297
Scene 7	2.29	1.10	2.61	1.16	−0.32	−0.946	0.364
Scene 8	3.57	1.16	3.87	1.14	−0.30	−0.857	0.198
Scene 9	3.71	1.27	3.87	1.66	−0.16	−0.346	0.366
Scene 10	4.14	0.91	3.83	1.34	0.32	0.910	0.184
Scene 11	3.90	1.41	4.09	1.08	−0.18	−0.483	0.316
Scene 12	6.05	1.12	6.26	0.96	−0.21	−0.571 [a]	0.568
Scene 13	4.57	0.98	4.48	1.20	0.09	0.280	0.390
Scene 14	4.95	1.24	4.00	1.17	0.95	2.619	0.006
Scene 15	5.86	0.91	6.26	0.81	−0.40	−1.497 [a]	0.134
Scene Total	62.62	9.30	62.87	8.43	−0.25	−0.094	0.463
Attention							
N correct signs	11.76	1.81	12.09	1.59	−0.33	−0.633	0.265
N danger signs	7.86	1.01	8.17	1.27	−0.32	−0.910	0.184
N obs	21		23				

[a] Mann–Whitney U test.

2.2.1. Results for Hypothesis H1

We evaluated the effect of positive and negative emotions on risk judgement by comparing the perceived risk of each of the 15 ski scenarios. We found no evidence that the participants who watched the positive ski movie evaluated the average risk differently from the participants that saw the negative ski movie (t = −0.094, $p = 0.463$). Only one of the 15 images (#14) was evaluated as less risky by the participants in the positive ski movie group (t = 2.619, $p = 0.006$). This effect became insignificant at a five percent level when we corrected for multiple testing (Bonferroni correction).

2.2.2. Results for Hypothesis H2

We evaluated attention effects by comparing the number of correctly identified cues of heightened avalanche danger in the sequence with 12 images. We found no evidence

that seeing a negative ski movie affected the number of correctly identified avalanche clues ($t = -0.633$, $p = 0.265$), or the number of remembered avalanche cues (correct or wrong) ($t = -0.910$, $p = 0.184$).

2.3. Discussion

The aim of study one was to test if positive and negative emotions, induced via a movie stimulus, influenced risk judgement and attention to danger signs. We predicted that positive (negative) emotions would reduce (increase) the perceived risk and reduce (increase) attention to danger signs. Our empirical analysis showed that, while the movies did affect the participants' reported emotions, they did not affect risk judgement or attention to danger signs. We measured powder fever with one single question on positive and negative affect. This did not enable us to explore the wider emotional experience of different classes of positive emotions connected to powder fever. We, therefore, changed from a single-item measure of positive emotions to a ten-item emotional measure in the second study.

3. Study 2

The purpose of study two was to replicate the findings in study one on a larger sample, and to evaluate within-subject changes.

3.1. Materials and Method

3.1.1. Hypotheses

Hypotheses 3 (H3). *Participants judge risk to be lower after seeing a positive ski film compared to participants seeing a negative ski movie.*

Hypotheses 4 (H4). *Participants are more willing to take ski-related risk after seeing a positive ski film compared to participants seeing a negative ski movie.*

3.1.2. Participants

We carried out the experiment during two avalanche seminars in two towns in northern Norway. Participants attended the seminars to learn about risk mitigation and decision-making in avalanche terrain. In total, 191 individuals over the age of 18 attended the two seminars. Attendance was uneven on the two locations, in spite of a similar population size of the two towns. One hundred and forty-eight individuals attended the first seminar (positive ski movie), while 43 attended the second seminar. Of the participants willing to state their gender, 105 were male and 69 were female. Average age was 37 (min = 20, max = 62, S.D = 10.38). One-hundred and thirty-nine participants provided complete answers to all questions (108 in the positive treatment, and 31 in the negative treatment).

3.1.3. Procedure

To prevent a priming effect on the results from the content of the avalanche seminar, the study was carried out in the beginning of the seminar, only preceded by a short welcome. The participants were asked to find their mobile phone and visit a link that led them to a questionnaire. They were told to answer the first part of the questionnaire including informed consent, a general willingness to take risk, assessment of current emotions, and their level of backcountry skiing experience, avalanche education, age, and gender. The film was then screened in the auditorium. Immediately after the film ended, the participants were asked to advance in the questionnaire to the second part of the questionnaire including the same assessment of current emotions. The participants were then presented with a scenario showing a photo of a ski descent and asked to imagine that they were standing at the top of the slope. The participants were provided with relevant risk information related to skiing the slope. The participants then indicated their perceived risk and willingness to ski this particular descent. The participants were then again presented with the question on how much risk they are willing to take when skiing.

The experiment was reviewed and approved by the Norwegian Center for Research Data prior to data collection (NSD 56569).

3.1.4. Materials

The movie stimuli used were the same as in study 1.

We measured the following nine different emotions before and after the movie stimuli: satisfaction, wellbeing, happiness, interest, engagement, focus, fear, anger, and sadness. The respondents answered the question "Feel how you feel right now. Please give a value for each of the emotions listed below" (scale: 1 = not at all, 7 = to a very high extent). There were only marginal differences between the different classes of positive emotions (hedonic emotions; pleasure, satisfaction, and happiness, and eudaimonic emotions; interest, engagement, enthusiasm, and immersion). The hedonic emotions returned a Cronbach's $\alpha = 0.90$ (pre) and $\alpha = 0.95$ (post). The eudaimonic emotions returned a Cronbach's $\alpha = 0.88$ (pre) and $\alpha = 0.90$ (post). We, therefore, create combined scores for items related to hedonic ("Happiness") and eudaimonic ("Excitement") emotions, respectively. The three variables theoretically measure distinct negative emotions, and we, therefore, kept them as separate measures.

Since neither the subscales of BSSS or SIRI had sufficient reliability coefficients in study 1, we chose to measure willingness to take risk with the simple question, "How willing are you to take risk when it comes to skiing" (scale: 1 = completely unwilling to take risk, 10 = very willing to take risk). This question has been shown to predict real-life risk-taking behavior relatively well [65]. As with questions on emotions, participants answered this question both pre- and post-treatment.

As in study 1, we also evaluated risk assessment in study 2. Due to the nature of the avalanche seminar, we could not evaluate a large set of different scenarios. Instead, we used a single scenario. Participants were shown a photo of a skier standing at the start of a ski run. The photo was from the perspective of the individual standing on the slope, i.e., Point of view (POV) and participants were asked to imagine that it was them standing on the top of the slope. We provided participants with relevant information about the risk associated with riding the slope. This information included inclination, temperature, geographical orientation of the slope, altitude, and an avalanche forecast describing the current snow conditions (see the Appendix A). Each participant answered the following three questions: 1) "How likely is it that you would ski this run?" (scale: 1 = very unlikely, 10 = very likely), 2), "How attractive is the run?" (scale: 1 = very unattractive, 10 = very attractive), and 3) "How risky do you think that it would be for you to ski the run, given current snow conditions?" (scale: 1 = very low risk, 10 = very high risk).

Finally, we asked participants about how many years and days per season they toured in avalanche terrain. Both these questions were measured on an interval scale (1 = 0–5, 2 = 5–10 . . . , 6 = 30+). All survey questions are available in Table S2 in the supplementary material.

3.2. Results

We present the descriptive statistics for the two samples in Table 3, below. The participants in group one (negative affect) had significantly more avalanche training and skied more days in avalanche terrain than group two (positive affect). The participants in group one also expressed stronger hedonic emotions (happiness), anger, and sadness prior to the movie stimuli than the participants in group two.

Table 3. Descriptive statistics.

	Group 1: Negative Affect		Group 2: Positive Affect				
	M	**S.D.**	**M**	**S.D.**	**Diff**	**Test-Statistic**	***p*-Value**
Age	35.55	10.74	37.50	10.24	−1.95	−0.975 [a]	0.330
Male gender	0.32	0.48	0.43	0.50	−0.10	1.069 [b]	0.301
Ski days per season	3.74	1.77	2.38	1.47	1.36	3.760 [a]	<0.001
Years BC experience	2.10	1.33	1.91	1.35	0.19	1.055 [a]	0.292
Avalanche training	2.65	1.36	1.90	1.16	0.75	2.951 [a]	0.003
Pre-test risk preferences (Dohmen)	4.74	1.97	4.41	1.89	0.33	0.895 [a]	0.371
Pre-test emotions							
Happiness	4.25	1.14	4.68	1.21	−0.43	−2.03 [a]	0.042
Excitement	4.76	1.23	4.66	0.99	0.10	0.609 [a]	0.542
Fear	2.23	1.73	1.60	1.08	0.62	1.708 [a]	0.088
Anger	1.65	0.95	1.14	0.44	0.51	4.030 [a]	<0.001
Sadness	1.97	1.47	1.31	0.69	0.65	3.086 [a]	0.002
N obs	31		108				

[a] Mann–Whitney U test. [b] Chi-Square test.

The main results of study two are presented in Tables 4 and 5 below. Table 4 shows the differences in response between the two groups (between-subject), while Table 5 shows the differences in emotions and risk preferences before and after the movie stimuli (within-subject). Due to the non-normality of most variables according to the Shapiro–Wilk test, we evaluated all the differences with the Mann–Whitney U test for between-subject comparisons, and with the Wilcoxon signed rank test for within-subject comparisons.

As in study one, we found that the movie stimuli had a significant impact on emotions. The participants in the positive affect treatment experienced significantly more positive emotions and less negative emotions after the stimuli. Since the participants in group one reported less happiness and more anger prior to the movie screening, it is possible that this result is partly caused by the differences between the two samples. However, our within-subject analysis (Table 5) confirmed that the participants in group one (negative affect) experienced a significant increase in negative emotions after the movie, while the participants in group two (positive affect) experienced a significant increase in positive emotions.

Table 4. Mean responses and bivariate tests of differences between negative and positive affect. Mann–Whitney U tests.

	Group 1: Negative Affect		Group 2: Positive Affect					
	M	**S.D.**	**M**	**S.D.**	**Diff**	**Test Statistic**	***p*-Value**	**Effect Size**
Affect								
Happiness	2.94	1.18	5.28	1.11	−2.35	−7.206	<0.001	−2.09
Excitement	4.56	1.14	5.34	1.11	−0.78	−3.350	<0.001	−0.70
Fear	4.68	1.83	2.13	1.35	2.55	6.284	<0.001	1.73
Anger	2.58	1.5	1.26	0.75	1.32	6.766	<0.001	1.37
Sadness	3.23	2.06	1.39	0.86	1.84	5.595	<0.001	1.49
Risk instruments								
Risk perception	6.16	2.16	5.45	2.04	0.71	1.757	0.079	0.34
Willingness to ski	4.74	2.59	5.23	2.72	−0.49	−0.836	0.403	−0.18
Risk preferences	4.32	1.76	3.87	1.76	0.45	1.275	0.203	0.26
N obs	31		108					

Table 5. Within-subject comparisons. Wilcoxon signed rank tests.

	Pre-Test		Post-Test					
	M	**S.D.**	**M**	**S.D.**	**Diff**	**z-Value**	***p*-Value**	**Effect Size**
Negative ski film								
Happiness	4.25	1.14	2.94	1.18	1.31	4.335	<0.001	1.13
Excitement	4.76	1.23	4.56	1.14	0.20	0.621	0.535	0.16
Fear	2.23	1.73	4.68	1.83	−2.45	−4.827	<0.001	−1.40
Anger	1.65	0.95	2.58	1.50	−0.94	−3.618	<0.001	−0.70
Sadness	1.97	1.47	3.23	2.06	−1.26	−3.644	<0.001	−0.73
Risk preferences	4.74	1.97	4.32	1.76	0.42	2.309	0.021	0.32
Positive ski film								
Happiness	4.68	1.21	5.28	1.11	−0.60	−5.977	<0.001	−0.62
Excitement	4.66	0.98	5.34	1.11	−0.68	−5.966	<0.001	−0.65
Fear	1.60	1.08	2.13	1.35	−0.53	−3.837	<0.001	−0.37
Anger	1.14	0.44	1.26	0.75	−0.12	−1.010	0.312	−0.15
Sadness	1.31	0.69	1.39	0.86	−0.07	−0.431	0.667	−0.09
Risk preferences	4.41	1.89	3.87	1.76	0.54	4.211	<0.001	0.44

3.2.1. Results for Hypothesis H3

We found no significant differences in risk perception between group one and group two.

3.2.2. Results for Hypothesis H4

We found no differences in the willingness to ski a potentially risky run or to take risk while skiing between the two groups. Indeed, we found that the participants in both treatment groups were less willing to take risks after having seen the ski movie.

3.3. Discussion

The results of study two replicated the findings in study one. Ski movies thus appear effective in terms of inducing positive and negative states of affect. However, we found no support for the hypothesis that emotions affect risk judgements or willingness to take risk. Our finding that the participants in both groups were less willing to take risks after seeing either ski movie may point to participants being more engaged to the setting and critical about risk decisions.

There are two potential problems with study two. The first is that the affective stimuli were relatively weak. The participants saw a movie about an unknown rider and were asked to judge risk in hypothetical scenarios. Riders enjoying real powder may experience stronger emotions. Second, the use of avalanche seminars may have made participants more self-conscious, and more focused on avalanche safety.

4. Study 3

The aim of study three was to test if "real" powder fever influences willingness to engage in behaviors that expose oneself and others to heightened levels of risk.

4.1. Materials and Method

4.1.1. Hypothesis

Hypotheses 5 (H5). *Willingness to expose oneself and others to heightened levels of risk is higher when a rider has just ridden or anticipates riding powder (hot state) than when at home (cold state).*

4.1.2. Participants

We recruited participants at the base of the Schlasman's lift at Bridger Bowl ski area in SW Montana, USA. The lift only serves extreme ski and avalanche terrain, with the ski area notifying all customers that this area has an "Increased risk of avalanches, has no hazard markings, no grooming, no marked trails, steep chutes which may end in unmarked cliffs,

and no easy way down" [66]. An avalanche transceiver is required to access this lift, and a shovel, probe, and partner are strongly recommended—all are items that are also required for safe backcountry travel. While this area is still within the ski area boundary, and is not backcountry, skiers using the ski lift can easily access complex and non-mitigated avalanche terrain by hiking a short distance from the top of the lift.

In total, 285 participants answered the in-field survey. Of these, 192 riders provided complete answers and were over 18 years old. Sixty participants are female and 132 are male. Mean age in the sample was 30 (SD = 11.54, min = 18, max = 68). About 40 percent were students at Montana State University. Sixty-one participants completed a follow-up survey at home.

4.1.3. Procedure

We asked skiers waiting to board the ski lift to complete a 2-page field survey. The survey was printed on waterproof paper that could be completed with gloved hands using a marker. On the first page of the survey, participants first answered questions about their emotional state, and thereafter answered questions about their willingness to engage in potentially risky backcountry activities. The second page of the survey contained questions about backcountry and avalanche skills, and basic demographics. Participants provided informed consent on a separate paper. The number of questions and layout of the survey were restricted by the fact that participants would complete the survey in the field at the base of the lift, while waiting for their next ski lift (approx. 2–10 min depending on crowds). Complete surveys were then placed into a survey "mailbox" at the front of the lift line, right before boarding the next available chairlift.

Within 14 days, we sent each participant a follow-up online survey with the same questions on emotional state and questions on risk taking in the backcountry. The online survey followed the same basic structure as the field-survey. Participants first answered questions about their emotional state, and thereafter indicated their willingness to engage in risky backcountry behavior. In the last sections of the online survey, we asked subjects about their risk preferences, and more detailed socio-demographic characteristics. The experiment was reviewed and approved by the MSU Institutional Review Board [JJ010919-EX] on 9 January 2019.

4.1.4. Material

Our experiment design was inspired by the approach used by Loewenstein and Ariely (9), who first asked subjects to answer questions related to sexual risk taking in a cold state, and thereafter in a sexually aroused state.

We first collected data from participants, who could be expected to be in a "powder aroused" state, at the base of Schlasman's ski lift. We thereafter asked the same questions when the subjects could be expected to be in a cold state (at home). To evaluate the effect of our arousal treatment, we used the following four emotional states: happiness, excitement (stoke), fear, and anxiousness (nervousness). Participants answered on a scale from 1 "Not at all" to 7 "To a very high extent".

We measured willingness to engage in risky behavior with seven questions. These questions were based on the set of questions used by Loewenstein and Ariely [9] but adapted to a backcountry setting.

Skiing in extreme terrain, whether inbounds at a ski area or in the backcountry, is associated with a set of obligatory behaviors conducive to safe skiing. This includes all skiers carrying and knowing how to use an avalanche transceiver, a type of emergency locator beacon that transmits and receives a radio signal for the purpose of finding people buried under snow, an avalanche probe for physically locating the victim, and a shovel for extrication. Skiers are also encouraged to ski with a partner and avoid avalanche terrain under high hazard conditions. As part of learning the technical skills to ski in increasingly hazardous terrain, there is also an associated body of knowledge that people participating in this sport are expected to acquire. These behaviors are deeply ingrained in the culture of

the sport. A couple of decades ago it would have been socially acceptable to ski without this equipment and knowledge, whereas contemporary skiers often carry the equipment and engage in avalanche awareness education as part of identifying as a backcountry skier [4,67].

The first four risk questions asked participants to what extent they could imagine engaging in behaviors that exposed themselves to heightened levels of risk. The last three questions asked participants to what extent they would engage in behaviors that potentially exposed others to risk. Participants answered on a scale from 1 "No" to 7 "Yes, absolutely". Four was defined as "Possibly". The full set of questions is presented in Table 6.

Table 6. Measures of intentions to engage in risky behavior in avalanche terrain.

	Can You Imagine Riding on Slopes That Could Avalanche . . . ? (Risk for Self)
1.	...if you forgot your avalanche beacon (but managed to get through the gate), when the avalanche danger is considerable [1]?
2.	. . . with a partner, who forgot his/her avalanche beacon (but managed to get through the gate), when the avalanche hazard is considerable?
3.	...alone, with the appropriate avalanche gear when the avalanche danger is high?
4.	. . . with a partner, who's backcountry travel skills are unknown to you, when the avalanche danger is considerable?
5.	. . . with a partner and the appropriate avalanche gear, including an avalanche backpack or Avalung, when the avalanche danger is high>
	Would you . . . ? (Risk for others)
6.	. . . feel frustrated if your ski partner is scared and refuses to ski an out of bounds run that you want to ski?
7.	...try to persuade a ski partner to ski an out of bounds run that you want to ski, if he or she is hesitant to ski?
8.	. . . try to persuade a ski partner to ski an out of bounds run that you want to ski, if he or she is nervous and says "no"?
9.	. . . leave your partner out of bounds to go ski a run if he or she is nervous and says "no"?

[1] The use of "considerable" has meaning to backcountry skiers. It is a term used in the North American Avalanche Danger scale to denote the level of risk of avalanche. The five-categories are Low, Moderate, Considerable, High, and Extreme. Most avalanche fatalities occur at Considerable danger.

Questions about backcountry experience and avalanche experience and knowledge were the same as in study 1. All survey questions are available in Table S3 in the supplementary material.

4.2. Results

The attrition out of the sample may have been systematically correlated with factors that affect the results. To ensure that the selection into the sub-sample did not distort the results in an important way, we analyzed differences between participants who only took the Hot survey (N = 176), and participants who took both the Hot and the Cold survey (N = 62). We performed Mann–Whitney U tests on all the non-normally distributed variables. The results are presented in Table 7.

As can be seen in Table 7, there were no statistically significant differences in intentions to engage in risky behaviors between group one and group two (hot and cold). There was neither any differences in self-assessed backcountry skills, avalanche training, or percentage of students. The percentage of women was slightly higher in group two (60.4 percent) than in group one (67.7 percent, $\chi^2 = 3.040$, $p = 0.081$).

Table 8 presents descriptive statistics and test statistics (Wilcoxon signed rank tests) for hot and cold states. As can be seen in the table, participants, on average, felt significantly happier and more excited when they were out skiing than when they were at home. We found no significant differences in negative emotions.

Table 7. Descriptive statistics—Group 1 (Hot) and Group 2 (Hot and Cold).

	Group 1		Group 2				
Variable	**Mean**	**S.D.**	**Mean**	**S.D.**	**Diff**	**Test Statistic**	***p*-Value**
Socio-demographics							
Age	28.82	11.13	31	12.33	−2.18	−1.222 [a]	0.223
Percentage Male	0.72	0.45	0.62	0.49	0.09	1.734 [b]	0.188
Student	0.40	0.49	0.44	0.50	−0.05	0.359 [b]	0.549
Avalanche training	3.28	1.24	3.02	1.16	0.27	1.365 [c]	0.172
BC skills	4.25	0.78	4.33	0.65	−0.08	−0.393 [c]	0.695
Emotions							
Excited	6.02	1.14	5.87	0.92	0.15	1.426 [c]	0.154
Happy	6.44	0.78	6.30	0.78	0.15	1.410 [c]	0.159
Anxious	2.26	1.48	1.97	1.21	0.29	1.315 [c]	0.188
Scared	1.66	1.26	1.44	0.92	0.22	1.324 [c]	0.186
Risk taking							
Can you imagine skiing a slope that could avalanche . . .							
. . . without a beacon?	1.68	1.32	1.59	1.35	0.09	0.962 [c]	0.336
. . . with a partner w/o a beacon?	1.54	1.10	1.48	1.18	0.07	0.848 [c]	0.396
. . . with a partner w unknown skills?	2.31	1.51	2.48	1.53	−0.17	−0.916 [c]	0.360
. . . alone on a high avi day?	1.75	1.53	1.39	1.04	0.35	1.500 [c]	0.134
. . . with a partner on a high avi day?	2.70	1.84	2.31	1.68	0.39	1.496 [c]	0.135
Total imagine	9.98	5.97	9.25	5.40	0.73	0.814 [a]	0.417
Would you?							
Feel frustrated if a partner says no?	2.02	1.29	2.13	1.52	−0.12	−0.227 [c]	0.821
Leave a partner who says no?	1.56	1.22	1.57	1.16	−0.02	−0.213 [c]	0.832
Persuade a partner who says no?	1.87	1.31	1.79	1.16	0.08	−0.042 [c]	0.967
Persuade a partner who hesitates?	2.21	1.32	2.18	1.40	0.03	0.365 [c]	0.715
Total would	7.66	3.82	7.67	4.10	−0.02	−0.026 [a]	0.979
N obs	131		61				

[a] *t*-test, [b] Chi-square test, [c] Mann–Whitney test.

Results for Hypothesis H5

We, in general, did not find significant differences in individual items measuring the willingness to engage in risky behavior. The exception is "willingness to ski with a partner with unknown backcountry travel skills" (z = 3.212, $p = 0.001$).

A factor analysis suggested that our questions on willingness to engage in behaviors that expose oneself or others to risk behavior loads on two factors corresponding to the "Can you imagine" (Cronbach's $\alpha = 0.788$) and "Would you" (Cronbach's $\alpha = 0.787$) questions. We, therefore, present the total scores on the two sets of questions, in addition to presenting results for individual items. While we did not find a significant difference on the sum of scores on the "Would you" questions, we did find a significant difference (z = 2.085, $p = 0.037$) between the sum of scores on the "Can you imagine" questions in a hot and cold state.

Table 8. Mean responses in hot and cold states (group 2). Wilcoxon signed rank tests.

	HOT		COLD					
	Mean	**S.D.**	**Mean**	**S.D.**	**Diff.**	**z-Value**	***p*-Value**	**Effect Size**
Emotions								
Excited	5.87	0.92	3.72	1.47	2.15	6.415	<0.001	1.32
Happy	6.30	0.78	4.69	1.31	1.61	6.037	<0.001	1.11
Anxious	1.97	1.21	2.33	1.61	−0.36	1.103	0.270	−0.19
Scared	1.44	0.92	1.38	0.99	0.07	−0.864	0.388	0.05
Risk taking and norm violations								
Can you imagine skiing a slope that could avalanche . . .								
. . . without a beacon?	1.59	1.35	1.66	1.42	−0.07	−0.268	0.789	−0.04
. . . with a partner without a beacon?	1.48	1.18	1.31	0.79	0.16	0.826	0.409	0.16
. . . with a partner with unknown skills?	2.48	1.53	1.82	1.04	0.66	3.214	0.001	0.43
. . . alone on a high avi day?	1.39	1.04	1.21	0.52	0.18	0.651	0.694	0.17
. . . with a partner on a high avi day?	2.31	1.68	1.77	1.23	0.54	1.836	0.066	0.31
Total score Imagine	9.25	5.40	7.77	3.65	1.48	2.085	0.037	0.31
Would you?								
Feel frustrated if a partner says no?	2.13	1.52	2.11	1.32	0.02	−0.615	0.539	0.01
Leave a partner who says no?	1.57	1.16	1.54	1.16	0.03	0.711	0.477	0.04
Persuade a partner who says no?	1.79	1.16	1.75	1.12	0.03	0.274	0.784	0.05
Persuade a partner who hesitates?	2.18	1.40	2.26	1.42	−0.08	−0.589	0.556	−0.07
Total score Would	7.67	4.10	7.67	4.28	0.00	−0.249	0.804	0.00
N obs	61		61					

4.3. Discussion

The aim of study three was to test if powder fever affects increase the willingness to engage in behaviors that potentially exposes oneself or others to risk. We found weak evidence that the participants were more willing to engage in behavior that exposes themselves to risk in the field than at home, but there was no support for the hypothesis that powder fever incentivized behavior that exposes others to risk.

A large percentage of our participants answered "No" (lowest possible answer) to many of our questions in the field. More than 70 percent answered no to questions related to wearing a beacon, skiing alone on a high avalanche danger day, and leaving a partner who says no. About 50 percent answered no to questions about skiing with a partner on a high avalanche danger day, feeling frustrated with a partner who refuses to ski, and persuading a partner who says no. This means that there was not much variation in the data between the hot and cold states. We reran our analysis on the sub-sample of participants who answered that they, at least to some extent, could imagine or would engage in the behaviors in a hot state. For this sub-sample, most differences were significant (see Table A1, in Appendix A). However, the sample sizes were very small, and the results may be biased by selection. It should also be noted that the sample obtained from the Schlasman's lift at Bridger Bowl may not be representative of the wider backcountry community. All riders boarding the lift must wear beacons, the terrain is extreme, and the level of avalanche awareness in the community is relatively high. As such, our estimates may represent a lower bound, and participants from a less avalanche aware community may show more willingness to engage in risky behavior.

5. Limitations and Future Research

5.1. Limitations

Our study constitutes a first attempt to test how emotions affect behavioral intentions among riders in the backcountry community. As such, it has limitations. Perhaps most importantly, deliberational or theoretical choices are different from real-life behavior. It is, therefore, important to test if our findings hold for choices made in the backcountry. Second, our sample sizes were relatively small. This prevented us from analyzing the

potential differences in the effects between different groups of backcountry riders. For example, Rydell et al. [10] found that group identification moderated the effect of anger on risk taking behavior. This effect may be present among backcountry riders as well, and the results from study three suggested that group differences are likely. Future studies should, therefore, try to reach a larger, and more heterogeneous (both in terms of socio-demographics and geographic location) sample of backcountry riders. Finally, powder fever is a well-known concept among backcountry riders, but it has no scientific definition.

Measuring emotions and its impact on risk behavior in backcountry skiing is challenging. Ideally, we would like to measure moment-to-moment emotions and their direct impact on objective risk exposure. However, measuring moment-to-moment emotions during skiing without them being affected by the measure itself is challenging. One way to do this is with face fronting cameras that capture facial expressed emotions. However, the current technology only records the participants' level of happiness, which does not resemble the full catalog of positive emotions that one may experience in skiing (See [20] for a description of this method) Another way is to recreate the experience via methods such as the day-reconstruction method [68]. Further research should explore the efficacy of these methods.

It is also challenging to measure participants' real behavior and what this means in terms of objective risk. Avalanche danger varies in space and time, and even with all the time and information available, it would be difficult to reach an objective measure of risk. We were, therefore, left with the option of directly asking the participants about their emotional experience and risk willingness or intentions in a post tense.

In our studies, we recorded self-reported emotions linked to the concept called "powder fever". However, we have no way of knowing if the emotions were strong enough to induce a sense of high emotion. Hence, it may be that we did not arouse our participants enough to induce the intended behavior changes. Passively watching ski movies of anonymous skiers may not engage respondents' emotions, even when participants are asked to imagine that it is them skiing. For future studies, it may prove fruitful to use methods including virtual reality cameras and ski-simulators, to induce a state of affect. To rule out that powder fever does not affect milder forms of risk-taking behavior, future studies should include scenarios with different levels of risk exposure.

In this paper, we have tried different ways of measuring participants' risk assessment and willingness. In the first study, we used multi-item measures of risk assessment where we showed the participants several descents and asked them to evaluate the level of risk for each descent. In the second study, we provided the participants with one scenario accompanied with information about the terrain and snow conditions. Such single item measures have inherent limitations [69,70] and conclusions from such measures should be drawn with caution.

5.2. Conclusions

The aim of this paper was to analyze the role of emotions in behaviors that expose backcountry riders to avalanche risk. We conducted the following three experiments: two movie experiments in the laboratory and one field experiment. Our results showed that both seeing a ski movie and skiing affect riders' emotional state. We operationalized powder fever as positive emotions. In the first study, we measured this with a single item, where the participants reported the level of positive and negative affect. In the second and third studies, we measured two different classes of positive emotions (hedonic and eudemonic) to see if this would give us a better understanding of the emotional profile of powder fever. Even though there are differences between these two types of positive emotions, they are rather small. Still, neither of our two first studies support the hypothesis that positive emotions affect risk assessment or risk taking. Our third study provided weak support that powder fever increases willingness to take risk. However, the majority of the sample found it completely unacceptable to engage in the suggested behaviors. These are reassuring findings, as it may indicate that backcountry experience and avalanche training

prepare riders to resist temptations, and that well established concepts related to risk are well entrenched in the populations tested in these studies.

Supplementary Materials: The following are available online at https://osf.io/36dhf/, Table S1: Study 1 questions, Table S2: Study 2 questions, Table S3: Study 3 questions.

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Appendix A

Table A1. Mean responses for participants who did not answer "No" in the hot state. Wilcoxon signed rank tests.

		HOT		COLD				
	N	**Mean**	**S.D.**	**Mean**	**S.D.**	**Diff.**	**z-Value**	***p*-Value**
Can you imagine skiing a slope that could avalanche . . .								
. . . without a beacon?	14	3.57	1.70	2.50	1.95	1.07	1.657	0.098
. . . with a partner without beacon?	13	3.23	1.64	2.15	1.34	1.08	1.962	0.050
. . . with a partner with unknown skills?	40	3.25	1.35	2.15	1.12	1.10	3.870	<0.001
. . . alone on a high avi day?	11	3.18	1.47	1.64	0.81	1.55	2.430	0.015
. . . with a partner on a high avi day?	31	3.58	1.50	2.32	1.47	1.26	2.943	0.003
Would you?								
Feel frustrated if a partner says no?	31	3.23	1.45	2.87	1.34	0.35	0.859	0.391
Leave a partner who says no?	17	3.06	1.34	2.41	1.58	0.65	2.177	0.030
Persuade a partner who says no?	29	2.66	1.17	2.34	1.32	0.31	2.152	0.031
Persuade a partner who hesitates?	36	3.00	1.29	2.92	1.44	0.08	0.273	0.785

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