Characterizing an Increasingly Diverse and Growing Backcountry Community: A Holistic and Informative Approach Using Audience Segmentation

by

Anneliese Neweduk

Bachelor of Science (Psychology), University of British Columbia, 2018

Project Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Resource Management (Planning)

in the
School of Resource and Environmental Management
Faculty of Environment

SIMON FRASER UNIVERSITY
Fall 2023

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Name:	**Anneliese Neweduk**
Degree:	**Master of Resource Management (Planning)**
Title:	**Characterizing an Increasingly Diverse and Growing Backcountry Community: A Holistic and Informative Approach Using Audience Segmentation**
Committee:	
	Pascal Haegeli Supervisor Associate Professor, Resource and Environmental Management
	Reto Rupf Committee Member Adjunct Professor, Resource and Environmental Management

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Abstract

Over the past two decades, there has been tremendous growth in winter backcountry recreation, challenging the traditional ways in which recreationists are understood, characterized, and communicated to. Best practices in risk communication highlight the importance of having an in-depth understanding of the audience for effective messaging. This research introduces audience segmentation, a widely applied technique to understand heterogeneous audiences and divide them into smaller, more homogenous, segments based on relevant characteristics. Two segmentation analyses are conducted using data from two avalanche forecast user research panels in Europe: The first focuses on motivations, whereas the second combines motivations with other characteristics such as activity type, level of avalanche safety training, experience, and terrain use preferences. Collectively, this research aims to illustrate how audience segmentation can offer a richer and more holistic picture of the backcountry community for the improvement, design, and evaluation of targeted avalanche safety initiatives.

Keywords: Risk communication, audience segmentation, user characterization.

Acknowledgements

The process of completing this thesis and program has challenged and rewarded me beyond I could have imagined and was only possible through the immense support I received along the way.

Thank you to Pascal Haegeli, whose guidance and patience over the past two years has been critical to my experience. I am so grateful to have had your compassion and encouragement along the way, and the amount of time and energy directed into this research is paramount to its level of meaning. Your care and dedication to bettering the avalanche safety community is inspiring and your efforts to create a supportive and collaborative team environment allowed me to create friendships that would not have otherwise happened.

Thank you to the rest of the SARP team and everyone who contributed to this research, I am constantly in awe of you all; Thank you for your support and insights, and for sharing this experiencing alongside of me. Thank you specifically to the risk communication team whose hard work and devotion are improving the avalanche safety community step by step, and whose efforts inspired this project.

Thank you to my cohort in REM, I cannot imagine a more insightful or inspiring (or wacky!) group of people I would have wanted to spend the last two years learning alongside. I am so grateful for the laughs, support, solace, lessons, memories, and lifelong friends I've made. Thank you to the rest of the REM faculty and staff who helped make this experience enjoyable and meaningful.

Thank you to the participants of this research. This research is not possible without your time, engagement, and enthusiasm.

Thank you to the partners of this research – the Swiss and Tyrolean Avalanche Warning Services who graciously funded this research. I am grateful for your dedication to avalanche safety and am honoured to contribute to your goals.

Thank you to my friends, old and new, and my family, specifically my sister Natasha, who supported me through the highs and lows along the way.

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Chapter 1. Introduction

Winter backcountry recreation, such as ski and snowboard touring, snowshoeing, ice climbing, and mountaineering allows people to engage with remote natural areas, immersing themselves in snow-covered landscapes while participating in outdoor pursuits. While being active in nature has tremendous benefits for mental and physical health (e.g., Lackey et al., 2021; Thomsen, Powell & Monz, 2018), the pursuit of these activities can also include serious personal risks including the exposure to snow avalanches, a complex and dynamic winter mountain hazard. The consequences of avalanches can be fatal, with avalanche fatalities in North America and Europe averaging at 140 per year over the past 10 years (Avalanche Canada, 2023; Colorado Avalanche Information Center, 2022; European Avalanche Warning Services, 2023a).

Despite the associated risks and potentially severe consequences, many individuals repeatedly and voluntarily venture into avalanche terrain. This requires recreationists to balance the risk from avalanches with the benefits, experiences, and connections that they seek from mountain recreation (Sole et al., 2010). To help recreationists manage their personal avalanche risk, avalanche warning services publish daily public avalanche forecasts that describe the severity and nature of existing conditions. In addition to daily forecasts, recreationists can access other risk informing products such as blogs, webinars, and decision aids (e.g., White Risk trip planning tool, avalanche terrain exposure maps, Avaluator, Graphical Reduction Method), or enroll in avalanche safety training courses.

Risk communication research in other fields has shown that personal and contextual differences impact how individuals perceive and apply risk messages (Lundgren & McMakin, 2018; Demuth, 2018; Wachinger et al., 2013), and it is a well-established principle in the risk communication literature that a good understanding of the target audience is critical for effective risk communication that resonates with the target audience and properly addresses their needs (e.g., Lundgren & McMakin, 2018; Balog-Way et al., 2020; NOAA Office for Costal Management, 2016; ERG Inc and NOAA, 2019). To account for a complex and diverse backcountry community, avalanche warning services are directing efforts to better understand their users and to find opportunities to improve the effectiveness of their messages, products, services, and

courses. This is particularly important in the context of recent growth in the popularity of winter recreation, which is likely accompanied by even greater variation in individuals' recreation preferences and behaviours, as well as their knowledge of and ability to manage avalanche risk. This challenges the traditional ways recreationists are understood, characterized, and communicated with.

The present research contributes to the understanding of backcountry recreationists through two main inquiries that are presented in separate chapters. Each of the chapters follows the format of a research manuscript and has been produced in collaboration with my supervisor, Pascal Haegeli.

In Chapter 2 we explore why people are motivated to engage in backcountry winter recreation. The objective of this chapter is to explore the motivations of winter backcountry recreationists and demonstrate how they can be used to contextualize the situations in which recreationists expose themselves to avalanche hazard for the purpose of designing of more targeted avalanche safety messages.

Chapter 3 builds on the findings from Chapter 2 and combines motivations with other characteristics to develop informative insights about winter backcountry recreationists for different risk messages. We performed several audience segmentation analyses, a commonly used technique to understand target audiences in other fields, which divides heterogeneous populations into smaller, more homogenous, segments based on relevant characteristics (Metag & Schäfer, 2018; Slater, 1996). We sought to understand how participant characteristics, related to their practical experience, risk mitigation practices, and training, varied within the community, and how they related to other recreation behaviours such as activity type and terrain use preferences. This study illustrates how audience segmentation can offer a richer and more holistic picture of the backcountry community for the improvement, design, and evaluation of targeted avalanche safety initiatives.

The data used for these studies draws from the avalanche forecast user research panels established in partnership between the Euregio[1] and Swiss Avalanche Warning

[1] Euregio is a cross-border region between Austria and Italy that includes the regions of Tyrol (Austria), South Tyrol, and Trentino (both Italy). The avalanche warning services of these regions have been publishing a combined avalanche forecast at https:lawinen.report/ since the 2018/19 winter season.

Services and Simon Fraser University's Avalanche Research Program (Haegeli et al., 2023a). The initiative was established to provide the two participating warning services with the important user perspective for making evidence-based decisions on future developments and improvements of their communications and products. The questions used in both studies draw from the sign-up survey for the research panels, which was first released in March of 2021 and is ongoing as of Fall 2023.

1.1. Positionality

The purpose of this section is to introduce the reader to my personal connection to this research, provide context about my background and motivations, and outline my goals and aspirations tied to this research.

This thesis is the outcome of a learning journey that is not distinct from the opportunities, experiences, and support systems that have shaped who I am today. It is a testament to my commitment to making a practical impact in the avalanche safety community, an endeavour deeply influenced by my own mountain experiences and academic pursuits.

In light of this, I approached this research from an intersecting recreationist and academic space. With a background in social science, my curiosity has always driven me to explore how people interact with their environment (built and natural), making the exploration of how people interact with such a complex and dynamic winter mountain environment a fitting topic. Throughout my life, I have been provided with endless opportunities and have been encouraged to explore remote natural places in the summer and winter seasons, bringing me a myriad of social, psychological, and physical benefits. I am insurmountably grateful for these experiences, how they have positively impacted my life, and contributed to who I am today. I am also acutely aware that my ability to be a "backcountry recreationist" is rooted in my privilege as a white-settler and my continued participation in settler colonial systems. While my research was focused on backcountry recreationists in Europe, the places where I live and recreate are unceded or treaty Indigenous lands, including the unceded and traditional lands of the Coast Salish Peoples, the Sḵwx̱wú7mesh (Squamish), xwməθkwəy̓ əm (Musqueam), and səlilwətaʔɬ (Tsleil-Waututh) First Nations whose lands I currently reside on.

Accountable to my privilege I aim to live and recreate in reciprocity and gratitude to the Nations who have cared for these lands since time immemorial.

My role in this research was to contribute to evidence-based improvements to avalanche risk communication, and the manifestation of this is rooted in my positionality, values, and interests, which have influenced my topic and how I present this research. I have two main hopes for how this research could impact the avalanche safety community. First, I aspire for all recreationists, regardless of their socioeconomic status, background, capabilities, or interests, to feel represented and supported by the avalanche risk communication products available in their pursuit of mountain experiences. Second, I hope this research contributes to a larger conversation about the impacts of who shapes access to backcountry spaces and which groups of people have traditionally been supported with risk management products. This requires an evaluation of existing cultural practices and perspectives to ultimately foster more equitable avalanche risk communication, and more inclusive and safer backcountry experiences for everyone.

Chapter 2. Exploring Motivations of Winter Backcountry Recreationists for Avalanche Risk Communication, Education, and Product Development

2.1. Introduction

Winter backcountry recreation, such as ski and snowboard touring, snowshoeing, ice climbing, and mountaineering, allows people to engage with remote natural areas, immersing themselves in snow-covered landscapes while participating in outdoor pursuits. While being active in nature has tremendous benefits for mental and physical health (e.g., Lackey et al., 2021; Thomsen, Powell & Monz, 2018), the pursuit of these activities can also include serious personal risks including the exposure to snow avalanches, a complex and dynamic winter mountain hazard. The consequences of avalanches can be fatal, with avalanche fatalities in North America and Europe averaging at 140 per year over the past 10 years (Avalanche Canada, 2023; Colorado Avalanche Information Center, 2023; European Avalanche Warning Services, 2023a).

Despite the associated risks and potentially severe consequences, many individuals repeatedly and voluntarily venture into avalanche terrain, and there has been tremendous growth in winter backcountry recreation in western countries over the past two decades. While this growth is well known in the community (e.g., Birkeland et al., 2017), direct evidence is limited. In Switzerland, however, population-wide sport participation surveys have shown that the engagement in backcountry winter activities has more than doubled in the last 15 years (Bürgi et al., 2021). While there are no explicit numbers of winter backcountry sport participation in Austria, the number of alpine club memberships have increased steadily over the last two decades, with over 725,000 memberships as of 2022 (Alpenverein Österreich, 2022). In Canada, there are reported increases in social media engagement and enrollment in avalanche safety courses, supporting the consensus that winter backcountry recreation is becoming an increasingly popular activity (Avalanche Canada, 2021; Avalanche Canada, 2022). While this trend already existed before COVID-19, the pandemic exacerbated the popularity of winter backcountry recreation and shifted the typically more resort-focused recreationists to

backcountry activities because of the uncertainties regarding ski resort closures (Schlemmer & Schnitzer, 2023).

Traveling in the backcountry requires recreationists to balance the risk from avalanches with the benefits from the mountain experiences they seek (Sole et al., 2010), and while some hire professional guides to make these decisions, most recreation is self-directed and the responsibility of assessing avalanche conditions and making informed decisions about when and where to expose themselves to avalanche hazard rests with individual recreationists. To help recreationists manage their personal avalanche risk, avalanche warning services publish daily public avalanche forecasts that describe the severity and nature of existing conditions. In addition to daily forecasts, recreationists can access other risk informing products such as blogs, webinars, and decision aids (e.g., White Risk trip planning tool, avalanche terrain exposure maps, Avaluator, Graphical Reduction Method), or enroll in avalanche safety training courses.

Risk communication research in other fields has shown that personal and contextual differences impact how individuals perceive and apply risk messages (Lundgren & McMakin, 2018; Demuth, 2018; Wachinger et al., 2013), and it is a well-established principle in the risk communication literature that a good understanding of the target audience is critical for effective risk communication that resonates with the target audience and properly addresses their needs (e.g., Lundgren & McMakin, 2018; Balog-Way et al., 2020; NOAA Office for Coastal Management, 2016; ERG Inc and NOAA, 2019).

In response, avalanche warning services are directing efforts to better understand their users and to find opportunities to improve the effectiveness of their information products and services. While research on how recreationists interpret and apply avalanche risk communication is growing (e.g., Morgan et al., 2023; Fisher et al., 2022a; Fisher et al., 2022b; Fisher et al., 2021; St. Clair, 2021; Burkeljca, 2013; Engeset et al., 2018; Winker & Techel, 2014), the question of why people are motivated to engage in backcountry winter recreation has not yet been explored in the context of avalanche risk communication.

Motivations are a well-established topic in recreation literature, as they help to explain why people engage in certain types of recreation in the manner that they do,

including why they start, continue, or stop participating, and they help to explain the consequences of people's engagement (Ewert et al., 2013; Manfredo et al., 1996). Motivations have been studied extensively in activities labeled as risk and adventure recreation (e.g., rock climbing, mountaineering, white-water rafting, and mountain biking) to better understand why individuals expose themselves to these voluntary risks (Buckley, 2012). Motivations have also been used as a practical foundation to curate desirable recreation experiences by tourism and recreation managers (e.g., Mlađenović & Virijević Jovanović, 2019; Albayrak & Caber, 2018; Byun et al., 2021; Carrascosa-López et al., 2021) and direct marketing and communication initiatives (e.g., Alexandris et al., 2009; Won et al., 2008; Konu et al., 2011).

The objective of this study is to explore the motivations of winter backcountry recreationists to see if it can provide a rich picture of the backcountry community for the design of more targeted avalanche safety messages. Having a comprehensive understanding of what types of experiences recreationists are after can help risk communicators contextualize the situations in which recreationists use and apply avalanche risk information. Furthermore, motivations can provide insight into how interested people are in developing avalanche risk management skills. Hence, the exploration of what motivates people to engage in winter backcountry activities can offer useful insights for the design of avalanche risk communication products and messages. A better understanding of these aspects is particularly important in the context of the recent growth in popularity of winter backcountry activities, which has likely resulted in a more diverse backcountry community with a wider range of motivations, needs, and capabilities.

We start the manuscript with a brief summary of the existing research on recreation motivations before describing our analysis approach in the methods sections. After presenting the results, we will discuss the practical insights and benefits that understanding recreationists' motivations can provide for effective avalanche risk communication messaging and product development. We will finish with our thoughts about future research in the conclusion.

2.2. Background

Efforts to understand motivations for recreation and leisure is a well-established body of literature, with research exploring what motivates individuals to participate in recreation involving risk contributing a substantial amount to this field. Earlier inquiries heavily focused on theoretical explanations of motivation such as arousal seeking (Berlyne, 1960), peak experience (Maslow, 1964), and expectancy valence theory (Atkinson, 1964). Later perspectives continue expanding on theoretical concepts to include edgework (Lyng, 1990), flow experience (Csikszentmihalyi & Csikszentmihalyi, 1990; Boudreau et al., 2020), normative influences (Celsi et al., 1993), and rush (Buckley, 2012). In addition to these theoretical developments, researchers attempted to categorize motivations into higher construct organizations of motivations such as seeking versus avoiding (Iso-Ahola, 1982), push versus pull (Dann, 1977; Crompton, 1979; Crompton & McKay 1997), internal versus external (Ewert & Hollenhorst, 1989; Buckley, 2012), and eudaimonics versus hedonics (Ewert et al., 2020). In adventure recreation, push and pull constructs have been used to explore destination choice attributes (e.g., He & Luo, 2020; Giddy & Webb, 2018; Giddy, 2018) whereas internal versus external constructs have been used in the exploration between motivations and level of experience (Ewert & Hollenhorst, 1989; Buckley, 2012).

While these theories have laid the foundation for research on motivations in risk recreation, they heavily concentrated on the sensation seeking dimension of risk as a primary motivator for participation (Kerr & Houge Mackenzie, 2012). For example, a notable conceptual framework is the Adventure Model (Ewert & Hollenhorst, 1989; Todd et al., 2002; Ewert et al., 2013). Based on the theory of specialization (Bryan 1977), the framework suggests risk itself to be a key motivator for risk recreation engagement, but as people become more specialized in their activities, they have different needs and expectations based on their skill level and activity type. Specifically, as engagement increases so will skill, frequency of participation, internalized locus of control, and preferred level of risk (Ewert & Hollenhorst, 1989). Later, Buckley (2012) proposed that, for unskilled participants, rush as opposed to risk is the key driver to risk recreation engagement. This has prompted adventure recreation providers to direct attention towards how they can maintain perceptions of risk, and the associated experiences of thrill, rush, or excitement, while simultaneously reducing actual risk (Dickson & Dolničar,

2004; Buckley, 2012). Despite their conceptual differences in sensation seeking motives, both Ewert & Hollenhorst (1989) and Buckley (2012) see sensation seeking as a primary motivator for risk recreation participation.

While risk may be one aspects that motivates individuals to participate in risk recreation, scholars have discovered that a wider range of motivations can better explain why people engage in these types of activities (Kerr & Houge Mackenzie, 2012; Barlow et al., 2013; Frühauf et al., 2017; Willig, 2008; Brymer, 2010), and that the involved risk is managed as a necessity to achieve other, more important and desirable benefits that participation can bring (Frühauf et al., 2017). Similarly, Giddy (2018) found risk to be relatively unimportant to adventure tourists compared to other motivations. Collectively, these results have expanded the directions motivation research is moving in. For example, Gilbertson and Ewert's (2015) study on participation in rock climbing, white-water kayaking, sea kayaking and canoeing found motives along dimensions of social, escape, sensation seeking, and self-image. Similarly, Willig (2008) found dimensions of context, challenge, suffering, and other people. Since both Willig (2008) and Gilbertson and Ewert (2015) assessed multiple high-risk sports in unison, these studies prove useful for understanding motivations of risk recreation in general. However, others are finding motivational differences between risk recreation activities (e.g., Galloway, 2012; Barlow et al., 2013) therefore looking at activities independently may be beneficial depending on the research goal. Whether activities are independently or collectively studied, other avenues are investigating how covariates such as age, gender, personality, and level of skill or experience are related to motivations (e.g., Frühauf et al., 2020; O'Connell, 2010; Ewert et al., 2013; Castanier et al., 2010).

In addition to the fundamental motivations research, there is also a body of research dedicated to using insights from motivations for practical applications. This can be seen in tourism and recreation management (e.g., Miragaia & Martins, 2015; Zeng et al., 2018; Albayrak et al., 2021), curriculum and education initiatives (e.g., Brown & Fraser, 2009; Collins & Brymer, 2020), and environmental management (e.g., Hall & Cole, 2010; Galloway, 2002). Similar to the winter backcountry recreation community, the outdoor climbing community has expanded from a few highly skilled individuals to be an accessible activity attracting many people with different skills, backgrounds, and motivations. Lee et al. (2020) investigated participants' motivations and characteristics to

inform destination management so that participants can gain the climbing experience and social rewards that they are looking for.

2.2.1. Motivations in Winter Recreation

Research on motivations in winter recreation follows similar directions to how the topic is explored on a more general scale, although it is less unified. Most studies focus on what motives underpin participation in various winter activities such as mountaineering (Pomfret & Bramwell, 2016) or freeride ski and snowboarding (Frühauf et al., 2017), or on how motivations can inform tourism management, visitor satisfaction, and targeted marketing communications (e.g., Bichler & Pikkemaat, 2021; Richards, 1996; Miragaia & Martins, 2015). Amongst this research, there has been an overwhelming focus on resort-based skiers as opposed to backcountry skiers. For example, Alexandris et al. (2009) segmented recreational skiers by motivations from a ski resort in Northern Greece to inform differentiated marketing techniques. They suggest that marketing to the “naturalists” segment should highlight the benefits of enjoying nature and relaxing, whereas the “multi-interested” segment would likely be interested in loyalty programs and relate more to promotions for upscale leisure and hospitality services. Other studies have segmented skiers’ motivations to understand destination choice attributes (Joppe et al., 2013; Konu et al., 2011; Miragaia & Martins, 2015) satisfaction (Tsiotsiou & Vasioti, 2006), visitor frequency (Tsiotsou, 2006), and constraints to participation (Hudson & Gilbert, 2000; Priporas et al., 2015).

Frühauf et al. (2017) took a qualitative approach to understand motivations of free riders, which they describe as skiers and snowboarders whose recreation behaviours involve jumping from cliffs in natural undeveloped snow-covered spaces. They found five themes and one subtheme: Challenge, nature, friends, freedom/pleasure, balance, and habit. They analyzed aspects of risk in freeriding separately from motivations and found risk management, risk taking, negative fear, and positive fear as key areas that recreationists attend to. Notably, deliberately seeking high risk situations was not a motive, and the aspect of challenge in developing appropriate risk management strategies was critical for taking part in the activity. Participants framed risk as a challenge to avoid rather than a sensation to seek.

2.3. Methods

2.3.1. Data Source

The data used for this study draws from an avalanche forecast user research panels established in partnership between the Euregio and Swiss Avalanche Warning Services and Simon Fraser University's Avalanche Research Program (Haegeli et al., 2023a). The initiative is ongoing and was established to provide the two participating warning services with the important user perspective for making evidence-based decisions on future developments and improvements of their communications and products.

Recruitment for the research panels began the Spring of 2021 and was conducted by the partnering avalanche warning services through country specific online sign-up surveys distributed using existing relationships with local stakeholders in winter recreation, tourism, and avalanche safety communities. The country-specific sign-up and research surveys are accessible in German, Italian, English, and French (Switzerland only). The initial sign-up survey asked participants a series of questions related to how they interact with avalanche hazard, their recreational and professional (if applicable) winter backcountry activities, formal avalanche safety training, use of existing avalanche warning services, and socio-demographics. Building on the research panels, the collaboration then started to conduct a series of targeted research surveys to better understand how backcountry recreationists use, understand, and apply the information provided in the existing avalanche forecast products. In March 2022, the first research survey was released, which focused on examining participants' use of avalanche forecast information, understanding of terminology, and how they navigate through the avalanche forecast website. In addition, the survey included additional background questions on participants' motivations and terrain preferences to augment the information collected in the sign-up survey. These questions were subsequently folded into the signup survey. A complete list of sign-up survey questions can be found in Appendix A.

2.3.2. Survey Questions

While the sign-up survey for the panel includes a wide range of questions, we will only discuss the response options to the questions relevant for the present analysis. While motivations are the main focus of this study, we felt it important to enrich our findings with additional variables relevant to avalanche risk communicators. Therefore, we also included questions about activity type, terrain use patterns, level of avalanche safety training, and experience in our analysis.

Motivations

Measuring motivations typically involves the use of psychometric scales. In active recreation research, the Recreation Experience Preference (REP) scales are the most widely used tool for exploring motivations. The REP scales were originally developed by Driver (1977, 1983) and later validated by Manfredo et al. (1996). The theoretical foundation of the REP scales are motivational theory and the experiential approach (Driver & Tocher, 1970), which suggests that recreational activities serve as behavioral pursuits that allow individuals to attain specific psychological and physical goals. In essence, when people participate in recreation, they are fulfilling a motivational force that is driving them to satisfy a need or reach a desired goal state, which is difficult to fulfill through non-recreational activities (Manfredo et al., 1996). Thus, the recreation experience is conceptualized as the “package” or “bundle” of psychological outcomes that one desires or hopes to achieve from engaging in recreation (Manfredo et al., 1996, p.189).

The experiential approach emphasizes that recreation should not be seen merely as recreation activities, but rather as a self-rewarding psycho-physiological experience that is engaged in voluntarily during free time as a result of free choice (Manfredo et al., 1996). It is the recreation experience that can explain why people engage, what people want from recreation, and how recreation can provide benefits. In this context, the REP scales were designed to measure the desired goal states that individuals seek through recreation participation in general (Manfredo et al., 1996).

While the REP scales include a total of 328 items across 19 domains, Manfredo et al. (1996) highlighted that researchers have the flexibility to use shortened versions of the scale based on the applicability to their specific study. We used fifteen items to

assess participants' motivations to participate in winter backcountry recreation (Table 2.1). Items were selected from the REP scales based on their applicability to winter backcountry recreation and phrasing was adapted to fit the avalanche risk context so that the information being gathered is meaningful and relevant for avalanche risk communicators. We selected 14 items across nine REP domains: Physical fitness, learning, similar people, achievement/stimulation, escape physical pressure, risk taking, enjoy nature, teaching-leading others, and autonomy/leadership. In addition to the REP scales, one additional item was added that is not directly based on a REP item but was deemed a relevant factor for avalanche risk communicators to know and understand. This item was 'enjoying powder snow (conditions permitting)' and was added to understand how motivated people by the opportunity backcountry travel presents to experience untracked snow.

The intent of the select items was to learn about the type of experiences participants are interested in pursuing in the backcountry, their interest in risk, and their motivation to further develop their avalanche safety and technical travel skills. In the sign-up survey, the order of the items was randomized, and respondents were asked to rate the importance of each motive on a seven-point Likert scale from *not at all important* to *extremely important*.

Table 2.1. Motivation items with associated label and REP domains

Phrasing of motivation item	Label	REP domain	REP Sub-domain(s)
Navigating through challenging terrain (conditions permitting)	Navigating challenge	Achievement/ stimulation	Competence test
Experiencing risk, thrill, or exhilaration	Risk/sensation seeking	Achievement/ stimulation & Risk taking	Excitement & Risk taking
Sharing a story, picture, or video on social media	Sharing on social media	Achievement/ stimulation	Telling others & Social recognition
Exploring new or different places	Exploring	Learning	Exploring
Reaching a summit or similar trip objective	Reaching summits/peaks	Achievement/ stimulation	Endurance
Completing classic/well known/respected trips	Completing classic trips	Achievement/ stimulation	Endurance
Feeling carefree and/or relaxed	Feeling relaxation	Escape physical pressure	Tranquility
Exercising and working on your physical fitness	Physical fitness	Physical fitness	Exercise-physical fitness
Being away from crowds	Escaping crowds	Escape physical pressure	Escape crowds
Being in nature	Enjoying nature	Enjoy nature	General nature experience
Sharing your outdoor skills and knowledge with others	Sharing skills	Teaching-leading others	Teaching-sharing skills and leading others
Challenging/improving your technical [primary activity] skills	Improving tech. skills	Achievement/ stimulation	Skill development
Practicing/improving your avalanche risk management skills	Improving aval. skills	Achievement/ stimulation	Skill development
Enjoying powder snow (conditions permitting)	Enjoying powder	n/a	n/a
Spending time with family and/or friends	Being social	Similar people	Being with similar people

Activity Type

Activity type is an important consideration as it has a strong effect on how recreationists interact with the landscape and avalanche hazard. Activity type was presented at the beginning of the sign-up survey as a categorical question, through which participants indicated their primary backcountry activity followed by any secondary or tertiary activities they engage in. Activity options included *backcountry skiing and snowboarding*[2]*, out-of-bounds skiing and snowboarding, on-piste skiing and snowboarding, snowshoeing, ice climbing, mountaineering*, and *other*. Since participants were then asked to complete the rest of the survey from the perspective of their primary activity to ensure consistency and avoid confusion, our analysis only includes participants' primary activity.

Terrain Use Preferences

Recreationists' personal terrain use patterns strongly affect their general, condition independent exposure to avalanche hazard and ultimately their risk of being caught in an avalanche. Some of the key variables that determine the severity of terrain with respect to exposure to avalanche hazard are slope angle, slope shape, forest density, the presence of terrain traps, typical avalanche frequency, and start zone density (Statham et al., 2006). Recreationists with motivations that drive them to recreate in areas with high avalanche hazard exposure will likely require more sophisticated risk mitigation practices to manage their exposure appropriately. Therefore, understanding where people are going and their exposure levels are important considerations for designing meaningful risk messages and support tools. While activity type already relates to the type of terrain that recreationists typically access, the range of possible exposure levels depends heavily on personal terrain preferences.

We measured participants' relevant terrain use patterns employing the avalanche terrain exposure scale (ATES), a five-level classification system that evaluates routes and terrain based on the severity of exposure to avalanche hazard (Statham et al., 2006, Statham & Campbell, 2023). The five classes of the scale are *non-avalanche terrain, simple avalanche terrain, challenging avalanche terrain, complex avalanche terrain*, and

[2] For the remainder of this chapter, we will use the term skiing to refer to both skiing and snowboarding.

extreme avalanche terrain. Participants were presented with simplified descriptions of the five different classes (Table 2.2) and asked to rate how frequently they recreated in each of the terrain classes, when avalanche conditions allow, on a five-point Likert scale from *never* to *always*. To simplify and speed-up the survey for participants, backcountry and out-of-bounds skiers were not presented with the non-avalanche terrain item because it is essentially not skiing terrain, and the snowshoe version of the survey did not include extreme terrain because it is too technical for snowshoeing. To further enhance our understanding of participants' terrain preferences, we asked skiers how often their trips include short scrambles to reach a summit or a ski line, and snowshoers how often they leave established trails and create their own routes using the same five-point Likert scale.

Table 2.2. Descriptions of terrain types using the avalanche terrain exposure scale

Terrain class	Description of terrain class
Non-avalanche terrain	Low angle open terrain (<20°) or densely forested slopes. No crossing of avalanche paths or runout zones.
Simple avalanche terrain	Exposure to low angle open terrain (<20°) or densely forested slopes. Some forest openings may involve runout zones of infrequent avalanches. Many options exist to reduce or eliminate exposure.
Challenging avalanche terrain	Treeline or alpine terrain with well-defined avalanche paths, start zones or terrain traps that can be dangerous to people. Typically only dealing with one path at a time, and options exist to reduce or eliminate exposure with careful route-finding.
Complex avalanche terrain	Alpine terrain with multiple overlapping avalanche paths or large expanses of open terrain. Commonly exposed to avalanche hazard from above. Travel requires commitment, and there are only minimal options to reduce exposure.
Extreme avalanche terrain	Very steep, open terrain averaging 35° with large proportions of terrain stepper than 45°. Steep faces with cliffs, couloirs, spines, and gullies. No options to reduce exposure, and even small avalanches can have severe consequences.

Practical Knowledge and Experience

Extensive research has already been dedicated towards understanding the relationship between motivations and expertise (e.g., Ewert & Hollenhorst, 1989; Ewert et al., 1994; Creyer et al., 2003; Gilbertson & Ewert, 2009; Ewert et al., 2013; Ewert et

al., 2020). We included two questions to capture participants' practical knowledge and experience in managing avalanche risk. Level of avalanche safety training and experience directly impacts individuals' ability to assess and manage risk effectively and in alignment with their motivations, as those with greater experience and higher levels of safety training are more likely to possess the skills necessary to comprehend avalanche forecasts and apply them to in field risk mitigation practices (e.g., Finn, 2020).

Experience was measured in terms of the total number of years involved in winter backcountry recreation in general as well as the average number of days per year in which they recreate. Both questions provided five response options. For collective years of experience, options ranged from *this is/was my first winter* to *more than 20 winters*, while days per year ranged from *1-2 days per winter* to *more than 50 days per winter.* To measure the level of formal avalanche safety training, participants were asked to indicate their highest level of completed avalanche safety training. Options included *none*, *indoor/live online avalanche awareness seminar* (e.g., evening seminar), *introductory recreational avalanche safety course with a field component* (typically a 1-2 day course), *advanced recreational avalanche safety course* (typically a 3-5 day course), and *avalanche training aimed at avalanche professionals* (e.g., guides, mountain rescue, avalanche technicians). For the analysis, we combined the seminar category with none since these seminars are not considered formal training.

2.3.3. Data Analysis

Our analysis was conducted in the R statistical environment (Version 4.2.3; R Core Team, 2023) and consisted of several steps. First, we sought to understand the nature of the dataset, then preprocessed some of the data for the analysis before clustering our participants based on their motivation responses. Finally, we related the motivation clusters to other variables to explore whether they meaningfully relate to stated behaviours in avalanche terrain and avalanche risk management practices.

We started with standard descriptive statistics to explore and visualize the nature of the dataset and relationships between different variables. To explore the response patterns in the motivation questions, we first calculated pairwise correlations for all combinations of variables and visualized them with a correlation plot using the corrplot function of the corrplot package (Wei et al., 2021). To present the motivation variables in

a meaningful way, we set the order parameter of the corrplot function to hclust, which groups motivations according to their correlation structure and presents variables with higher correlations closer together. For the rest of the analysis, we present the motivation questions in this order.

In the recreation literature, large batteries of motivation questions are commonly analyzed in two steps. First, the number of dimensions is reduced by applying a principal component analysis (PCA) or correspondence analysis (CA), which groups motivation items with similar response patterns together to produce a smaller number of more general themes. In a second step, participants are clustered on their factor scores on the identified themes. Examples of this analysis approach include Alexandris (2009), Torbidoni (2011), Mauricio et al. (2019), Komossa et al. (2019), and Bichler and Pikkemaat (2021). Even though a standard practice, this so-called “tandem approach” may not produce optimal cluster solutions as the two methods optimize different criteria (e.g., Markos, D’Enza & van de Velden, 2019). While the dimension reduction step aims to retain as much variance as possible in as few dimensions as possible, the subsequent clustering aims to find similar and dissimilar observations in the data. Dolničar and Grün (2008) explicitly showed that direct clustering on the data consistently outperformed the factor-cluster technique. To address this issue, several joint dimension reduction and clustering methods have been developed for continuous and categorical data including the recently introduced clustrd package by Markos et al. (2019).

However, given the limited correlations between the different motivation items, we decided to follow the recommendation of Dolničar and Grün (2008) and cluster participants directly on their responses after subtracting the sample means. This approach provides a rich characterization of the clusters as it relates directly to the original motivation items and is not muted by general themes. We used K-means clustering for our analysis, a deterministic, non-hierarchical form of clustering that maximizes between cluster differences and minimizes within group differences (Hair, 2006). We estimated solutions for a wide range of cluster numbers and used the Akaike Information Criterion (AIC; Akaike, 1974) and the Bayesian Information Criterion (BIC; Schwarz, 1978) as well as the interpretability of the clusters to identify meaningful solutions. To present the cluster solutions visually, we plotted the average deviations from the sample mean for each item and each cluster.

We used a Latent Class Analysis (LCA; McCutcheon, 1987) to reduce the terrain preference items into a single ordinal variable. A LCA is a probabilistic clustering technique for categorical variables where the observed variables are considered indicators of a latent (i.e., not directly observable), higher level grouping variable with a limited number of mutually exclusive classes (Collins & Lanza, 2010). Similar to the k-means clustering, the goal of the analysis was to identify the number of classes that best describes the variations in the observed response patterns. The output of the analysis consists of a set of class-specific response probabilities that describe the likely response patterns of individuals belonging to the identified classes, and conditional class membership probabilities for each participant. Respondents are then assigned to the class with the highest probability, and the likely response pattern is used to describe characteristics of the particular class. We used the poLCA package (Linzer & Lewis, 2011) to perform this analysis, and we estimated a range of models with different numbers of classes. In addition to the AIC, BIC, and interpretability of the estimated model, we also examined classification diagnostics (e.g., average assignment probabilities) to identify the best model fit.

To analyze the responses of backcountry skiers, out-of-bounds skiers, and snowshoers together in a single LCA, we set the use of non-avalanche terrain to never for all backcountry and out-of-bounds skiers, and we did the same with extreme terrain for snowshoers. To assess the validity of the combined classification approach, we also classified the two groups separately and compared the resulting classes with the classes of the combined analysis.

To examine the relationship between the motivation clusters and the other participant characteristics and preferences described above, we utilized Pearson chi-squared tests, Kruskal-Wallis tests, and pairwise Wilcoxon rank-sum tests depending on the nature of the variable. All tests were evaluated using a p-value of 0.05 to determine statistically significant differences. We used the mosaic plot from the vcd package in R (Meyer et al., 2021) to visualize the observed patterns.

2.4. Results

2.4.1. Sample Characteristics

Overall, 2339 participants completed all motivation items and were included in the clustering analysis. This dataset consisted of 80% identifying as male, 19% as female, and 27% of participants were between the ages of 25-34. Almost half of the participants were from Switzerland (43%), followed by 24% from Germany, and 17% from Austria, with the remaining 16% of participants from other countries (Table 2.3).

Table 2.3. Sociodemographic characteristics of the sample

Variable	Quantity (N)	Proportion (%)
Gender		
Female	453	19.4
Male	1868	80.0
Prefer not to say	5	0.2
Prefer to self-describe	7	0.3
Non-binary/third gender	2	0.1
Age		
Under 20	37	1.6
20 - 24	106	4.5
25 - 34	623	26.6
35 - 44	533	22.8
45 - 54	485	20.7
55 - 64	384	16.4
64 and above	171	7.3
Country of Residence		
Switzerland	1006	43.0
Germany	553	23.6

Variable	Quantity (N)	Proportion (%)
Austria	407	17.4
All Other	373	16.0
Forecasting Agency		
Euregio	1149	49.1
SLF	1190	50.0

Backcountry skiers presented an overwhelming majority of the sample representing 81% of all participants (Table 2.4), followed by out-of-bounds skiers (9%), snowshoers (5%), on-piste skiers (4%). Collectively, mountaineers and ice climbers only made up 1.5% of the sample. Avalanche training level was distributed more evenly, with the majority of participants reporting introductory level training (42%), followed by advanced training (29%), with 13% reporting no training. Similar distribution patterns were seen with total years of experience and average days per year. Overall, 34% of participants reported participating in their winter activity for 20 or years and only 1% reported that it was their first year. Most people recreate on average between 21-50 days in a season (43%), while only 0.5% reported 1-2 days per season and 13% between 3-10 days per season.

Table 2.4. Characteristics of Sample

Variable	Quantity (N)	Proportion (%)
Primary backcountry activity		
Backcountry skiing (BC)	1901	81.3
Out-of-bounds skiing (OB)	219	9.4
Snowshoeing (SS)	106	4.5
On-piste skiing (OP)	82	3.5
Mountaineering (MT)	25	1.1
Ice climbing (IC)	6	0.1
Years of experience		

Variable	Quantity (N)	Proportion (%)
First year	31	1.3
2-5 years	488	20.9
6-10 years	457	19.6
11-20 years	559	24.0
20 or more years	795	34.1
Average number of days per winter		
1-2 days	11	0.5
3-10 days	304	13.1
11-20 days	780	33.7
21-50 days	989	42.7
50 or more days	230	9.9
Level of avalanche safety training		
None	283	12.7
Introductory	943	42.2
Advanced	656	29.4
Professional	15	15.5

2.4.2. Avalanche Terrain Exposure Measure

Using the lowest BIC as the primary guide, the LCA conducted on the responses to the terrain use question, by backcountry skiers, out-of-bounds skiers, and snowshoers combined, revealed five distinct terrain use patterns ordered from most conservative to most aggressive terrain choices. The identified patterns agreed well with the patterns that emerged in the LCA analyses that examined the responses for skiers and snowshoers separately, which confirms the appropriateness of our approach to set skiers' answer for non-avalanche terrain and snowshoers' answer to extreme avalanche terrain to never by default. Furthermore, the identified terrain use patterns lined up well

with skiers' answers to whether their trips include short scrambles and snowshoers' responses to whether they leave marked trails (i.e., more aggressive patterns associated with higher proportions of scrambles and leaving marked trails) giving us confidence in the terrain use pattern classes.

To create a general variable for exposure to avalanche terrain, we added the mountaineers and ice climbers as separate classes due to the unique terrain use patterns of these activities. This resulted in a new seven-level categorical variable that describes participants' exposure to avalanche terrain (Table 2.5).

Table 2.5. Avalanche terrain exposure variable

		Likelihood of spending at least "sometimes" in ATES terrain class (%)					Proportion of participants within activity (%)		
Label	**N**	**Cl. 0[a]**	**Cl. 1**	**Cl. 2**	**Cl. 3**	**Cl. 4[b]**	**BC**	**OB**	**SS**
Most conservative	187	28.6	94.0	42.3	0.5	0.5	6.1	5.8	50.0
Conservative	278	7.9	99.9	94.5	3.9	0.8	15.9	16.1	30.4
Moderate	503	3.1	88.6	97.7	26.8	0.0	23.1	14.7	19.6
Aggressive	739	0.0	87.0	99.9	96.3	22.0	34.2	33.9	0.0
Most aggressive	470	0.0	70.3	99.4	97.8	70.1	20.8	29.5	0.0
Mountaineers	83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ice climbers	30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[a] ATES terrain class 0 not presented to backcountry and out-of-bounds skiers; assumes "never".
[b] ATES terrain class 4 not presented to snowshoers, assumes "never".

2.4.3. Motivation Ratings

All motivation items were rated on a seven-point Likert scale from *not at all important* (1), *important* (4), to *extremely important* (7). For a motivation to be considered important, it must have received a rating of at least 4. Out of the 15 motivation questions (Figure 2.1), the highest rated, and therefore most important, motivations across all participants were *Being in nature* (mean = 6.5, SD = 0.8), followed by *Escaping crowds* (mean = 5.8, SD = 1.2), *Enjoying powder* (mean = 5.7, SD = 1.3), and *Physical fitness* (mean = 5.6, SD = 1.2). Interestingly, Improving avalanche safety skills (mean = 4.8,

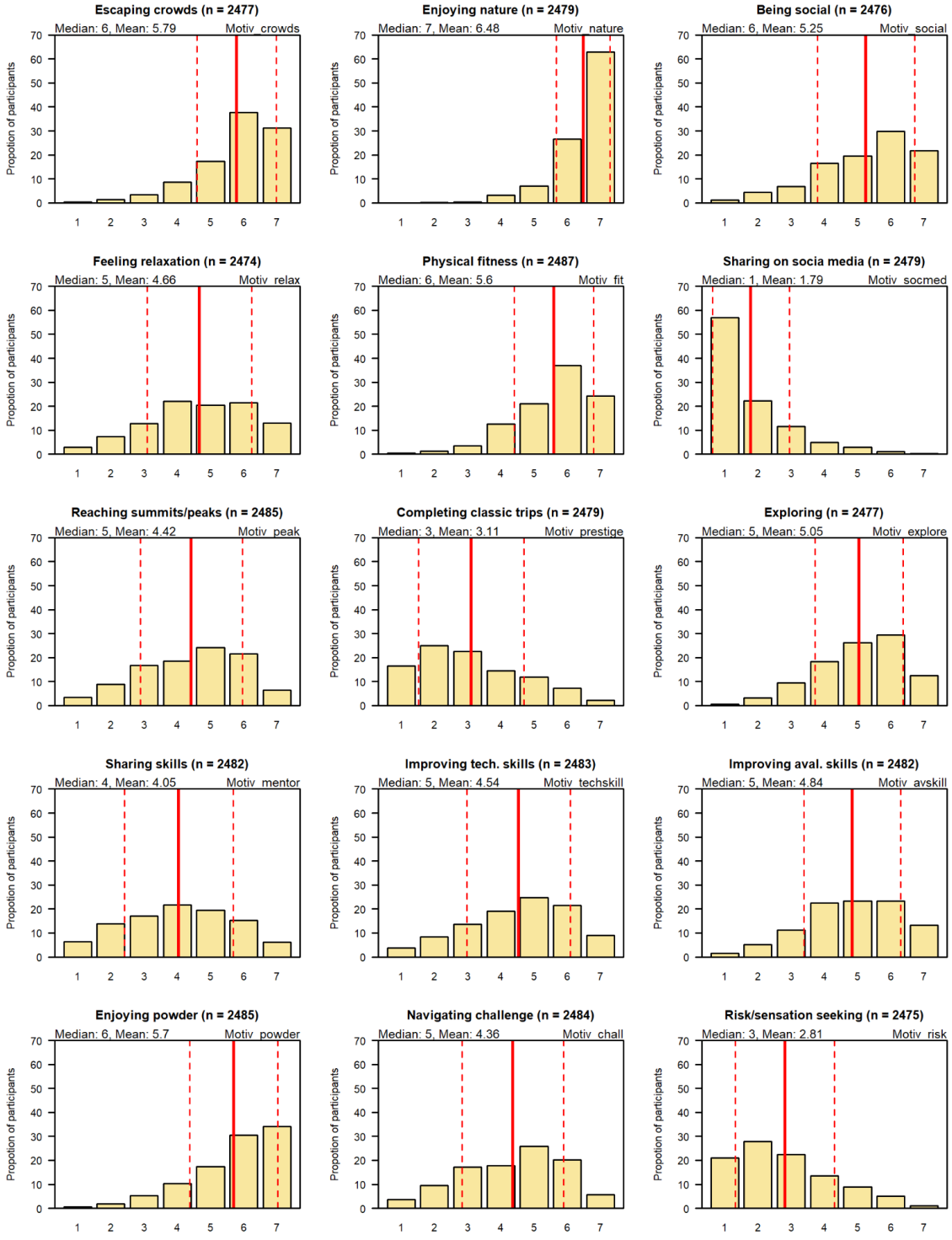

Figure 2.1. Distribution of the ratings for each motivation item. Rantings go from not at all important (1) to important (4) and extremely important (7). Vertical lines indicate the mean (solid red) and the mean +/- standard deviation (dashed red).

SD = 1.5) and *Improving technical skills* (mean = 4.5, SD = 1.6) were rated very similarly to *Feeling relaxation* (mean= 4.7, SD = 1.6). All motivation items on average were rated as important (4) or above, except for three: *Completing classic trips* (mean = 3.1, SD = 1.6), *Risk/sensation seeking* (mean = 2.8, SD = 1.5), and *Sharing on social media* (mean = 1.8, SD = 1.2), which were the lowest ranked motivations overall and collectively considered unimportant.

The correlations between the motivation items (Figure 2.2) ranged from -0.06 for *Feeling relaxation* and *Navigating challenge* to 0.49 for *Improving technical skills* and *Improving avalanche safety skills*. The hierarchical clustering of the correlations grouped the motivations into general themes around *Escaping crows* and *Enjoying nature*, *Reaching summits* and *Completing classic trips*, as well as skill development and *Sharing skills*. In general, however, the correlation structure is quite flat.

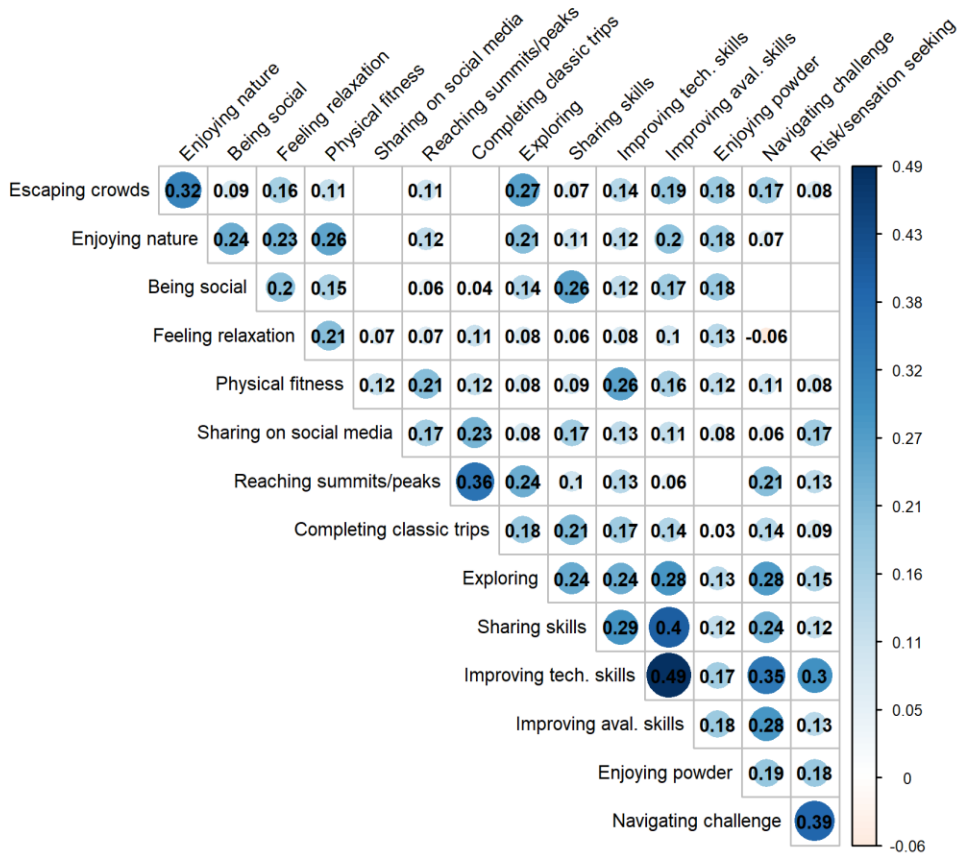

Figure 2.2. Correlation plot of motivation items.

2.4.4. Clustering Results

We estimated solutions with 2 to 100 clusters. The BIC value continued to drop as the number of clusters created increased, and suggested a best fit model of 61 clusters, which captured 53% of the total variance. The relatively low value of the captured variance highlights that the point cloud of the motivation ratings is more of a continuum than a collection of very distinct clusters. Since having 61 clusters is neither practical nor informative, we explored the solutions with 2 to 8 clusters in more detail (see Appendix B) and used interpretability and classification diagnostics as the primary guides for identifying the most informative solution. Ultimately, the seven-cluster solution proved to be most informative (Figures 2.3 and 2.4). We labelled each cluster based on the dominant characteristics of each cluster, which are discussed in detail below.

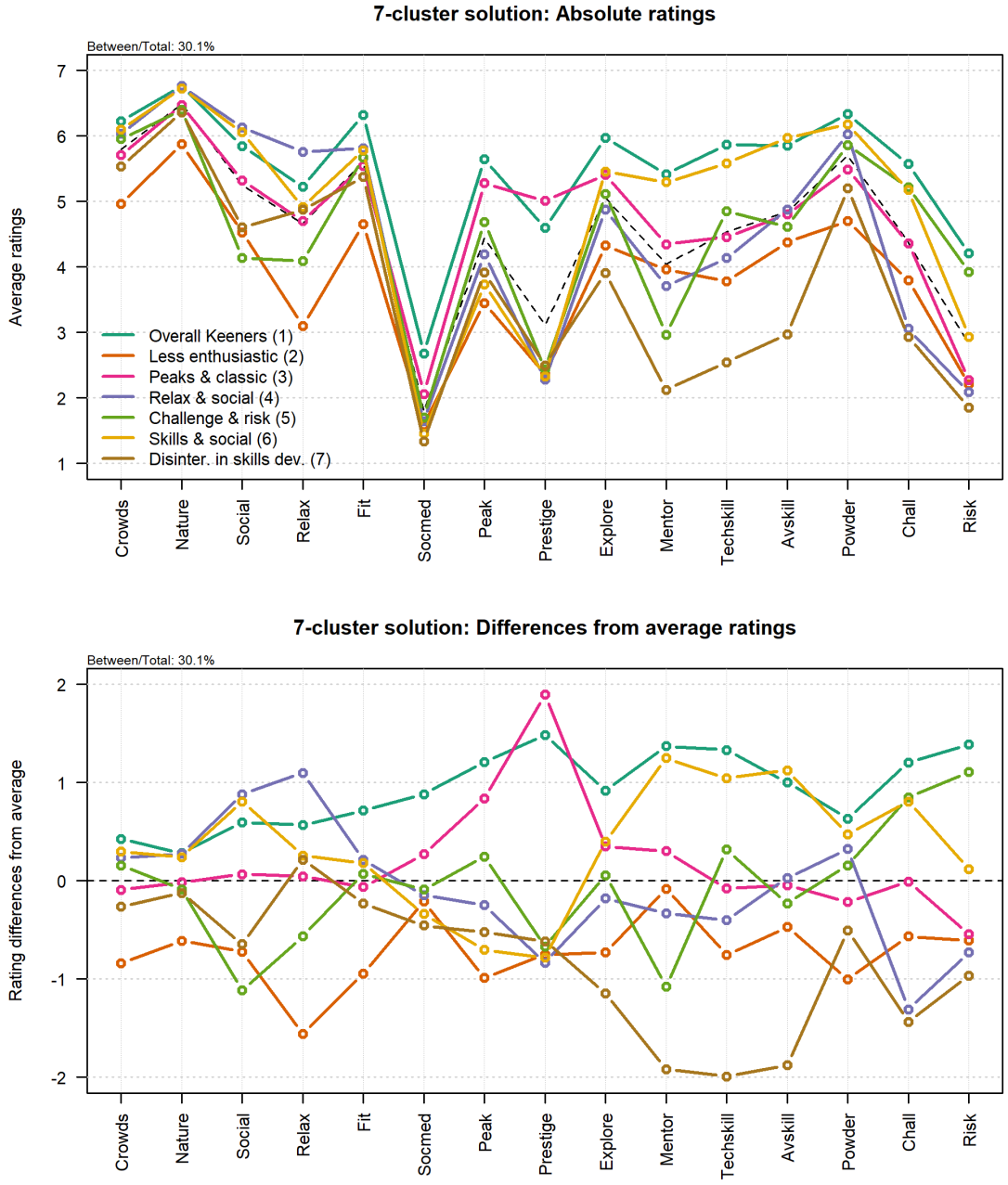

Figure 2.3. **Motivation ratings of 7-cluster solution. Top panel shows absolute ratings. Bottom panel shows differences from average ratings. Dashed black line shows the average rating across the entire sample.**

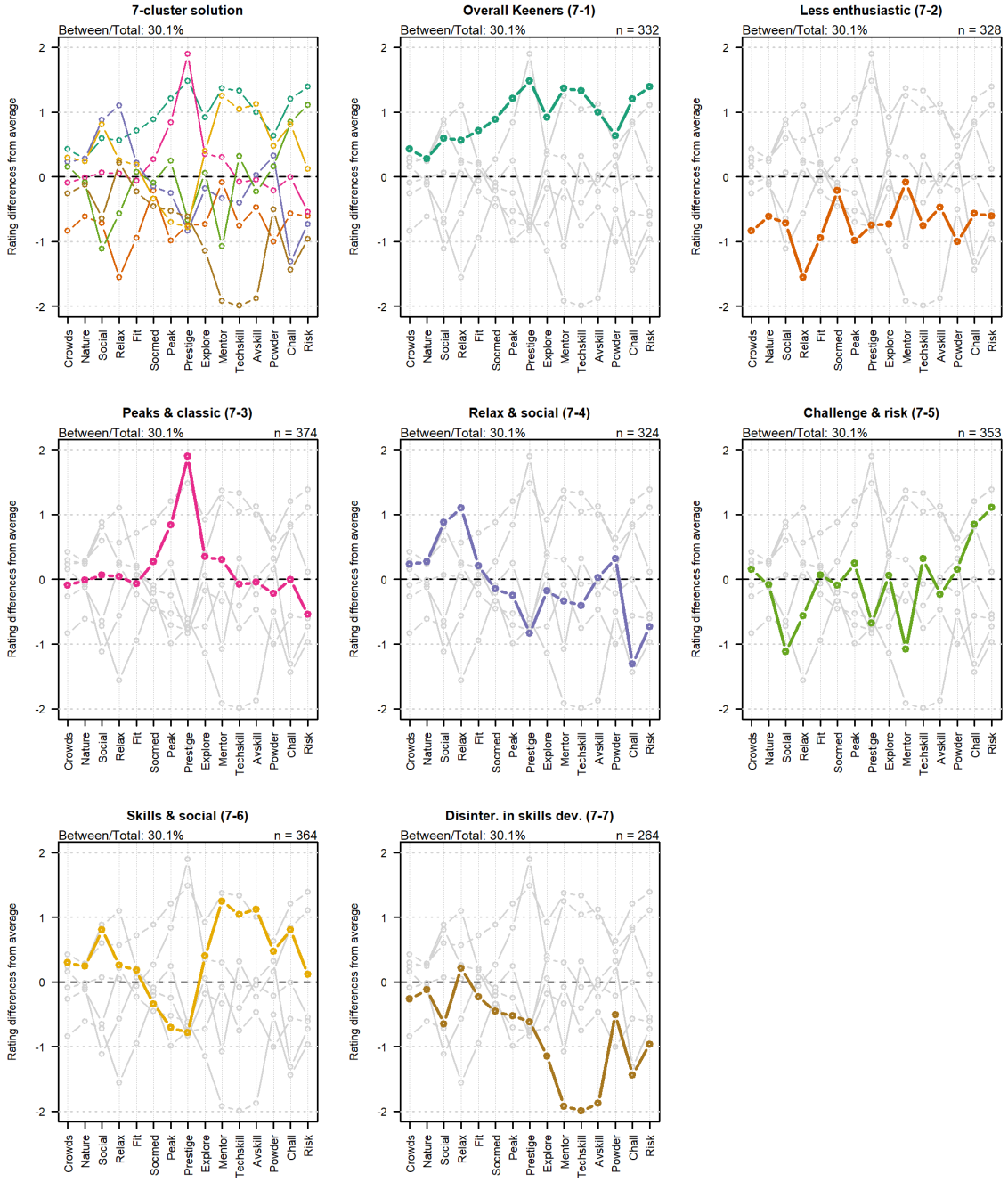

Figure 2.4. Motivation rantings of 7-cluster solution. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.

As Figures 2.3 and 2.4 shows, the first cluster rated every motivation item as more important than sample averages, hence the name *Overall keeners*. Compared to the other clusters, the *Overall keeners* average ratings were highest for almost every motivation item, except for *Being social, Feeling relaxation, Completing classic trips,* and

Improving avalanche safety skills. Ratings for *Enjoying nature* (mean = 6.8), *Escaping crowds* (mean = 6.2), and *Enjoying powder* (mean = 6.3) were most closely aligned with sample averages. Interestingly, these three items also happen to be the three highest rated motivation items by the entire sample. This highlights the increased relative importance this cluster places on the motivations ranked considerably above the sample's average ratings, such as *Navigating challenge* (mean = 5.6), *Sharing skills* (mean = 5.4), *Completing classic trips* (mean = 4.6), and *Risk/sensation seeking* (mean = 4.2).

The second cluster's motivation pattern is opposite from the *Overall keeners*, as Cluster 2 rated the importance of every motivation below sample averages, prompting this cluster to be labeled as *Less enthusiastic*. The motivations rated most similar to the sample's average ratings were *Sharing on social media* (mean = 1.6), albeit a motivation considered not important to the overall sample, and *Sharing skills* (mean = 4.0). *Feeling relaxation* (mean = 3.1) was this cluster's least important motivation and was the lowest average of all clusters. Despite an overall expressed lack of motivation, this cluster only held the lowest average ratings on six of the fifteen items. The *Challenge & risk* (Cluster 5) cluster, for example, had average ratings lower than this cluster for *Being social* (mean = 4.1 vs 4.5) and *Sharing skills* (mean = 3.0 vs 4.0).

Cluster 3, *Peak & classic,* had average ratings for almost all motivation items that aligned with the rest of the clusters and overall sample, except for *Completing classic trips* (mean = 5.0) and *Reaching summits/peaks* (mean = 5.3). These two items were rated considerably above average and therefore considered most important to this group. All other clusters, except for *Overall keeners,* who rated *Completing classic trips* similarly (mean = 4.6), rated this motivation item below the overall sample average (sample mean = 3.1).

Cluster 4, the *Relax & social* cluster, is defined by their drive for *Feeling relaxation* (mean = 5.8) and *Being social* (mean = 6.1)*. Being social* is rated an important motivation by all clusters, although only the *Overall keeners* (cluster 1; mean = 5.8) and the *Skills & social* cluster (Cluster 6; mean = 6.1) also rated the item well above average. While *Completing classic trips* (sample mean = 3.1) and *Risk/sensation seeking* (sample mean = 2.8) are overall rated as relatively unimportant motivations (i.e., averages below 4), this cluster considered them even less important (mean = 2.3 and 2.0 respectively).

Little to no differences between this cluster and the sample averages exists for *Enjoying nature* (mean = 6.8), *Improving avalanche safety skills* (mean = 4.9), *Exploring* (mean = 4.9), and *Sharing on social media* (mean = 1.6).

Cluster 5, *Challenge & risk*, is composed of a group of recreationists who rank the importance of *Risk/sensation seeking* (mean = 3.9) and *Navigating challenge* (mean = 5.2) higher than all other clusters (except for *Overall keeners*) and higher than the overall sample averages for these two motivations. Despite this cluster being defined by a heightened desire to experience risk, thrill, or exhilaration, the cluster's average rating for this item falls slightly short of being an important motivator. Other responses by this cluster align more closely with the sample averages, except for *Being social* (mean = 4.1), *Feeling relaxation*, (mean = 4.1), and *Sharing skills* (mean = 3.0) which fall noticeably below average. Interestingly, this cluster rated *Improving avalanche safety skills* slightly below the samples average (means = 4.6 vs 4.8).

In Cluster 6 all but three items are rated above average. The three below average rated items are *Completing classic trips* (mean = 2.3), *Reaching summits/peaks* (mean = 3.7), and *Sharing on social media* (mean = 1.5). As expected by the name, *Skills & social*, this cluster rated *Being social* (mean = 6.1), *Improving technical skills* (mean = 5.6), and *Improving avalanche safety skills* (mean = 6.0) considerably above sample averages, with the importance of *Improving avalanche safety skills* above all other clusters. This cluster also had noticeably high and above average ratings for *Sharing skills* (mean = 5.3) and *Navigating challenge* (mean = 5.2).

While Cluster 6 was defined by a distinct interest in skill development, Cluster 7 exhibited the opposite. The responses by participants from the *Disinterested in skills development* cluster present a unique pattern. All motivations were rated below average, except for *Feeling relaxation* (mean = 4.9), which was only slightly above the sample's average. As the name explains, this cluster exhibited remarkably below average ratings, the lowest of all clusters, for *Sharing skills* (mean = 2.1), *Improving technical skills* (mean = 2.5), and *Improving avalanche safety skills* (mean = 3.0). This cluster's average rating for *Risk/sensation seeking* (mean = 1.9) was also the lowest of all clusters. Motivations rated important and above by the entire sample, including *Reaching summits/peaks, Exploring,* and *Navigating challenge*, were considered less than important by this cluster (mean = 2.5, 3.9, and 3.0 respectively).

2.4.5. Analysis of Motivation Clusters

Activity Type

Cross comparisons revealed statistically significant differences in the distributions of activity type across the motivation clusters (Table 2.6; $\chi^2 = 91.21$, df = 30, $p < 0.001$), except in the *Relax & social* cluster (Cluster 4). Specifically, significantly more on-piste skiers were included in the *Disinterested in skills development* cluster (Cluster 7; 6%), while significantly more out-of-bounds skiers were clustered to the *Challenge & risk* (Cluster 5; 13%) and *Skills & social* clusters (Cluster 6; 13%). The *Less enthusiastic* and *Peak & classic* clusters (Clusters 2 and 3) contained significantly more snowshoes (7% and 9% respectively), whereas they were found significantly less often in the *Skills & social* (Cluster 6; 2%). No significant distribution differences in backcountry skiers or mountaineers were found across the motivation clusters.

Table 2.6. Motivation clusters and activity type

	Proportion by cluster (%)								
Activity type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**χ^2**	***p*-value**
Backcountry skiing	81.6	78.4	82.6	83.0	81.9	81.3	79.5	91.21	< 0.001
On-piste skiing	2.4	4.6	3.5	5.6	0.8↓	2.5	6.1↑		
Out-of-bounds skiing	10.5	9.8	3.5↓	7.4	12.7↑	12.9↑	8.7		
Mountaineering	1.8	0.3	1.1	0.6	1.7	1.1	0.8		
Ice climbing	0.9↑	0.0	0.5	0.0	0.0	0.3	0.0		
Snowshoeing	2.7	7.0↑	8.8↑	3.4	2.8	1.9↓	4.9		

↑ Significantly higher than average
↓ Significantly lower than average

Terrain Use Preferences

All motivation clusters had significantly different terrain use preferences from at least four of the other motivation clusters (Table 2.7; H = 173.65, df = 6, $p < 0.001$). *Relax & social* (Cluster 4) has the highest proportion of members who recreate in the most conservative terrain class, although this cluster also has significantly higher proportions who chose conservative and moderate terrain. Overall, members of the

Relax & social and *Disinterested in skills development* clusters (Clusters 4 and 7) have the most conservative terrain use patterns, whereas the *Less enthusiastic*'s (Cluster 2) terrain choices are more evenly distributed from most conservative to most aggressive. The *Peak & classic* cluster's (Cluster 3) patterns are not significantly different from the *Less enthusiastic*, although members of this cluster chose less conservative terrain. The terrain use patterns of the *Overall keeners* (Cluster 1), *Challenge & risk* (Cluster 5), and *Skills & social* (Cluster 6) clusters are significantly different from the other clusters, but not from each other. These three clusters contain more individuals who recreate in the most aggressive terrain class, with the *Challenge & risk* (Cluster 5) cluster containing the highest proportion.

Table 2.7. Motivation clusters and terrain use preferences

	Proportion by cluster (%)								
Terrain use preference	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**H**	***p*-value**
Most conservative	3.2	9.1	10.8	15.2	1.5	3.8	13.8	173.65	< 0.001
Conservative	11.5	20.9	21.9	21.3	12.1	9.9	19.2		
Moderate	20.1	21.9	19.8	27.7	19.4	20.7	27.1		
Aggressive	35.4	29.0	30.6	27.0	34.1	37.9	27.5		
Most aggressive	27.1	18.9	15.2	8.1	31.2	1.8			
Mountaineers	1.9	0.3	1.2	0.7	1.8	1.2	0.8		
Ice climbers	1.0	0.0	0.6	0.0	0.0	0.3	0.0		

Practical Knowledge and Experience

The differences in the years of experience across the motivation clusters was more evenly distributed than activity type and terrain use patterns distributions, although significant differences were still identified (Table 2.8; $\chi^2 = 104.62$, df = 24, $p < 0.001$). Interestingly, there are significantly more individuals in their first year (3%) or with 2-5 years (28%) of experience in the *Overall keeners* (Cluster 1). However, it is the distribution of individuals with 20 or more years of experience that differs most significantly across the motivation clusters. Cluster 7, *Disinterested in skills development*, contains significantly more (52%) and *Overall keeners* (Cluster 1; 26%),

Relax & social (Cluster 4; 27%), and *Skills & social* (Cluster 6; 27%) contain significantly less individuals with this many years of experience.

Annual engagement, as measured by average number of days per year, also exhibited minimal distribution differences (Table 2.8). No significant differences were found for 1-2 days per year, and 21-50 days per year across the clusters. However, *Disinterested in skills development* (Cluster 7) had significantly more individuals who recreate between 3-10 days per year (19%) and the *Challenge & risk* (Cluster 5) cluster contained significantly less individuals who recreate 11-20 days per year (27%; $\chi^2 = 63.21$, df = 24, $p < 0.001$). In comparison, the *Relax & social* (Cluster 4) contained significantly more individuals who recreate 11-20 days per year (40%), and significantly less who recreate above 50 days (6%).

Significant differences exist in distributions of all levels of training, but only in three clusters (Table 2.8; $\chi^2 = 75.02$, df = 24, $p < 0.001$). The *Less enthusiastic* (Cluster 2) contained significantly more professionally trained individuals (22%). In addition, the *Skills & social* (Cluster 6) cluster contains significantly more individuals with advanced training (38%), whereas the *Disinterested in skills development* cluster contains significantly more with introductory level training (Cluster 7; 52%).

Table 2.8. Motivation clusters and practical knowledge and experience variables

	Proportion by cluster (%)								
Years of experience	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**χ^2**	***p*-value**
First year	2.7↑	0.9	0.8	1.5	1.4	0.8	1.1	104.62	< 0.001
2-5 years	27.6↑	15.4↓	19.3	24.1	21.3	24.0	13.3↓		
6-10 years	23.9	16.9	19.0	24.1	18.8	22.3	10.3↓		
11-20 years	20.3	29.2	21.7	22.9	24.4	26.2	23.2		
20 or more years	25.5↓	37.5	39.3	27.2↓	34.1	26.7↓	52.1↑		
Average number of days per year									
1-2 days	0.6	0.6	0.5	0.3	0.3	0.6	0.4	63.214	< 0.001
3-10 days	7.3↓	13.5	12.5	16.8	14.2	10.3	18.8↑		
11-20 days	30.8	35.7	36.5	40.4↑	26.7↓	30.9	36.0		
21-50 days	48.5	37.5	42.5	37.0	47.2	46.5	38.3		
50 or more days	12.8	12.6	7.9	5.6↓	11.6	11.7	6.5		
Level of avalanche safety training									
No training	15.2	7.7↓	13.9	11.3	14.7	11.2	15.4	75.02	< 0.001
Introductory	43.0	35.4	42.0	47.6	47.3	32.5↓	51.5↑		
Advanced	28.2	35.4	28.4	28.3	24.9	37.5↑	20.7↓		
Professional	13.6	21.5↑	15.6	12.9	13.2	18.8	12.4		

↑ Significantly higher than average
↓ Significantly lower than average

2.5. Discussion

The primary objective of this study was to explore the motivations of winter backcountry recreationists and see how these findings can contribute to a more comprehensive understanding of the backcountry community to inform avalanche risk communication. Recreationists' exposure to avalanche hazard and their abilities to manage this hazard are influenced by their choice of activity, level of avalanche safety training, and experience. Therefore, this research also sought to understand if and how motivations relate to these variables. Within the literature no study has explored the motivations of winter backcountry recreationists explicitly to inform avalanche risk communication. Our discussion begins by synthesizing insights gained from our results and situating them within the existing research, followed by presenting implications for the avalanche safety community and limitations of this study.

2.5.1. Findings and Practical Insights

Motivation Ratings

Overall, we found a clear hierarchy of motivations from least to most important. The most important motivation was *Enjoying nature*, followed by *Escaping crowds* and *Enjoying powder* snow. Conversely, the three motivation items that consistently received the lowest ratings included *Completing classic trips*, *Risk/sensation seeking*, and *Sharing on social media*, which was considered the least important motivation overall. Interestingly, the two most important motivations (*Enjoying nature* and *Escaping crowds*) had the least variability in response ratings (i.e., lowest standard deviations), and they also do not require exposure to avalanche hazard or risk management expertise to satisfy. Conversely, the motivations with the greatest variability in the ratings (SD > 2.0) includes items more closely related to managing risk and level of exposure to avalanche hazard. This includes items such as *Improving technical skills, Improving avalanche safety skills, Reaching summits/peaks*, and *Navigating challenge*. The difference in response variability amongst motivations relevant to avalanche exposure and developing skills, compared to other motivations, supports the objective of this research. These initial findings suggest that motivations are able to segment the backcountry recreation community meaningfully for avalanche safety messaging.

The order of the motivation ratings agrees with existing literature in multiple domains. Enjoying nature, escaping, and being social consistently emerge as important motivators for participation in backcountry recreation (e.g., Frühauf et al., 2017; Bichler & Pikkemaat, 2021; Gilbertson & Ewert, 2015; O'Connell, 2010). Our finding of *Risk/sensation seeking* as the second lowest rated motivation also aligns with a trend in the recent literature that challenges the longstanding believe that sensation and risk seeking is the primary motive for adventure recreation (e.g., Barlow et al., 2013; Kerr & Houge Mackenzie, 2012; Brymer, 2010). Specifically, research shows that risk is managed as a necessary component to participation (e.g., Ewert et al., 2013; Ewert et al., 2020) and as a means to achieve other more important and desirable benefits (Frühauf et al., 2017; Sole et al., 2010). Brymer (2010), for example, conducted a series of interviews with extreme sport participants (base-jumpers, surfers, skiers, kayakers, mountaineers, and free-solo climbers) revealing that participants did not deliberately seek risk. Instead, they were motivated by a wide range of positive experiential outcomes, were aware of associated risks, and therefore mitigated them with deliberate actions. Our findings, even before participant clusters are identified, contribute to the growing body of literature that de-emphasizes risk and highlights greater motivational variability. Hence, risk communication built on the assumption that risk is a primary motivator may not resonate with a significant proportion of recreationists. This is consistent with Fisher et al.'s (2022b) recommendation that avalanche risk communication should avoid fear-based messaging, as most recreationists are aware of and plan for, but are not primarily motivated by risk.

Motivation Clusters

The continuum of response ratings combined with the gradually decreasing BIC value up to the minimum at 61 clusters suggests that a range of cluster solution options could be used to describe the motivational differences in the recreation community. Evidently, 61 clusters are not functional to use or insightful for our research objective. Therefore, we opted for the seven-cluster solution as it offered meaningful and practical insights that describe the overall structure of participants' motivations and highlight the most extreme response patterns. Hence, each cluster is defined by two or more motivational items, where the responses of that item by that cluster varies in a way that makes it distinct from the other clusters. For example, *Peak & classic* (Cluster 3) rated almost every item on average yet rated *Completing classic trips* and *Reaching*

summits/peaks considerably above average. Both *Relax & social* (Cluster 4) and *Skills & social* (Cluster 6) clusters are motivated to be social, yet one cluster prefers relaxation whereas the other is motivated to develop their skills.

We then explored the relationship between each motivation cluster and variables directly linked to risk management: level of safety training, years of experience, average number of days per year, and terrain preferences. Comparisons revealed variations across the motivation clusters for all four variables, with the most extreme differences exhibited in terrain use patterns. Notably, the *Overall keeners* (Cluster 1) tend to be in their first to fifth year of recreation, yet choose challenging, complex, and extreme terrain that has increasing levels of avalanche hazard exposure. The *Challenge & risk* (Cluster 5) and *Skills & social* (Cluster 6) clusters also have more aggressive terrain use patterns, but their distributions for years of experience and annual number of days per year is more even. These two clusters both contains more out-of-bounds skiers. The *less enthusiastic* (Cluster 2) and the *Peak & classic* (Cluster 3) clusters also had even distributions of experience and terrain use patterns, as well as a larger number of snowshoers. The *Relax & social* (Cluster 4) cluster had the most variability across all variables, with more members with overall less experience, who recreate between 11-20 days per year, and make the most conservative terrain choices out of all of the clusters.

Our study used level of avalanche safety training, total years of experience, and average number of days per year to gauge the expertise and skillset of recreationists. Our results indicate that all three variables vary independently across the motivation clusters. For example, the *Less enthusiastic* (Cluster 2) cluster contains more professionally trained individuals, yet their years of experience and recreation days per year are evenly distributed. In contrast, the *Disinterested in skills development* (Cluster 7) cluster contains more individuals with 20 or more years of experience, yet their training level is predominantly introductory, and they recreate minimal days per year.

Avalanche safety training was mostly evenly distributed across the clusters, suggesting that individuals across all training levels have relatively similar motivations, except for a few notable patterns. Logically, the *Disinterested in skills development* (Cluster 7) contains less trained individuals whereas the *Skills & social (*Cluster 6) cluster contains more trained individuals. It is likely that Cluster 6 relies heavily on skills

to access other important motivations, such as navigating challenging terrain, mentoring and sharing these skills with others, and exploring, which also corresponds with their more aggressive terrain use patterns. This aligns well with research by Sole et al. (2010), who found a strong link between recreationists motivations and training levels. As opposed to using training opportunities to reduce risk, the findings of their study show that recreationists utilize training so they can access greater benefits and satisfy motivational needs that prompt them to explore higher risk situations. These findings underscore the importance of avalanche safety training to recreationists. Not only do these courses aim to help recreationists make informed decision about safe backcountry travel, but they also enable people to satisfy a more complete range of their individual motivational needs.

It is important to note that the term “experience” is inconsistently used across the literature, making it challenging to draw meaningful connections with our research findings. For example, Creyer et al. (2003) asked mountain bikers to self-report their level of experience, and discussed experience relatively (i.e., less or more experienced) in their findings. They found that as experience increased, perceived risk decreased, and positive affective outcomes increased. Alternatively, O’Connell (2010) directly asked sea kayakers their total years of participation to assess experience level but found that experience had minimal impact on their motivations. Ewert et al. (2013) took a different approach by creating an experience index to classify rock climbers, kayakers, and canoers as beginner, intermediate, or advanced. They cross-referenced self-reported skill level with a corresponding course to assign an experience index level. Their findings showed that motivational differences exist across the activities and experience levels. Despite these insights, the inconsistency in experience measurements make it difficult for direct comparisons and it appears that the relationship between experience, skillset, and motivation is intricate and specific to each activity. Ultimately, this highlights the need to clearly articulate experience measures and evaluate expertise through a combination of indicators, as neither level of training nor practical experience alone can indicate a specific level of expertise. This is an important insight for risk communicators, who are already using level of safety training to tailor risk communication (e.g., avalanche forecast information pyramids), and can use these insights to better reach their intended audience. This insight is also important for future researchers to carefully

consider their research objective so that an appropriate measure of expertise or experience is used.

2.5.2. Practical Examples for Avalanche Risk Communication

The practical significance of these findings stems from the evident and meaningful associations observed among motivations, level of training and experience, activity type, and terrain use preferences. This gives us confidence in the usefulness of these clusters for characterizing the recreation community and informing the development of more effective avalanche safety initiatives. The ability to use motivations to guide risk communication is illustrated through the following two examples.

First, our analysis showed that the *Challenge & risk* (Cluster 5) and *Skills & social* (Cluster 6) clusters contain more out-of-bounds skiers. Due to these clusters heightened interests in challenge, risk, skills, and being social, individuals from both clusters may be more likely to venture into more complex terrain to satisfy their motivational needs. This was confirmed through our comparison between the motivation clusters and terrain preferences, which showed that these two clusters recreate most often in aggressive terrain with high avalanche hazard exposure. The *Skill & social* cluster contains less individuals with 20 or more years of experience yet more with advanced training. Despite similar motivations and terrain use patterns, the *Challenge & risk* cluster exhibits more even distributions of years of experience and training.

Haegeli et al. (2012) also advocates for tailored supports for out-of-bounds skiers, highlighting this cohort as a meaningful starting place for tailored risk communication products and education outreach. Based on these findings, avalanche warning services may be interested in greater collaboration with ski resorts. This could help to effectively intersect out-of-bounds skiers with education outreach. Alternatively, the partnership could facilitate efforts to provide local scale avalanche forecasts for areas immediately outside of controlled avalanche ski boundaries. While out-of-bounds skiers in the *Skill & social* (Cluster 6) cluster are motivated to progress their skills, and exhibited a more well-rounded array of motivations, the participants included in the *Challenge & risk* (Cluster 5) cluster are predominantly driven by both challenge and sensation seeking. Therefore, risk messaging tailored to help these recreationists

understand the limits of their capabilities may help them be more confident in their terrain selection when in high exposure areas.

Another example explores the characteristics and preferences of the *Disinterested in skills development* (Cluster 7) cluster, who have a distinct disinterest in skills development compared to their other motivational interests. This cluster includes more on-piste skiers and ice climbers, and members tend to recreate more often in conservative terrain. They are also more likely to have introductory level training, minimal recreation days per year, but at least 20 years of collective experience. Given this clusters disinterest in skill development, individuals with decades of recreational experience may have been highly involved in backcountry activities earlier in their lives but may now rely on outdated training and expertise. Finn (2020) found that older demographics performed less well on bulletin literacy tests, and Peitzsch et al. (2020) showed that the age of avalanche victims has increased over time. These findings suggest recreationists with currently low levels of yearly engagement but a high number of cumulative years of experience may exhibit a misalignment between their skillset to manage risk and the motivations they seek to satisfy through backcountry experiences. While more research is required to understand this group in more detail, it appears to be a potential target audience who may benefit from tailored risk messaging that is very different from how other cohorts, such as out-of-bounds skiers, would be addressed. This motivation cluster, for example, may benefit from targeted outreach emphasizing the importance of early season skills practice or messages that suggests hiring a guide when recreating in more complex terrain. Additionally, this cluster could help inform curriculum development for refresher avalanche safety courses and webinars.

Another important takeaway for the avalanche safety community to consider is that some individuals do not see it necessary or are willing and able to develop their skillset. Therefore, they will not perceive messages targeting skill development or highlighting training opportunities as relevant or applicable. While some recreationists rely heavily on training (Atkins & McCammon, 2004) and see it as beneficial for skill development (Greene et al., 2022), others will require different avenues and more creative approaches. In this instance, recreationists uninterested in developing skills may benefit from a guidebook that matches different trips with a recommended skill level to safely travel in that particular area. This would help recreationists to reflect on their

skillsets and may help them increase their confidence in aligning their trip selection with their motivations and capabilities.

2.5.3. Limitations

The chosen result of our k-means cluster solution for the motivation items was based on interpretability rather than the lowest BIC value, which suggested a cluster solution of 61. Therefore, the cluster solution presented signifies how our dataset could be segmented into a manageable and informative number of clusters. While this is valuable for demonstrating the utility of motivations as we use the seven-cluster solution as an illustration as to how knowledge of motivations can be used to provide meaningful insights to avalanche risk communicators, it is important to remember that our clusters do not necessarily represent the motivation archetypes of the full population.

In addition, based on our recruitment efforts, it is likely that the sample is not representative of the backcountry recreation community. Specifically, it is highly likely that snowshoeing, ice climbing, and mountaineering are underrepresented in this study. Surveys like this tend to attract already highly engaged demographics (e.g., Fisher, 2022b; Haegeli & Strong-Cvetich, 2020), such as backcountry skiers, which makes gaining the perspective of new or harder to reach recreationists, such as ice climbers, more difficult. In addition, the motivations of mechanized forms of winter backcountry travel, such as mountain snowmobiling and snow-biking, are not captured in our sample. Different motivation items may need to be incorporated into the methods to gain a better sense of these recreationists' motivations. For all these reasons, caution should be applied when extrapolating our results to the larger recreation community, especially communities with mechanized backcountry travelers.

While our results align with some of the general observations in risk recreation motivation studies, our study was focused on understanding motivations to inform avalanche risk communication and did not aim to study motivations for winter backcountry recreation comprehensively. Hence, our study should only cautiously be compared directly with general explorations of backcountry recreation motivations.

2.6. Conclusions

In an era characterized by the growth of winter backcountry activities, the backcountry recreation community is likely becoming increasingly diverse. Consequently, having a better understanding of the characteristics of winter backcountry travelers is important for ensuring that risk messages are aligned with their needs, interests, and capabilities. The motivations of winter backcountry recreationists have so far not been explicitly explored for the purpose of informing avalanche risk communication.

Our study sample came from the Euregio and Swiss avalanche forecast research panels, on which we performed a k-means clustering analysis on participants answers to 15 motivation items. Our results indicate that the motivations of our sample exist on a continuum, with most recreationists rating nature as very important, and other items such as risk/sensation seeking as relatively unimportant. We chose a seven-cluster solution mainly based on interpretability. Activity type, years of experience, average number of days per year, and terrain use preferences all varied between the motivation clusters.

The findings of this study are able to provide an overview of and insights into the structure of how motivations vary together in the recreation community, and the avalanche safety community can benefit from this research in several ways. First, motivations can help explain why people engage in backcountry recreation in the manner that they do. In the context of avalanche risk communication, motivations can serve as a valuable guide for developing and improving products and services aimed at supporting recreationists' ability to make informed decisions about traveling safely in the backcountry. Knowledge of motivations, for example, can help risk communicators to direct individuals to risk supporting products that can best help them meet their risk management needs as well as fulfill a larger range of their motivational needs in their mountain pursuits. Or, in instances where terrain use preferences and risk management practices diverge, motivations can help us identify these cohorts and understand how to tailor products in ways that best support them. Avalanche risk communicators already tailor products to recreationists based on activity type (e.g., handbooks) and level of avalanche safety training (e.g., forecasts with tiered information pyramids). However, knowledge and incorporation of motivations, terrain use preferences, training, and

experience can supplement existing efforts to tailor products and provide even richer information about recreationists.

This study centers recreationists as the starting place for bottom-up and meaningful improvements to avalanche risk communication. Future research should continue this approach, and focus more on understanding how recreationists characteristics, preferences, recreational behaviours, and risk management practices relate to each other. Segmentation studies prove to be a useful tool to understand target audiences and are therefore recommended for further exploring the nature of the backcountry community. Long-term partnerships between researchers and avalanche forecasting agencies are well positioned to create more representative population samples, which could provide clearer insights of recreationists motivations. These efforts should include study samples that include mechanized forms of travel. While Haegeli et al. (2023b) highlighted challenges in implementing social science research into the practitioner and operational environment, these types of partnerships would be an effective way to help close the gap between researchers, practitioners, and recreationists and could establish communication pathways for a more user-centric and systems approach to avalanche risk communication.

While customized avalanche forecast products for different audience segments have so far been unthinkable due to limited resources, the current trends towards an increased use of models and automation (e.g., Pérez-Guillén et al., 2022) creates the foundation for the efficient production of a more diverse set of avalanche safety communication products that may be able to better meet the needs of different individuals, fostering safer backcountry experiences for everyone.

Chapter 3. Characterizing an Increasingly Diverse and Growing Backcountry Community: A Holistic and Informative Approach Using Audience Segmentation

3.1. Introduction

Winter backcountry recreation, such as ski and snowboard touring, snowshoeing, ice climbing, and mountaineering, allows people to engage with remote natural areas, immersing themselves in snow-covered landscapes while participating in outdoor pursuits. While being active in nature has tremendous benefits for mental and physical health (e.g., Lackey et al., 2021; Thomsen, Powell & Monz, 2018), the pursuit of these activities also includes serious personal risks including the exposure to snow avalanches, a complex and dynamic winter mountain hazard. The consequences of avalanches can be fatal, with avalanche fatalities in North America and Europe averaging at 140 per year over the past 10 years (Avalanche Canada, 2023; Colorado Avalanche Information Center, 2022; European Avalanche Warning Services, 2023a).

Despite the associated risks and potentially severe consequences, many individuals repeatedly and voluntarily venture into avalanche terrain. In comparison to skiing or snowboarding on controlled slopes at a ski area where avalanche hazard is managed by the resort operations, winter backcountry travel requires individuals to manage their personal risk. This involves assessing avalanche conditions and balancing one's perception of whether exposing themselves to these conditions and the associated risks is acceptable for the benefits they seek from the mountain experiences (Sole et al., 2010). While some hire professional guides to make these decisions, most recreation is self-directed and the responsibility of assessing avalanche conditions and making informed decisions about when and where to expose themselves to avalanche hazard rests with individual recreationists.

To help recreationists manage the risk from avalanches, avalanche warning services publish daily avalanche forecasts that describe the severity and nature of existing conditions. Many forecasts employ a tiered information system (European Avalanche Warning Services, 2023b) that presents information progressively with

increasing complexity to appeal to a range of recreationists' abilities. The pyramid begins with an avalanche danger rating, followed by descriptions of the relevant avalanche problems, a detailed hazard summary, and finally the raw observations. In addition to daily forecasts, recreationists can access other risk informing products such as blogs, webinars, and decision aids (e.g., White Risk trip planning tool, avalanche terrain exposure maps), or enroll in avalanche safety training courses.

Risk communication research in other fields has shown that personal and contextual differences impact how individuals perceive and apply risk messages (Lundgren & McMakin, 2018; Demuth, 2018; Wachinger et al., 2013), and it is well established in risk communication literature that a good understanding of the target audience is critical for effective risk communication that resonates with the target audience and properly addresses their needs (e.g., Lundgren & McMakin, 2018; Balog-Way et al., 2020; NOAA Office for Costal Management, 2016; ERG Inc and NOAA, 2019). Because of this, avalanche warning services are currently increasing their efforts to better understand their users and find opportunities to improve the effectiveness of their information products and services.

A common approach to better understand target populations is audience segmentation. Initially derived from social marketing techniques (Smith, 1956), this approach divides heterogeneous audiences into smaller, more homogeneous segments based on relevant characteristics (Metag & Schäfer, 2018; Slater, 1996). Once meaningful segments have been identified, tailored risk messages can be created that target the specific needs of individual groups.

In the avalanche safety community, backcountry recreationists have traditionally been segmented and understood primarily through their activity type and level of formal avalanche safety training. This is an example of conceptual segmentation (Dolničar, 2002), as the grouping criteria are known in advance and are used to inform outreach initiatives and risk communication. The avalanche forecast information pyramid, for example, is related to formal avalanche training levels. Each tier presents information that is less synthesized and more detailed, intended for individuals with higher levels of training who are more likely to possess the skills necessary to understand and apply the provided information (European Avalanche Warning Services, 2023b; Statham and Jones, 2006). Similarly, avalanche safety course curricula and materials have been

customized based on different backcountry activities. For example, the textbook for Canadian avalanche safety courses exists in two versions: one for backcountry skiers (Floyer & Robine, 2020) and one for mountain snowmobile riders (Floyer et al., 2020). Together, this demonstrates how these two variables have shaped the avalanche safety community's understanding and communication with recreationists.

While activity type and training level are valuable starting points, they are unable to help identify other types of segments that might be more informative for the design and evaluation of risk communication. For example, it does not include any information about what type of experiences recreationists are seeking in the backcountry and what type of terrain they expose themselves to. This information is critical for determining the required level of avalanche risk management and what constitutes relevant information. Similarly, the current segmentation approach does not consider risk management practices, which could allow warning services to tailor their information products even further. Nor does it include information about recreationists' preferences about when and where to recreate, which could be used to identify the best times for specific messages. Relying solely on activity type and level of formal avalanche safety training to characterize the community likely overlooks the needs of certain recreationists, potentially resulting in safety messaging that is perceived as irrelevant or inapplicable to certain cohorts of the backcountry community. Hence, having a richer understanding of the characteristics and needs of the recreating public can provide avalanche warning services and educators with valuable insights to ensure that their products are as informative as possible and resonate well with the needs of the intended audience.

A more holistic characterization of backcountry recreationists and avalanche forecast users seems particularly pertinent given the tremendous growth in winter backcountry recreation over the past two decades. While this growth is well known in the community (e.g., Birkeland et al., 2017), direct evidence is limited. In Switzerland, however, population-wide sport participation surveys have shown that the engagement in backcountry winter activities has more than doubled in the last 15 years (Bürgi et al., 2021). The proportion of Swiss people backcountry skiing and snowboarding increased from 1.5% in 2008 to 3.5% in 2020. Over the same period, participation in snowshoeing rose from 1.3% to 3.3%. While there are no explicit numbers of winter backcountry sport participation in Austria, the number of alpine club memberships have increased steadily over the last two decades, with over 725,000 memberships as of 2022 (Alpenverein

Österreich, 2023). In Canada, reported increases in social media engagement and enrollment in avalanche safety courses support the overall consensus that winter backcountry recreation is becoming increasingly popular (Avalanche Canada, 2021; Avalanche Canada, 2022). While this trend already existed before COVID-19, the pandemic exacerbated the popularity of winter outdoor recreation and shifted the typically more resort-focused recreationists to backcountry activities because of the uncertainties regarding ski resort closures (Schlemmer & Schnitzer, 2023).

With this rise in winter recreation popularity and influx of new and novice recreationists, the nature of the backcountry community and avalanche forecast users is likely changing, which means that avalanche warning services' current conceptual segments and assumptions about their audience may no longer be as reliable or informative as they once were. Instead, different user segments may exist that prove to be more informative for tailoring and targeting risk communication efforts.

The objective of this study is to introduce the avalanche safety community to audience segmentation and illustrate how this technique can offer a richer and more holistic picture of the backcountry recreation community for the design, evaluation, and improvement of targeted avalanche safety initiatives. Our approach builds on a long tradition of segmentation research, which has proven to be a powerful tool to increase the effectiveness and efficiency of communication in a wide range of fields from consumer marketing (e.g., Slater, 1996; Smith, 1956) and health campaigns (e.g., Duong et al., 2022; Rimal et al., 2009) to climate change awareness (e.g., Hine et al., 2014), disaster preparedness (e.g., Guion et al., 2007), sustainable resource management (e.g., Lai et al., 2009) and more.

We start with a brief summary of the existing research in audience segmentation in relevant neighbouring fields before describing our segmentation variables and analysis approach in the methods sections. After presenting the results, we will discuss the practical insights and benefits that meaningful segmentation can provide and how the methodology can be leveraged for effective avalanche risk communication messaging and product development. We will finish with our thoughts about future research in the conclusion.

3.2. Background

As stated in the introduction, audience segmentation divides large heterogeneous populations into smaller and more homogeneous segments on the basis of shared characteristics, behaviours, and preferences (Slater, 1996; Metag & Schäfer, 2018). The goal is to provide communicators with information on the specific needs and traits of each segment to better target and tailor communications directed at specific segments (Slater, 1996; Metag & Schäfer, 2018). This ensures that communication efforts are informed by the community, which strategically maximizes the communicators' ability to reach the intended audience and have the desired impact.

Segmentation analyses employ variables that are considered relevant to serve as the criteria for differentiating a population. Analyses are typically based on socio-demographic, psychographic (i.e., attitudes, interests, and preferences), and behavioural dimensions (Metag & Schäfer, 2018) with some suggesting geographic as a fourth dimension (Bigné, 2008). Because the resulting segmentations are based on these dimensions, the step of variable selection is critical to ensuring segments are created meaningfully (Dolnicar & Grün, 2008). In other words, it is important that the dimensions and variables chosen strongly relate to the objective the communication is attempting to achieve (Metag & Schäfer, 2018; Slater, 1996). Approaches that incorporate multiple dimensions have shown to result in stronger and more rigorous segmentations than studies that rely on a single dimension of variables (Metag & Schäfer, 2018).

The fields where audience segmentation has been applied are diverse. In the rest of this background section, we will provide a brief overview of how audience segmentation has been adapted to fit the needs of fields that are related to avalanche risk communication. This includes public health, science and environmental communication, disaster, crisis and risk communication, recreation, and tourism.

3.2.1. Public Health, Science, and Risk Communication

Audience segmentation has become integral to public health sectors, as most health communication efforts are targeted to particular subgroups of the population (Boslaugh et al., 2005). Application examples exist in health education (e.g., Moss et al., 2009; Mathijssen et al., 2012), health promotion (e.g., Boslaugh et al., 2005; Rimal et al.,

2009), and health prevention (e.g., Gomez et al., 2019; Chon & Park, 2017). It is commonly used to increase the effectiveness of health campaigns, as well as influence health and other socially relevant behaviours (Noar et al., 2007; Slater, 1996). For example, Duong (2022) segmented individuals by risk perceptions, protective behaviours, and efficacy beliefs around COVID-19 to increase the effectiveness of tailored campaigns and intervention programs. Similarly, Rimal et al. (2009) used risk perceptions and efficacy beliefs around HIV prevention to segment individuals to inform tailored HIV protective behaviour campaigns and education outreach.

In the science and environmental sectors, audience segmentation has been used extensively to understand people's general and specific attitudes, beliefs, and preferences around science and environmental issues (Metag & Schäfer, 2018). For example, it has been widely applied to understand perceptions around climate change (see Hine et al. (2014) for an overview of climate change studies). In this context, the aim is to help policy makers, scientists, and others engage the public meaningfully by tailoring and targeting subgroups of the population based on their values, beliefs, and policy preferences. Hence, segmentations give organizations and governments empirical knowledge to strategically allocate limited resources to achieve the most effective communication outcomes (Hine et al., 2014). Other related segmentation studies have looked at topics such as energy consumption (e.g., Sütterlin et al., 2011), environmental conservation (e.g., Kidd et al., 2019), and recycling (e.g., Vicente & Reis, 2007).

Similar to avalanche risk communication, disaster and crisis risk communication experiences difficulties in achieving effective and efficient public safety messaging on a population wide scale (Bartolucci et al., 2023). To date, applications of audience segmentation in this field are limited, but promising and expanding. Based on a systematic literature review on the effectiveness of audience segmentation in instructional risk communication, Bartolucci et al. (2023) found it to be effective at targeting and supporting vulnerable groups, adapting messaging in situational variability, improving community participation, and engaging specific groups among other benefits.

Other research focuses on risk communication in general, such as Kim et al.'s (2016) segmentation of the public with respect to crisis communication in the digital era. Their framework - Communicative Action in Problem Solving - helps to communicate with active and passive segments of the public based on how involved they are in media

activism and gives insight into who takes initiative to communicate and mobilize action in the community in crisis situations. Other segmentation analyses focus on specific risk and crisis communication situations such as tropical storm communication and disaster preparedness (Guion et al., 2007), sea level rise (Covi & Kain, 2016), flood risk (Martens et al., 2009), and wildfire smoke health risks (Hano et al., 2020).

3.2.2. Recreation and Tourism

Segmentation studies in winter sport tourism have overwhelmingly focused on resort skiers as opposed to backcountry skiers due to the implications of these findings in tourism management, visitor satisfaction, and targeted marketing communications for increasing profitability of resort operations and tourist destinations. For example, Alexandris et al. (2009) segmented recreational skiers by motivations from a ski resort in Northern Greece to inform differentiated marketing techniques. They suggest that marketing to the “naturalists” segment should highlight the benefits of enjoying nature and relaxing, whereas the “multi-interested” segment would likely be interested in loyalty programs and relate more to promotions for upscale leisure and hospitality services. Other studies have also segmented skiers’ motivations to understand destination choice attributes (e.g., Joppe et al., 2013; Konu et al., 2011; Miragaia & Martins, 2015; Bichler & Pikkemaat, 2021; Won et al., 2008), satisfaction (e.g., Tsiotsiou & Vasioti, 2006), visitor frequency (e.g., Tsiotsou, 2006), and constraints to participation (e.g., Priporas et al., 2015; Hudson & Gilbert, 2000).

3.3. Methods

3.3.1. Data Source

The data used for this study draws from an avalanche forecast user research panels established in partnership between the Euregio and Swiss Avalanche Warning Services and Simon Fraser University’s Avalanche Research Program (Haegeli et al., 2023a). The initiative is ongoing and was established to provide the two participating warning services with the important user perspective for making evidence-based decisions on future developments and improvements of their communications and products.

Recruitment for the research panels began the Spring of 2021 and was conducted by the partnering avalanche warning services through country-specific online sign-up surveys that were distributed using existing relationships with local stakeholders in winter recreation, tourism, and avalanche safety communities. The country-specific sign-up and research surveys are accessible in German, Italian, English, and French (Switzerland only). The initial sign-up survey asked participants a series of questions related to how they interact with avalanche hazard, their recreational and professional (if applicable) winter backcountry activities, formal avalanche safety training, use of existing avalanche warning services, and socio-demographics. Building on the research panels, the collaboration then started to conduct a series of targeted research surveys to better understand how primarily backcountry recreationists use, understand, and apply the information provided in the existing avalanche forecast products. In March 2022, the first research survey was released, which focused on examining participants' use of avalanche forecast information, understanding of terminology, and how they navigate through the avalanche forecast website. In addition, the survey included additional background questions on participants' motivations and terrain preferences to augment the information collected in the sign-up survey. These questions were subsequently folded into the sign-up survey. A complete list of sign-up survey questions is presented in Table 3.1, and screenshots of the sign-up survey are provided in Appendix A.

Table 3.1. Complete list of sign-up survey questions

Theme	Questions
Winter backcountry activities	What recreational winter backcountry activities do you most often engage in?
	Overall, how much experience do you have in all your recreational winter backcountry activities combined?
	Which of the following regions do you commonly visit for winter backcountry recreation? [country specific wording and response options]
	During what part of the winter season do typically recreate in these regions?
	On what days do you typically recreate in these regions?
	In which other countries have you pursued your recreational winter backcountry activities?
Preferred terrain	When conditions allow, how often do you spend time in the following types of terrain when recreating in the backcountry? [activity specific wording]
	How often do your backcountry trips involve short scrambles to either reach a summit or a ski line? [activity specific wording]
Desired backcountry experience	In general, how important are the following motivations/experiences for your desired backcountry experience? [activity specific wording]
	How important are the following motivations to your identity and self-esteem?
Avalanche safety training	How important have the following knowledge sources been for the development of your avalanche risk management skills to date?
	What is the highest level of formal avalanche safety training you have completed?
	Have you or somebody you know ever been caught in an avalanche?
Decision-making role	Which of the following statements best describes how you typically contribute to the decision on when and where to go into the backcountry and any avalanche risk management decision in the field? [activity specific wording]
Trip planning	When planning a backcountry trip, which of the following information sources do you typically consult for getting an understanding of the current avalanche conditions? [country specific wording and response options]
	How often do you use the avalanche forecast to check avalanche conditions?
	Which of the following statements best describes your use of the avalanche forecast when planning a backcountry trip?
In the field	Which of the following safety equipment items do you typically bring into the backcountry in the winter?
	Do you regularly track your winter backcountry activities with a GPS device and upload your tracks to a website like Strava, Garmin Connect or similar?
Personal background	Which gender do you identify with?
	In which year were you born?
	Are you part of any identifiable outdoor communities, organizations, or clubs (e.g., trip report blogs, FB groups, hiking or mountain clubs)?
	Where is your primary residence?

3.3.2. Survey Questions

While the sign-up survey for the panel includes a wide range of questions, we will only discuss the response options to the questions relevant for the present analysis.

Winter Backcountry Activities

Building on the existing conceptualization of winter backcountry recreationists for avalanche risk communication, activity type remains an important consideration as it has a strong effect on how recreationists interact with the landscape and avalanche hazard. Activity type was presented at the beginning of the sign-up survey as a categorical question, through which participants indicated their primary backcountry activity followed by any secondary or tertiary activities they engage in. Activity options included *backcountry skiing and snowboarding*[3], *out-of-bounds skiing and snowboarding*, *on-piste skiing and snowboarding*, *snowshoeing*, *ice climbing*, *mountaineering*, and *other*. Since participants were then asked to complete the rest of the survey from the perspective of their primary activity to ensure consistency and avoid confusion, our analysis only includes participants' primary activity.

Experience was measured in terms of the total number of years involved in winter backcountry recreation in general as well as the average number of days per year to learn about participants' annual engagement. Both questions provided five response options. For collective years of experience, options ranged from *this is/was my first winter* to *more than 20 winters*, while days per year ranged from *1-2 days per winter* to *more than 50 days per winter*.

To better understand when and how risk messages can be presented, participants were asked when they typically recreate with options including *regular weekends, statutory holidays/long weekends, winter vacations, and regular weekdays*. Additionally, participants were asked to report their home residence and their preferred areas for winter backcountry recreation.

[3] For the remainder of this chapter, we will use the term skiing to refer to both skiing and snowboarding.

Preferred Terrain

Recreationists' personal terrain use patterns strongly affect their general, condition independent exposure to avalanche hazard and ultimately their risk of being caught in an avalanche. Some of the key variables that determine the severity of terrain with respect to exposure to avalanche hazard are slope angle, slope shape, forest density, the presence of terrain traps, typical avalanche frequency, and start zone density (Statham et al., 2006). Recreationists who travel in areas with high avalanche hazard exposure will likely require more sophisticated risk mitigation practices to manage their exposure appropriately. Therefore, understanding where people are going, and their exposure levels, are an important consideration for designing meaningful risk messages and support tools. While activity type already relates to the type of terrain that recreationists typically access, the range of possible exposure levels depends heavily on personal terrain preferences.

We measured participants' relevant terrain use patterns employing the avalanche terrain exposure scale (ATES), a five-level classification system that evaluates routes and terrain based on the severity of exposure to avalanche hazard (Statham et al., 2006; Statham & Campbell, 2023). The five levels of the scale are non-avalanche terrain, simple avalanche terrain, challenging avalanche terrain, complex avalanche terrain, and extreme avalanche terrain. Participants were presented with simplified descriptions of the five different classes (Table 3.2) and asked to rate how frequently they recreated in each of the terrain classes, when avalanche conditions allow, on a five-point Likert scale from *never* to *always*. To simplify and speed-up the survey for participants, backcountry and out-of-bounds skiers were not presented with the non-avalanche terrain item because it is essentially not skiing terrain, and the snowshoe version of the survey did not include extreme terrain because it is too technical for snowshoeing. To further enhance our understanding of participants' terrain preferences, we asked skiers how often their trips include short scrambles to reach a summit or a ski line, and snowshoers how often they leave established trails and create their own routes using the same five-point Likert scale.

Table 3.2. Description of terrain types using the avalanche terrain exposure scale

Terrain class	Description of terrain class
Non-avalanche terrain	Low angle open terrain (<20°) or densely forested slopes. No crossing of avalanche paths or runout zones.
Simple avalanche terrain	Exposure to low angle open terrain (<20°) or densely forested slopes. Some forest openings may involve runout zones of infrequent avalanches. Many options exist to reduce or eliminate exposure.
Challenging avalanche terrain	Treeline or alpine terrain with well-defined avalanche paths, start zones or terrain traps that can be dangerous to people. Typically only dealing with one path at a time, and options exist to reduce or eliminate exposure with careful route-finding.
Complex avalanche terrain	Alpine terrain with multiple overlapping avalanche paths or large expanses of open terrain. Commonly exposed to avalanche hazard from above. Travel requires commitment, and there are only minimal options to reduce exposure.
Extreme avalanche terrain	Very steep, open terrain averaging 35° with large proportions of terrain stepper than 45°. Steep faces with cliffs, couloirs, spines, and gullies. No options to reduce exposure, and even small avalanches can have severe consequences.

Desired Backcountry Experience

Motivations are a widespread variable used in segmentation analyses to understand why people engage in activities in the manner that they do, and its overall relevance and importance to recreation and tourism research is well established in the literature (Buckley, 2012). We measured motivations using 15 items (Table 3.3) selected from the recreation experience preference (REP) scales developed by Driver (1977,1983) and later validated by Manfredo et al. (1996). Items were selected based on their applicability to winter backcountry recreation and phrasing was adapted to fit the avalanche risk context so that the information being gathered is meaningful and relevant for avalanche risk communicators. The intent of the items was to enrich the segmentation with information about the type of experiences participants are interested in pursuing in the backcountry, their interest in risk, and their motivation to further develop their avalanche safety and technical travel skills. For each item, respondents were asked to rate the importance of each motive on a seven-point Likert scale from *not at all important* to *extremely important*.

Table 3.3. List of motivation question items with associated label and REP domains

Phrasing of motivation item	Label	REP domain	REP Sub-domain(s)
Navigating through challenging terrain (conditions permitting)	Navigating challenge	Achievement/ stimulation	Competence test
Experiencing risk, thrill, or exhilaration	Risk/sensation seeking	Achievement/ stimulation & Risk taking	Excitement & Risk taking
Sharing a story, picture, or video on social media	Sharing on social media	Achievement/ stimulation	Telling others & Social recognition
Exploring new or different places	Exploring	Learning	Exploring
Reaching a summit or similar trip objective	Reaching summits/peaks	Achievement/ stimulation	Endurance
Completing classic/well known/respected trips	Completing classic trips	Achievement/ stimulation	Endurance
Feeling carefree and/or relaxed	Feeling relaxation	Escape physical pressure	Tranquility
Exercising and working on your physical fitness	Physical fitness	Physical fitness	Exercise-physical fitness
Being away from crowds	Escaping crowds	Escape physical pressure	Escape crowds
Being in nature	Enjoying nature	Enjoy nature	General nature experience
Sharing your outdoor skills and knowledge with others	Sharing skills	Teaching-leading others	Teaching-sharing skills and leading others
Challenging/improving your technical [primary activity] skills	Improving tech. skills	Achievement/ stimulation	Skill development
Practicing/improving your avalanche risk management skills	Improving aval. skills	Achievement/ stimulation	Skill development
Enjoying powder snow (conditions permitting)	Enjoying powder	n/a	n/a
Spending time with family and/or friends	Being social	Similar people	Being with similar people

Avalanche Safety Training

Expanding on the existing practice of linking risk messages to avalanche safety training levels, participants were asked to indicate their highest level of completed formal avalanche safety training. Options included *none, indoor/live online avalanche awareness seminar (e.g., evening seminar), introductory recreational avalanche safety course with a field component (typically a 1-2 day course), advanced recreational avalanche safety course (typically a 3-5 day course)*, and avalanche training aimed at avalanche *professionals* (e.g., guides, mountain rescue, avalanche technicians). For the analysis, we combined the seminar category with none since these seminars are not considered formal training.

Trip Planning

Risk mitigation involves taking specific actions to minimize potential avalanche risks, which can be undertaken while planning a backcountry trip and once in the backcountry. The main tool to mitigate risk while trip planning is to consult daily avalanche forecasts to learn about current conditions, which then allows recreationists to incorporate this information into localized hazard assessments and terrain choices. However, research by St. Clair et al. (2021) highlighted that there are distinct patterns in how recreationists interact with avalanche forecasts, which they describe in their bulletin user typology. The typology consists of five levels that categorizes forecast users based on their ability to find, interpret, and incorporate bulletin information into their travel decisions.

To better understand the distribution of bulletin users within the recreation community, we used St. Clair's typology as the foundation to understand trip planning risk mitigating behaviours. Participants were first asked about the types of information they use for planning trips. Only participants who checked that they consult the avalanche forecast were then presented with bulletin user typology statements (Table 3.4) developed by St. Clair et al. (2019). They were asked to indicate which statement best described their personal forecast use practices. The statement for user type A was not presented as every participant shown this question had already indicated that they use the bulletin, nor was the statement for user type F, as our sample consists of recreationists only and not professionals.

Table 3.4. Statements used to describe the typical avalanche bulletin routines of each of the user types described in St. Clair (2019)

User Type	Characterization Statement
A	It is not typical for me to consult the avalanche bulletin or public forecast online (website or mobile app) when making backcountry travel plans.
B	I typically use the bulletin to check the danger rating which informs my decision of whether or not it's safe to travel in the backcountry.
C	I typically combine the danger rating from the bulletin with knowledge of how avalanche prone an area is to determine where to travel in the backcountry.
D	I typically make a decision about where or when to go based on the specific nature of the avalanche problem conditions reported in the bulletin and whether I feel that I can manage my travel in the terrain given these conditions.
E	I typically use the available information about the specific nature of the avalanche problem conditions from the bulletin as a starting point for my continuous assessment in the field to confirm or disconfirm the information where I am travelling.
F	It is not typical for me to consult public avalanche bulletins or forecasts because I have access to professional information sources (e.g., InfoEx) that offer more detailed insight into current conditions.

To supplement the bulletin user type information, participants were also asked to indicate how frequently they checked the warning service platform using a five-point scale including *never, rarely, before most backcountry trips in the forecast region, before every backcountry trip in the forecast region, before every backcountry trip in the forecast regions and occasionally in between,* and *every day during the winter.*

In the Field

While the sign-up survey did not cover in-field risk management practices in detail, it did include a question on the use of avalanche safety equipment where participants were asked to indicate items they typically bring into the backcountry. The items covered in the survey include *avalanche transceiver, avalanche shovel, avalanche probe, first aid kit, mobile phone, other (emergency) communication device (radio, satellite messenger of phone), avalanche airbag,* and *helmet*. For this research, we used this information to determine who brings essential safety gear (i.e., transceiver, shovel, and probe) into the backcountry.

3.3.3. Data Analysis

Our analysis plan consisted of several steps. We started with standard descriptive statistics to explore and visualize the nature of the dataset and relationships between different variables, which was followed by preprocessing several sets of questions to make them more suitable for the segmentation analysis. We then employed two different approaches of audience segmentation to illustrate its utility:

a) a conventional audience segmentation analysis that identifies distinct latent (i.e., not directly observable) segments and

b) an exploratory and more targeted segmentation that starts with a specific question of interest.

To further explore the nature of the identified segments, we performed various post-hoc comparisons using Pearson chi-squared tests, Wilcoxon rank-sum tests, or Kruskal-Wallis tests depending on the nature of the variable of interest. We used a *p*-value threshold of 0.05 to determine whether differences are statistically significant. All our data preparation and analyses were conducted in the R statistical environment (Version 4.2.3; R Core Team, 2023).

The main analytical tool for our study was latent class analysis (LCA; McCutcheon, 1987). LCA is a probabilistic clustering technique for categorical variables where the observed variables are considered indicators of a latent (i.e., not directly observable), higher level grouping variable with a limited number of mutually exclusive classes (Collins & Lanza, 2010). The goal of a LCA analysis is to identify the number of classes that best describes the variations in the observed response patterns. The output of the analysis consists of a set of class-specific response probabilities that describe the likely response patterns of individuals belonging to the identified classes, and unconditional class membership probabilities for each participant. Respondents are then assigned to the class with the highest probability, and the likely response pattern is used to describe characteristics of the particular class. We used the poLCA package (Linzer & Lewis, 2011) to perform all our LCAs in R. In each of our analyses, we estimated a range of models with different numbers of classes. Our primary tools for selecting the best fitting models were the Bayesian Information Criterion (BIC; Schwarz, 1978) and Akaike's Information criterion (AIC; Akaike, 1974) with lower values indicating better

model fit. However, we also considered classification diagnostics (e.g., average assignment probabilities), as well as the interpretability and utility of the estimated models.

Pre-processing of Sign-up Survey Responses

Several variables required pre-processing before they could be included in the segmentation analysis. The responses to the 15 motivation items were converted into a single categorical variable using k-means clustering as described in Chapter 2. Each participant was assigned to one of seven motivation profiles (Table 3.5) that describes their general motivations for engaging in their particular winter backcountry activity.

Table 3.5. Motivation cluster types

Id	Label	Above avg. ratings	Below avg. ratings	N
1	Overall keeners	All		332
2	Least enthusiastic		All	328
3	Peak & classic	Completing classic trips, reaching summits		374
4	Relax & social	Spending time with family and friends; feeling relaxation	Navigating challenging terrain; experiencing risk, thrill, and exhilaration	324
5	Challenge & risk	Navigating challenging terrain; experiencing risk, thrill, and exhilaration	Spending time with family and friends; feeling relaxation	353
6	Skills & social	Developing skills (technical & avalanche); sharing skills with others, spending time with family and friends	Completing classic trips, reaching summits/peaks	364
7	Disinterested in skill development		Developing skills (technical & avalanche); sharing skills with others, navigating challenging terrain, experiencing risk, thrill, or exhilaration	264

We used a LCA to reduce the terrain preference items into a single ordinal variable. To analyze the responses of backcountry skiers, out-of-bounds skiers, and

snowshoers combined in a single LCA, we set the use of non-avalanche terrain to never for all backcountry and out-of-bounds skiers, and we did the same with extreme terrain for snowshoers. To assess the validity of this approach, we also classified the two groups separately and compared the resulting classes with the classes of the combined analysis. The analysis revealed five distinct terrain use patterns ordered from most conservative to most aggressive terrain choices. We added the mountaineers and ice climbers as separate classes due to the unique terrain use patterns of these activities. This resulted in a new seven-level categorical variable that describes participants' exposure to avalanche terrain (Table 3.6).

Table 3.6. Avalanche terrain exposure variable based on terrain use preferences

		Likelihood of spending at least "sometimes" in ATES terrain class (%)					Proportion of participants within activity (%)		
Label	**N**	**Cl. 0[a]**	**Cl. 1**	**Cl. 2**	**Cl. 3**	**Cl. 4[b]**	**BC**	**OB**	**SS**
Most conservative	187	28.6	94.0	42.3	0.5	0.5	6.1	5.8	50.0
Conservative	278	7.9	99.9	94.5	3.9	0.8	15.9	16.1	30.4
Moderate	503	3.1	88.6	97.7	26.8	0.0	23.1	14.7	19.6
Aggressive	739	0.0	87.0	99.9	96.3	22.0	34.2	33.9	0.0
Most aggressive	470	0.0	70.3	99.4	97.8	70.1	20.8	29.5	0.0
Mountaineers	83	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ice climbers	30	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[a] ATES terrain class 0 not presented to backcountry and out-of-bounds skiers; assumes "never".
[b] ATES terrain class 4 not presented to snowshoers, assumes "never".

Lastly, participants were categorized into locals, close-by residents, and more distant tourists based on the location of their primary residence in relation to the forecast agency that they typically access to assess how far people were willing to travel to access the recreation destination of their choice. Participants whose postal codes were within the forecast regions of the local avalanche warning services were considered locals; participants residing within roughly a three-hour drive from the forecast regions were classified as close-by residence, and everybody else was considered a tourist.

Segmentation Approaches

As stated, to illustrate the benefits of audience segmentation, we conducted two segmentation analyses. The first aimed to provide a richer overview of the backcountry communities' risk competency levels compared to relying on training level alone. The conventional audience segmentation analysis used the following variables in a LCA to create what we call competency profiles: participants' total years of experience, average number of days per winter, level of avalanche safety training, bulletin user type, frequency of bulletin use, and use of essential safety gear. The aim of the competency profiles is to describe what common combinations of experience, training, and risk mitigation practices exist within the research panel participants.

Following this, two separate question-driven analyses identified and explored two participant segments of interest in greater detail. This targeted approach first identified the segments of interest and then compared them with the rest of the sample. The purpose was to see if the segments were potentially at-risk groups who might benefit from targeted risk communication initiatives. The two segments explored were:

- Panel members included in the motivation cluster that is characterized by a distinct disinterest in developing avalanche safety skills (Cluster 7; *Disinterested in skills development*).
- Panel members that recreate in terrain with considerable exposure to avalanche hazard (aggressive and most aggressive terrain use pattern classes, mountaineers, and ice climbers) but do not check the avalanche forecast before every trip.

Both groups might be of interest to warning services as they represent potential higher risk cohorts where avalanche risk management skills or practices may be misaligned with their exposure to hazard.

3.4. Results

3.4.1. Sample Characteristics

Our dataset included 7277 recreationists. It consisted of 79% identifying as male, 21% as female, and 34% of participants were between the ages of 25-34. Most participants were from Switzerland (34%), followed by 27% from Austria, and 25% from Germany, with the remaining 15% of participants from other countries (Table 3.7).

Table 3.7. Sociodemographic characteristics of sample

Variable	Quantity (N)	Proportion (%)
Gender		
Female	1419	20.9
Male	5348	78.6
Prefer not to say	16	0.2
Prefer to self describe	14	0.2
Non-binary/third gender	8	0.1
Age		
Under 20	105	1.5
20 - 24	531	7.8
25 - 34	2281	33.5
35 - 44	1611	23.6
45 - 54	1211	17.8
55 - 64	792	11.6
64 and above	288	4.2
Country of Residence		
Switzerland	2296	33.7
Austria	1814	26.6
Germany	1697	24.9
All Other	1008	14.8
Forecasting Agency		
Euregio	4123	60.5
SLF	2696	39.5

Backcountry skiers presented an overwhelming majority of the sample representing 79% of all respondents (Tables 3.8 and 3.9). The least represented activities were mountaineers at 1%, and ice climbers at 0.5%. Avalanche training level

was distributed slightly more evenly, as 15% reported no training, 43% reported intro level training, 28% reported advanced level, and 14% reported professional level. Overall, 28% of participants reported participating in their winter activity for 20 or years followed by 24% recreating between 2-5 years. Only 2% reported that it was their first year of participation. Most people recreated on average between 21-50 days in a season (42%) while only 1% reported 1-2 days per season. Similarly, bulletin users who reported a Type E use pattern represented 40% of the sample and 2% did not check the bulletin at all. Almost the entire sample carried the essential safety equipment while recreating (97%).

Table 3.8. Characteristics of sample's experience, level of training, and risk mitigation

Variable	Quantity (N)	Proportion (%)
Years of Experience		
1st year	109	1.6
2-5 years	1656	24.4
6-10 years	1547	22.8
11-20 years	1603	23.7
20 or more years	1863	27.5
Avg. number of days per winter		
1-2 days	49	0.7
3-10 days	890	13.3
11-20 days	2261	33.7
21-50 days	2835	42.2
50 or more days	681	10.1
Avalanche Safety Training		
None	1041	15.3
Introductory	2938	43.1
Advanced (adv.)	1896	27.8
Professional (prof.)	944	13.8

Variable	Quantity (N)	Proportion (%)
Avalanche Bulletin User Type (self-reported)		
Not checked	132	2.0
Type B	504	7.5
Type C	1641	24.4
Type D	1753	26.0
Type E	2702	40.1
Avalanche Bulletin Use Frequency		
Not Checked	132	2.0
Rarely	165	2.4
Before most trips (sometimes)	458	6.8
Before every trip (every)	782	11.6
Before every trip and occasionally in between (every+)	3506	51.8
Every day during the winter (daily)	1721	25.4
Use of Essential Safety Equipment		
Yes	215	3.2
No	6570	96.8

Table 3.9. Characteristics of sample's activity type, proximity to recreation, and timing of recreation

Variable	Quantity (N)	Proportion (%)
Primary backcountry Activity		
Backcountry skiing (BC)	5406	79.3
Out-of-bounds skiing (OB)	796	11.7
Snowshoeing (SS)	257	3.8
On-Piste skiing (OP)	254	3.7
Mountaineering (MT)	77	1.1
Ice climbing (IC)	29	0.4
Primary residence proximity to forecasting		
Within forecast region (local)	2963	43.5
Within a 3-hour drive of forecast region (nearby)	2404	35.3
Beyond a 3-hour drive of forecast region (tourist)	1448	21.2
Timing of recreation		
Long weekends and vacations only	112	4.7
Weekends and other times except weekdays	1010	42.8
All times including weekdays	1239	52.5

3.4.2. Conventional Segmentation

The conventional audience segmentation LCA (N = 6590) using participants' total years of experience, average number of days per winter, level of avalanche safety training, bulletin user type, frequency of bulletin use, and use of essential safety gear produced four distinct competency profiles (Table 3.10): *Limited* (2%), *Rudimentary* (10%), *Foundational* (43%), and *Developed* (45%). As we move from the *Limited* to the *Developed* profile, there is an observable and gradual increase in complexity of bulletin user typology, bulletin use frequency, and level of avalanche safety training, with *Limited* profile members defined by not accessing avalanche forecast bulletins at all. The

Developed competency profile contains individuals with primarily advanced training (39%) and sophisticated bulletin use routines (Type E User: 62%; Daily bulletin use: 46%), as well as individuals with more than 11 years of experience (64%) and more than 20 days of recreation per year (81%). Comparatively, the other profiles gradually decreased in bulletin use complexity, bulletin use frequency, and level of avalanche safety training from *Foundational* to *Limited*. However, no distinct pattern of progression was seen for participants' combined years of experience and annual engagement levels. For example, the majority of participants in both the *Limited* (42%) and *Developed* (60%) profiles recreate on average 21-50 days per year. Moreover, the majority of participants in the *Foundational* (36%), *Rudimentary* (51%), and *Limited* (30%) profiles have been recreating for a total of 2-5 years. Majority of participants in all profiles carried essential safety equipment (Developed: 99%; Foundational: 100%; Rudimentary: 78%; Limited: 85%).

Table 3.10. Risk competency profiles of sample participants showing the most frequent and second most frequent response pattern for each variable

Competency profile	Developed N = 2999 (45%)		Foundational N = 2808 (43%)		Rudimentary N = 658 (10%)		Limited N = 125 (2%)	
Distribution frequency	**Most frequent**	**2nd frequent**	**Most frequent**	**2nd frequent**	**Most frequent**	**2nd frequent**	**Most frequent**	**2nd frequent**
Bulletin user type	Type E 62%	Type C 18%	Type D 41%	Type C 28%	Type B 42%	Type C 41%	Not Checked 100%	n/a
Bulletin use frequency	Daily 46%	Every Trip+ 41%	Every Trip+ 70%	Every Trip 16%	Every Trip 33%	Some-times 24%	Not Checked 100%	n/a
Essential safety equipment	Yes 99%	No 1%	Yes 100%	No 0%	Yes 78%	No 22%	Yes 85%	No 15%
Avg number of days per year	21-50 60%	50+ 21%	11-20 51%	21-50 27%	3-10 32%	11-20 32%	21-50 42%	11-20 26%
Total number of years	20+ 44%	11-20 30%	2-5 36%	6-10 31%	2-5 51%	20+ 13%	2-5 30%	20+ 28%
Avalanche safety training	Adv. 39%	Prof. 29%	Intro 67%	Adv. 23%	None 64%	Intro 35%	Intro 42%	None 34%

The post-hoc comparisons provide additional insight into the characteristics of the panel members across the competency profiles. There are significant differences in the distributions of activity type across the four competency profiles (Table 3.11; χ^2 = 339.24, df = 15, p < 0.001). More specifically, there were significantly more out-of-bounds skiers (13%) in the *Developed* profile and more on-piste skiers (10%) and snowshoers (13%) in the *Rudimentary* profile.

Table 3.11. Risk competency profiles and activity type

Activity type	Proportion by profile (%)					
	Developed	Foundational	Rudimentary	Limited	χ^2	*p*-value
Backcountry skiing	81.0	82.7	62.8↓	64.8	339.24	< 0.001
On-piste skiing	2.0↓	3.7	9.6↑	10.4↑		
Out-of-bounds skiing	13.4↑	9.2↓	12.8	16.0		
Mountaineering	1.1	0.7	1.7	3.2↑		
Ice climbers	0.5	0.3	0.5	0.8		
Snowshoeing	2.0↓	3.4	12.8↑	4.8		

↑ Significantly higher than average
↓ Significantly lower than average

Cross comparisons between the competency profiles and exposure patterns also elicited significant differences (Table 3.12; H = 164.99, df = 18, p < 0.001). From *Rudimentary* to *Developed*, each profile contains significantly more individuals who are recreating in increasingly aggressive terrain. Because mountaineers have their own distinct terrain use class, we were able to see that there are significantly more mountaineers in the *Rudimentary* (16%) and *Limited* profiles (6%). Mountaineering is known to occur in high exposure terrain making these results noteworthy.

Table 3.12. Risk competency profiles and avalanche hazard exposure

Avalanche hazard exposure	Proportion by profile (%)					
	Developed	Foundational	Rudimentary	Limited	H	*p*-value
Most conservative	26.3	46.7	24.0	3.0	164.99	< 0.001
Conservative	38.3	51.7	9.5	0.6		
Moderate	38.0	54.8	6.2	1.1		
Aggressive	60.1	36.2	3.5	0.1		
Most aggressive	71.5	24.9	2.9	0.7		
Mountaineers	48.6	30.0	15.7	5.7		
Ice climbers	51.9	33.3	11.1	3.7		

The distribution of each motivation cluster was relatively even in each profile, demonstrating that participants' motivations are consistent irrespective of their risk competency. However, results revealed statistically significant differences for all competency profiles except for the *Limited* profile (Table 3.13; $\chi^2 = 48.18$, df = 18, $p < 0.001$) with respect to three out of seven of the motivation clusters. There are significantly more from the *Skills & social* (Cluster 6; 19%) in the *Developed* profile, whereas the *Foundational* profile contains significantly more from the *Relax & social* (Cluster 4; 18%). The *Rudimentary* profile contains significantly more from the *Peak & classic* (Cluster 3; 22%).

Table 3.13. Risk competency profiles and motivation clusters

Motivation Cluster	Proportion by cluster (%)					
	Developed	Foundational	Rudimentary	Limited	χ^2	*p*-value
1 Overall keeners	15.1	13.3	17.5	14.3	48.175	< 0.001
2 Less enthusiastic	15.5	12.5	11.2	14.3		
3 Peak & classic	14.6	15.7	21.9↑	14.3		
4 Relax & social	10.8↓	17.6↑	13.8	28.6		
5 Challenge & risk	15.6	14.6	15.0	9.5		
6 Skills & social	18.8↑	14.2	8.1↓	9.5		
7 Disinterested in skill development	9.6	12.0	12.5	9.5		

↑ Significantly higher than average
↓ Significantly lower than average

The *Developed* profile has a significantly larger proportion of local participants (48%) and the *Rudimentary* (26%) and *Limited* (41%) profiles have significantly more tourists (Table 3.14; $\chi^2 = 126.86$, df = 6, $p < 0.001$). In addition, the *Foundational* profile recreates during the weekend and on holidays (51%) significantly more as opposed to the *Limited* profile that contains significantly more who recreate on long weekends and holidays only (21%; $\chi^2 = 87.64$, df = 6, $p < 0.001$).

Table 3.14. Risk competency profiles and proximity to recreation and time of recreation

	Proportion by cluster (%)					
Variable	**Developed**	**Foundational**	**Rudimentary**	**Limited**	**χ^2**	***p*-value**
Proximity to forecasting region					126.86	< 0.001
Local	48.4↑	37.9↓	46.7	33.6		
Nearby	34.6	38.4↑	27.2↓	25.6		
Tourist	17.0↓	23.7↑	26.0↑	40.8↑		
Timing of recreation					87.642	< 0.001
Long weekends & vacations only	3.2↓	5.7	7.8	21.1↑		
Weekends & other times (excl. weekdays)	35.5↓	50.8↑	48.8	36.8		
Any time (Inc. weekdays)	61.3↑	43.5↓	43.4	42.1		

↑ Significantly higher than average
↓ Significantly lower than average

3.4.3. Question-driven Segmentation

While the conventional segmentation provides a meaningful overview of the sample, the question-driven approach provides the opportunity to explore segments in more detail. We began by exploring the characteristics of motivation Cluster 7 (N = 241), who were categorized based on their distinct disinterest in technical and avalanche safety skills development. Interestingly, a significant difference was observed in the distribution years of experience. There are significantly more people who reported recreating for 20 or more years (53% vs 32%; W = 296835, $p < 0.001$) and 45 years or older in age (68% vs 41; W = 313336, $p < 0.001$) in the motivation cluster compared to the rest of the sample. Conversely, the motivation profile also contained a significantly higher proportion of individuals who recreate between 3-10 days per year (19% vs 12%; W = 205567, $p < 0.001$) and whose highest formal avalanche safety training is introductory level (52% vs 41%; $\chi^2 = 15.46$, df = 3, $p < 0.01$). This cluster also contained a significantly lower proportion of Type E bulletin users (34% vs 46; $\chi^2 = 16.28$, df = 4, $p < 0.01$) and individuals who recreate significantly less frequent in the most aggressive terrain class (12% vs 21%; $\chi2 = 23.15$, df = 6, $p < 0.001$) compared to the rest of the

sample. No significant differences were found when comparing the competency profiles, bulletin use frequency, preferred recreation times, proximity to recreation areas, and activity type.

The second question-driven exploration led us to separate participants who recreate in the two highest terrain classes (aggressive and most aggressive) or are a mountaineer or ice climber, but do not check the avalanche bulletin before every trip (N = 72). Out of the comparisons between this group and the rest of the sample, no statistically significant distributions were found when comparing motivations, preferred recreation time, and level of formal avalanche safety training. However, this group exhibited a similar pattern to the *Disinterested in skills development* motivation cluster with respect to experience and age. There are significantly more people who have been recreating for 20 or more years (48% vs 27%; W = 301448, $p < 0.001$) and members between the ages of 45-54 (28% vs 18%; $\chi^2 = 14.44$, df = 6, p = 0.025). In addition, there are statistically more participants who recreate only 1-2 days per year (4% vs 1%; W = 255674, p = 0.04) compared to the rest of the sample. The interest group members contained significantly more individuals from the *Limited* competency (14% vs 2%; $\chi^2 = 62.78$, df = 3, $p < 0.01$), and they were statistically less likely to carry the essential safety equipment (9% vs 3%; $\chi^2 = 4.90$, df = 1, p = 0.026).There was also a significantly larger proportion of the interest group who reported that they never check the bulletin (15% vs 2%; W = 26794. $P < 0.001$), significantly more who reported a type C (36% vs 24%) bulletin user type, and significantly less who reported a type D (13% vs 26%) bulletin use type ($\chi^2 = 77.09$, df = 4, $p < 0.001$).

3.5. Discussion

The intent of this research was to demonstrate the informative value of audience segmentation as an evidence based and holistic approach to understanding and characterizing the backcountry recreation community. While current efforts to assist recreationists are mainly guided by recreationists level of avalanche safety training and activity type, these two characteristics alone are limited in their ability to inform avalanche risk communication that properly resonates with the diverse needs, interests, and capabilities of the community. We start our discussion by synthesizing the practical insights gained from our approach and contextualizing it within existing research. We

then present the limitations of our study, followed by future directions and applications of our research.

3.5.1. Findings and Practical Insights

In the conventional segmentation, we clustered participants using training levels, safety equipment practices, bulletin use frequency and user type, years of experience, and number of days per year to produce a richer picture of the risk management practices than just training alone. Our analysis identified four distinct risk competency profiles, which we labeled as *Limited, Rudimentary, Foundational,* and *Developed*. Our findings showed that in these profiles, training levels and bulletin use practices varied together, however total years of experience and average numbers of days per year varied independently. Members of the *Developed* profile, for example, typically had advanced or professional training, and bulletin use routines indicative of more frequent and in-depth use practices. This group typically had more than 11 years of experience and recreated more than 20 days per year. Conversely, the *Rudimentary* profile members tended to have no or introductory level training, and less sophisticated bulletin use routines. However, this group had equal frequencies of individuals with 2-5 years of experience to individuals with more than 20 years. A similar pattern was exhibited by the *Limited* profile, whose members have no bulletin use and tended to have little to no training, yet similar proportions of individuals with 2-5 or more than 20 years of experience. Most participants assigned to the *Limited* profile are highly engaged and tend to recreate between 21-50 days per year. This finding shows that within the recreation community, there are people with high yearly engagement and many years of experience, however their risk mitigative actions are minimal. Therefore, we cannot assume that more experienced individuals have more sophisticated risk management practices. An individual's experience level in risk recreation research is often used as an indicator for expertise and skill level (e.g., Ewert et al., 2015; Gilbertson & Ewert, 2013) however this finding suggests that experience alone may not be a well-suited measure of ability to manage hazard and risk.

To gain further insight, we explored how activity type, terrain and recreation preferences, and motivations relate to each of the risk competency profiles. We found a gradual increase in terrain use that has more avalanche hazard exposure from the *Limited* to *Developed* profile. Furthermore, the *Developed* profile members tended to live

in closer proximity to the recreation sites they access, which also explains why they tend to recreate any time during the week, weekend, and on holidays. Conversely, tourists, who travel from farther away and recreate more on long weekends and holidays, were more likely to have *Rudimentary* or *Limited* risk competencies. Snowshoers and on-piste skiers were also more likely to have *Rudimentary* risk competencies as opposed to out-of-bounds skiers whose risk competencies were more *Developed*.

Motivations were relatively evenly distributed across the profiles, suggesting that individual's motivations are consistent irrespective of their risk competency. Individuals with heightened interests in being social and improving their technical and avalanche safety skills, the *Skills & social* (Cluster 6) cluster, tended to have more *Developed* risk competencies. Alternatively, those motivated by being social and feeling relaxation, The *Relax & social* (Cluster 4) cluster, had more *Foundational* risk competencies. Interestingly, the *Rudimentary* profile contained more individuals motivated by completing classic trips and reaching summits or peaks (Cluster 3). Through these comparisons, we found that, for most recreationists, risk competency was well matched to their terrain preferences, activity type, and aligned with the desired backcountry experiences they sought. However, when risk competency levels are poorly aligned to terrain use preferences, motivations can provide important context to understand why, providing valuable information to help avalanche risk communicators to better support these recreationists and more effectively reach the intended audience.

Our second segmentation approach independently explored two potentially at-risk groups that might benefit from targeted risk communication initiatives: (1) the motivation cluster disinterested in developing avalanche and technical safety skills (Cluster 7) and (2) those who recreate in high exposure terrain but do not check the bulletin before every trip. Our explorations aimed to create a rich picture of these groups, who they are, and what motivates them.

Compared to the rest of the sample, the motivation cluster differed in several significant respects. The cluster contained primarily introductory trained recreationists with low annual engagement levels who travel in conservative terrain, suggesting that their disinterest in developing skills may not be a concerning issues for majority of the sample. It is likely that these people are content with an introductory level of knowledge and skills, which is well suited for their recreational pursuits in mainly simple and

challenging avalanche terrain, as opposed to more aggressive options. However, a proportion of the study participants assigned to this motivation cluster may have risk competency levels that are poorly matches the experiences they seek and terrain they recreate in. For example, while this group has statistically more individuals who recreate in the most conservative terrain compared to the rest of the sample, it is still a relatively small proportion of individuals. More than half of the participants in this cluster recreate in moderate to very aggressive terrain. There were no significant differences in the distribution of risk competency, however most members from this cluster have *Foundational* level competencies.

The findings presented here represent a starting place for further investigation into the needs of this cohort and reasons for their disinterest in developing skills. However, it is important for the avalanche safety community to consider that some individuals do not see it necessary or are willing and able to develop their skillset. Therefore, they will not see messages tailored to development and training opportunities as relevant or applicable. The findings of this research can facilitate different avenues and more creative approaches to reach this audience. This cluster, for example, may benefit from targeted outreach helping recreationists understand the limits and capabilities of their skillsets, messages that suggest hiring a guide when recreating in more complex terrain, and they could help to inform curriculum development for refresher avalanche safety courses and webinars.

Comparatively, the high-exposure-low-risk-mitigation interest group contained significantly more mountaineers, ice climbers, and *Limited* competency profile members. Mountaineers and ice climbers have already been flagged as a cohort who recreate in terrain with high avalanche hazard exposure (e.g., New Zealand Mountain Safety Council, 2023; Avalanche Canada, 2021; Statham & Hueniken, 2023). In national parks of the Canadian Rocky Mountains, ice climbers account for a greater proportion of avalanche fatalities than backcountry skiers (41% vs 37%), who far outnumber ice climbers (Statham et al., 2023). To address this, products tailored to the specific needs of ice climbers are being developed. The ATES scale, for example, was recently updated to include classifications for both backcountry travel and ice climbing (Statham & Campbell, 2023), and the Ice Climbing Atlas (Statham & Hueniken, 2023) provides information about ice climbs in avalanche terrain. This project marks a significant milestone of the exciting possibilities on the horizon for customized supports. In addition

to tailored products like the Ice Climbing Atlas, the unique needs of ice climbers can be addressed through tailoring risk messaging even further. For example, this cohort may benefit from avalanche forecasts specifically focused on avalanche problems that pose a higher risk to ice climbers, such as dry loose avalanches, than to other forms of backcountry activities.

To-date, fatality rates and an accident analysis helped to identify ice climbers as an at-risk cohort, which is a typical practice within the avalanche safety community (e.g., Atkins & Williams, 2000; Zweifel et al., 2012). Our approach offers a more nuanced avenue to proactively identify at-risk users, with the benefit of gaining greater insights on the entire community, and not just those involved in fatal avalanches. A proactive strategy could offer the opportunity to identify and target at-risk groups before accidents occur, ultimately creating a safer backcountry environment for everybody and reducing the avalanche safety community's reliance on accident data.

Interesting findings from both the *Disinterested in skills development* motivation cluster and high-exposure-low-risk-mitigation interest group further highlight the need to proactively explore recreationists to find potential at-risk segments. Both interest groups contained significantly more participants who have been recreating for 20 or more years yet recreate minimal days per year compared to the rest of the sample. An initially unsuspecting finding, this information is informative when combined with other research. Finn (2020) highlighted that older demographics performed less well on bulletin literacy tests, and Peitzsch et al. (2020) showed that the age of avalanche victims has increased over time. Combined, these findings suggest recreationists with currently low levels of recreation days per year but a high number of cumulative years of experience may exhibit a misalignment between their risk competency and recreational practices. Individuals with decades of recreational experience may have been highly involved in backcountry activities earlier in their lives but may now rely on outdated training and expertise. While more research is required to understand this group in more detail, it appears to be a potential target audience who may benefit from tailored risk messaging that is very different from how other cohorts, such as mountaineers and ice climbers, would be addressed.

In additional to the direct practical insights for risk communication, our findings contribute to a larger academic discussion around how individuals' motivations,

preferences, and risk competency influences their recreation habits and decisions regarding safe backcountry travel, and how this information can be leveraged to improve risk communication. While motivations for risk recreation research traditionally emphasized risk and sensation seeking (see, e.g., Ewert & Hollenhorst, 1989; Csikszentmihalyi & Csikszentmihalyi, 1990; Buckley, 2012), more recent literature has established that recreationists exhibit a wider range of motivations (e.g., Kerr & Houge Mackenzie, 2012; Barlow et al., 2013; Frühauf et al., 2017; Willig, 2008). Our findings are consistent with this body of literature, which emphasizes that risk is managed as a necessary component to participation (e.g., Ewert et al., 2013; Ewert et al., 2020) and as a means to achieve other, more important and desirable, benefits (Frühauf et al., 2017; Sole et al., 2010), rather than something that is deliberately sought (Brymer, 2010).

Sole et al. (2010), for example, found a strong link between recreationists motivations and training levels. As opposed to using training opportunities to reduce risk, the findings of their study show that recreationists utilize training so they can access greater benefits and satisfy motivational needs that prompt them to explore higher risk situations. Weber et al. (2002) show that risk taking is likely a result of context-dependent choices that seek to balance perceived risk and expected benefits in recreational, financial, health/safety, ethical and social domains. Our findings agree with this perspective, which is reflected through the trend in risk competencies and avalanche terrain exposure. The trend demonstrates how people rely on training, experience, and risk mitigation to feel more competent in their ability to manage higher levels of avalanche exposure, and therefore recreate in more challenging and complex terrain. This behavioural pattern is described as risk homeostasis, which states that as individual's increase their risk mitigative actions, they tend to expose themselves to higher levels of hazard, and therefore higher levels of risk, however their perception of the risk stays the same because of the risk mitigative actions they employ (Wilde, 1982). In essence, individuals' actions inadvertently maintain a consistent level of perceived risk, such that a risk mitigative action in one direction may facilitate a riskier choice in another. While the concept of risk homeostasis is complex and context-dependent, it has been exhibited in other studies on backcountry recreationists as well. Haegeli et al. (2019) found that recreationists more motivated by thrill-seeking were more likely to make riskier choices when using an avalanche airbag. In this instance, the avalanche airbag acted as a moderator that allowed the recreationist to ski a riskier slope and fulfill

a motivational state that they saw as otherwise inaccessible. Collectively, these findings highlight the complex interplay between motivations, risk competency, and terrain choices, emphasizing the need for risk communication products to be informed by all factors.

These findings underscore the importance of avalanche safety products, messages, and courses to recreationists. Not only do they aim to help recreationists make informed decision about safe backcountry travel, but they also enable people to satisfy a more complete range of their individual motivational needs. This perspective is supported by existing research, such as Greene et al. (2022) who found that avalanche education was effective at changing risk perceptions and providing recreationists with useful skills. Both Fisher et al. (2021) and Finn (2020) found that avalanche education was a strong predictor of performance on bulletin literacy tests, and recreationists have reported a heavier reliance on avalanche safety training to inform their decision making as opposed to professionals, who attributed their practices to be more influenced by personal experience (Atkins & McCammon, 2004). Therefore, it is important that improvements to these products, services, and course curricula consider the multitude of purposes they provide, to ensure that all recreationists see these products as relevant and feel supported. The recreation community is complex, diverse, and will be best supported through a range of supportive messages, products, and education initiatives that align with the needs of different subgroups in the community.

3.5.2. Limitations

While the present analysis provided useful insights into the characteristics of the members of the Euregio and Swiss avalanche forecast user panel, it is important to remember that our sample is likely not representative of the respective forecast user communities nor the backcountry community at large. Our study contained a high proportion of male backcountry skiers with high experience levels, a demographic known to be highly engaged in other avalanche research surveys (e.g., Fisher et al., 2022a, Haegeli & Strong-Cvetich, 2020). On the other side, snowshoers, ice climbers, and mountaineers are very likely underrepresented in this study, and mechanized forms of winter backcountry travel, such as mountain snowmobiling and snow-biking, are not captured in our sample. Hence, caution should be used when extrapolating our results to these and other populations. This is particularly true for the conventional segmentation,

which is more sensitive to the characteristics of the sample than the question-driven segments.

An additional limitation of our study is that the current sign-up survey for the research panels does not include a question meaningful at capturing the in-field risk mitigation and decision-making practices of recreationists. This limits our ability to describe participants' risk mitigation practices more holistically, yet recent research that explored recreationists' in-field risk mitigation decision making processes shows that their decision processes are complex and context specific (Langford, 2023). Since knowledge of both recreationists' pre-trip and in-field risk mitigation decisions and behaviours are critical for a more complete picture of recreationists risk competency, it is an important consideration that should be incorporated into future segmentation analyses.

3.5.3. Future Directions

Our findings augment existing methods to understand and communicate with recreationists. Instead of mainly relying on activity type and avalanche safety training, we propose to inform the development of and improvements to risk communication products and services through examining the alignment between recreationists' risk competency, terrain preferences, and motivations using empirically derived segments of recreationists that showcase similarities and differences amongst the community. This is a departure from traditional interpretations of existing models such as the deficit model of risk communication, which positions expert knowledge and decision-making as superior to non-experts, presuming that non-experts inherently possess an inferior understanding of risk (Rickard, 2021; Höppner et al., 2010). Our approach offers a more nuanced way for avalanche safety practitioners and researchers to evaluate recreationists habits and practices, that is more explicitly grounded in providing recreationists with the tools and information they need to manage their risk and help them understand the limitations of their knowledge and skills.

To help make these methods and this perspective more accessible, we foresee expanding upon the methods presented in this paper in multiple ways. First, we envision developing a dashboard interface, that would allow for the collaborating avalanche warning services to explore the nature of their research panel. While our paper presents

examples on what could be explored, a dashboard would allow avalanche warning services to explore other research questions of interest. This would enable the warning services to perform the type of analyses presented in this paper with their own research questions to gain broader insights into who is accessing their services, why, and how they could be better supported. While our analyses only explored two interest groups, the methodology allows exploration into any group of potential interest.

Second, while the research panels provide a valuable opportunity to explore the recreationist community, its associated limitations described above make it difficult to generalize findings to all user communities. To overcome these limitations of the research panel, warning services may be interested in developing an (optional) membership program for those accessing their forecast products, where an initial sign-up asks questions paralleling the ones used in this study (Table 3.1). While Haegeli et al. (2023b) highlighted challenges in implementing social science research into the practitioner and operational environment, a membership system could help close the gap between researchers, practitioners, and recreationists and could establish communication pathways for a more user-centric and systems approach to avalanche risk communication. In addition, the warning services that implement this would acquire a more representative sample, which could help identify a more meaningful range of users and their needs. Knowing how users navigate forecasting websites would provide even broader insights into the user community as well as product challenges and opportunities.

3.6. Conclusions

The increasing growth of winter backcountry recreation has resulted in a more diverse community that might not be well represented by the avalanche community's traditional ways of characterizing their target audiences, which focuses on activity and avalanche safety training alone. It is well established in the risk communication literature that having an in-depth understanding of the characteristics and needs of the target audience is critical for the design of risk communication products and services that effectively address user needs. As a starting point, audience segmentation provides a comprehensive and in-depth overview of the recreation community. From there, it provides a framework for intentional and systematic explorations into the community that centers recreationists as the key informants to effective risk communication.

The sample for this study came from the Euregio and Swiss avalanche forecast research panels and two segmentation approaches were used to demonstrate the value of the method. First, we performed a latent class analysis with participants' level of avalanche safety training, experience, and risk mitigation practices to identify four competency profiles: *Limited, Rudimentary, Foundational*, and *Developed*. From the *Limited* to *Developed* profile, training and risk mitigation increased, however no consistent pattern emerged for experience. Second, we explored two potential at-risk groups with a more targeted segmentation approach and found that some recreationists' risk mitigation practices may be poorly matched to the terrain they expose themselves to and experiences they seek.

With our findings, we highlight that there are differences exhibited in the recreation community, and most recreationists' motivations and risk competencies are well-matched to the terrain they access. Although, the tools of this research also helped to identify segments whose risk competency, terrain choices, and motivations may be poorly aligned, indicating a starting place for more targeted and tailored avalanche risk supports. Ultimately, this demonstrates that all risk competency levels, from limited to developed, are valid and appropriate for different situations, similar to St. Clair's perspective regarding bulletin user types (St. Clair, 2019). This perspective shifts the approach to avalanche risk communication, moving away from a mainly expert-driven approach towards a community-driven one.

This study shows that by incorporating information about users' recreational engagement and preferences, backcountry experiences, motivations, avalanche risk mitigation practices, training, and demographics into the segmentation approach, we are able to gain a richer picture of the community. This richer picture can be effectively utilized to inform the improvement and tailoring of avalanche risk communication messages, products, and curricula.

Future research should continue this approach and focus on understanding the contextual factors that can help explain recreationists' practices, decisions, and needs. Once meaningful segments are identified, future inquiries can look more deeply into the needs of each segment. Partnerships between researchers and avalanche warning services can collaborate on gaining a more representative sample, providing even greater insights into the community. While customized avalanche forecast products for

different audience segments have so far been unthinkable due to limited resources, the current trends towards an increased use of models and automation (e.g., Pérez-Guillén et al., 2022) creates the foundation for the efficient production of a more diverse set of avalanche safety communication products that may be able to better meet the needs of different individuals, facilitating safer backcountry experiences for everyone.

Chapter 4. Conclusions

The increasing growth of winter backcountry recreation has likely resulted in a more diverse community that might not be well represented by the avalanche community's traditional ways of understanding, characterizing, and communicating to their target audiences. The current understanding relies heavily on characterizing the recreation community through their activity type and level of avalanche safety training. While a good starting point, these variables alone are limited in their ability to inform meaningful improvements to avalanche risk communication. Best practices in risk communication suggest that a comprehensive and holistic understanding of the characteristics, preferences, and needs of the intended audience can lead to more effective risk communication. Therefore, this research used audience segmentation to explore participants motivations and characteristics to identify latent or potentially high-risk segments of the recreation community. The aim of this research is to demonstrate how our methods and insights from our research findings can be leveraged for the improvement, design, and evaluation of targeted avalanche safety initiatives.

Audience segmentation is commonly used to understand target audiences and has been widely applied in related fields such as public health and science communication (Metag & Schäfer, 2018). Building on this body of research, this study consisted of two audience segmentation analyses. In the first study (Chapter 2), we explored the motivations behind why people engage in backcountry winter recreation, a topic that has received extensive attention in other risk recreation activities, but little attention in winter backcountry recreationists. The method of this study was to segment winter backcountry recreationists by motivations to demonstrate how they can contextualize the situations in which recreationists use and apply avalanche risk communication for the design of more targeted avalanche safety messages.

The second study (Chapter 3) included a segmentation analysis that combined motivations with other characteristics, such as activity type, level of avalanche safety training, experience, and terrain use preferences, to gain a more holistic picture of how recreationists' risk competencies align with their recreation habits and avalanche hazard exposure. This study also included a more targeted segmentation analysis that further

explored two potential at-risk groups that might benefit from more targeted risk communication initiatives.

Collectively, our findings demonstrate that the recreation community is diverse in their motivations, capabilities, and habits. While most recreationists risk competency is well-matched to their terrain preferences and activity type, and aligns with the desired backcountry experiences they seek, other segments of the community would benefit from tailored and targeted risk communication efforts aimed to address their specific needs more effectively. Our approach offers a more nuanced way for avalanche safety practitioners and researchers to understand recreationists' habits and practices, that is more explicitly grounded in providing recreationists with the tools and information they need to manage their risk and help them understand the limitations of their knowledge and skills. Ultimately, the methods in this study can be leveraged by forecasting agencies interested in gaining a better sense of who is accessing their services and how they could be better supported, and overall demonstrates the benefits of a more user-centric and evidenced-based approach to avalanche risk communication that can better support recreationists for safer mountain pursuits.

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Appendix A. Screenshots of Sign-up Survey

Research Panel
for Euregio Avalanche Report

Deutsche Umfrage | Sondaggio Italiano | English Survey

How do different stakeholders use our products?
How well is the content understood by various users?
How can we enhance clarity?
...

Together with the Avalanche Research Program of **Simon Fraser University** in Canada and the **Swiss avalanche warning service** at the SLF in Davos, we are seeking to find answers to these and other questions. The goal is to support the further development of our products.

To do this, we are **building a community of backcountry users and decision-makers** interested in providing feedback, playing an active part in improving avalanche safety products, and brainstorming about new opportunities. **You do not have to be an avalanche expert to participate** in our research. **We are interested in the perspectives of everybody**, particularly individuals who are just starting their backcountry adventures or only occasionally go into the backcountry.

If you are interested in participating in this initiative, please click the 'Sign me up' button below to provide us with your contact information and a little bit of background information about yourself.

Sign me up >>

It takes **approximately 15 minutes** to fill our signup survey.

Thank you for taking the time to participate on our research.
Euregio Avalanche Warning Services
Simon Fraser University Research Team

Deutsche Umfrage | Sondaggio Italiano | English Survey

Informed Consent Contact Information

*Simon Fraser University is located on the unceded ancestral territories of the **xʷməθkʷəy̓əm** (Musqueam), **Sḵwx̱wú7mesh** (Squamish), **səlililw̓ətaʔɬ** (Tsleil-Waututh), **kʷikʷəƛəm** (Kwikwetlem), **Líl̓wat** (Lil'wat), and **Stát̓imc Tmícw** (St'at'imc) Peoples. We understand this acknowledgement to be a starting place for further reflection on historical and ongoing settler colonialism and for ongoing critical self-location. In addition to this statement, we hold ourselves accountable to meaningful learning and action at home, in the office, and on the skin track.*

Figure A.1. Landing page of sign-up survey (Euregio version, English)

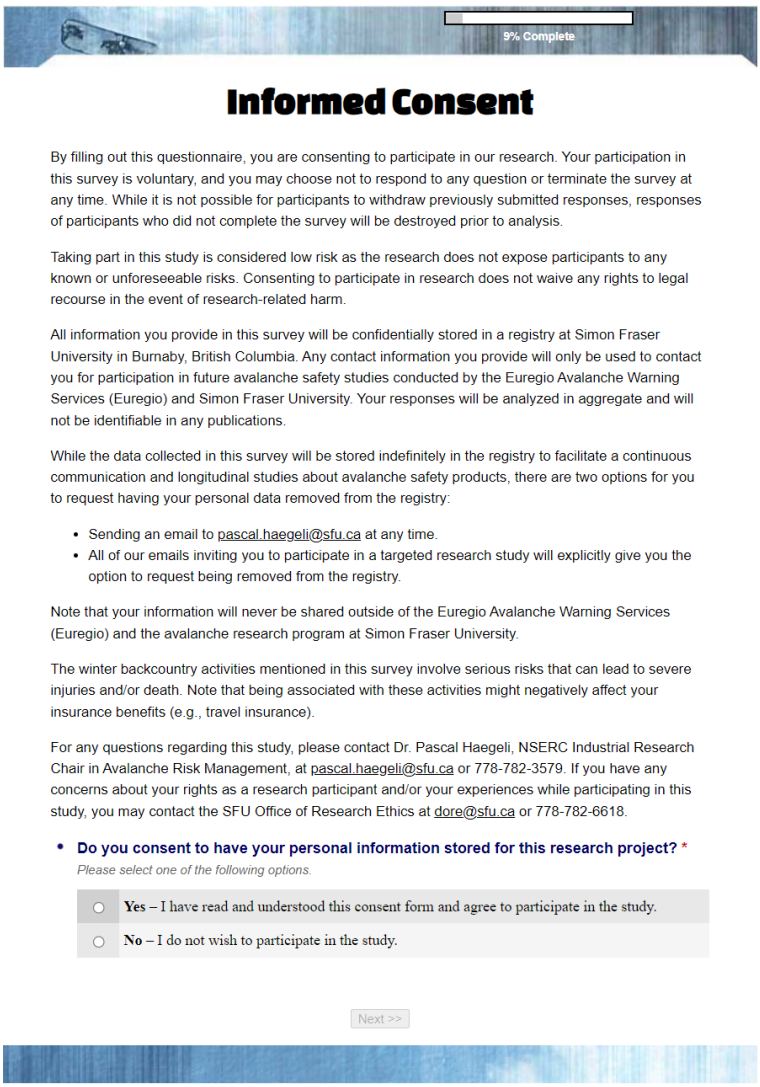


Figure A.2. Informed consent page of sign-up survey (Euregio version, English)

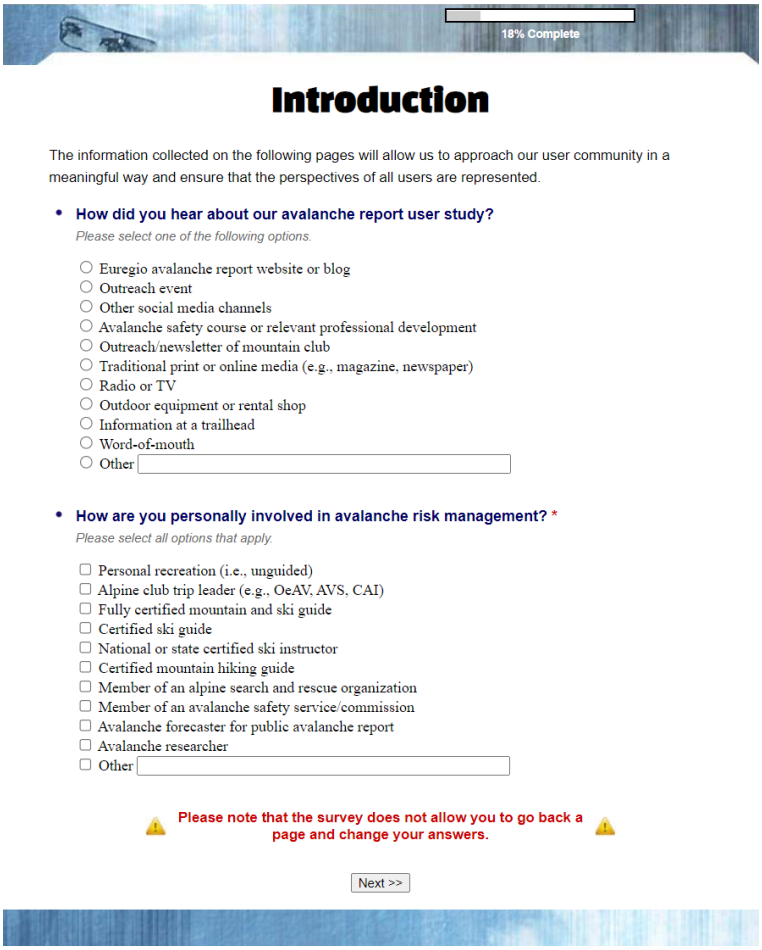


Figure A.3. Introduction page of sign-up survey (Euregio version, English)

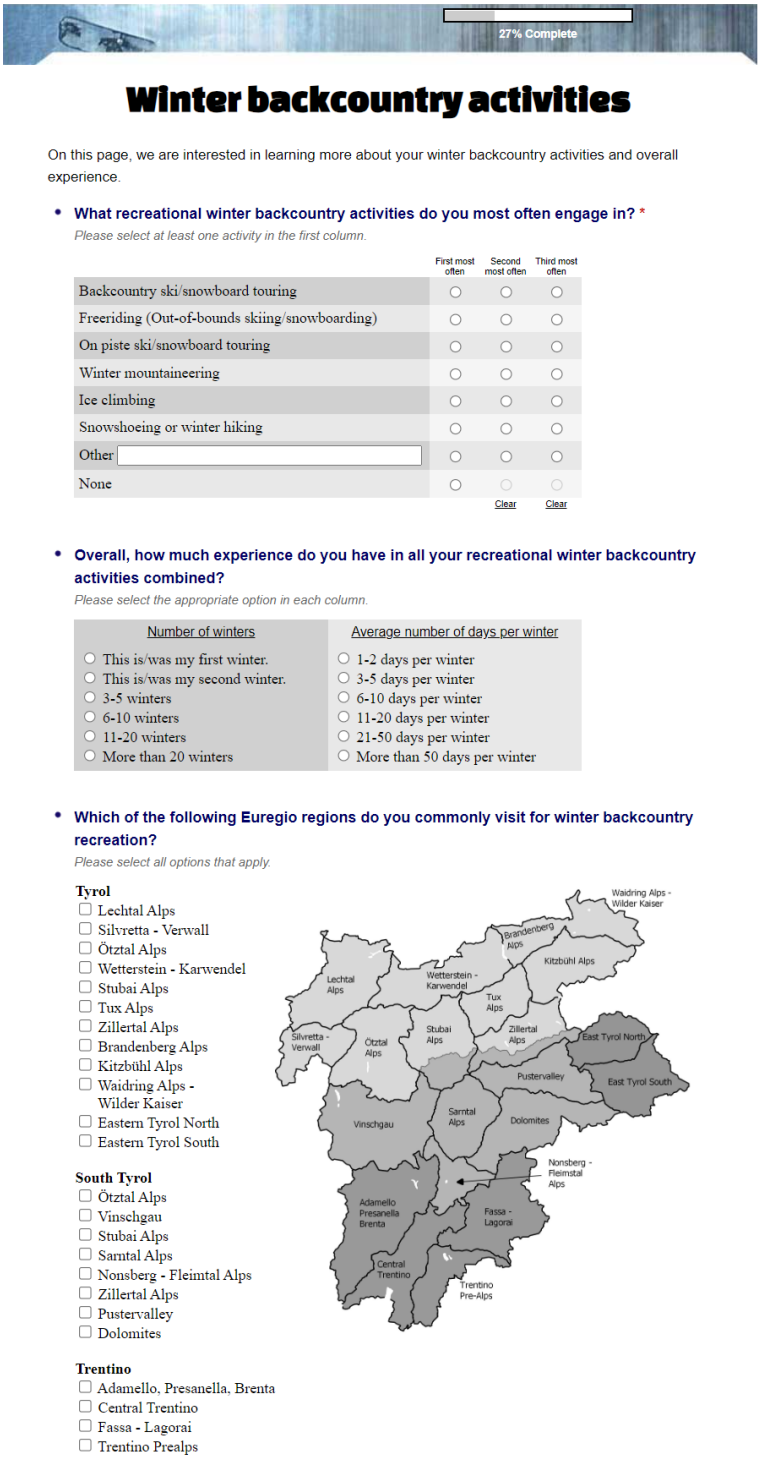
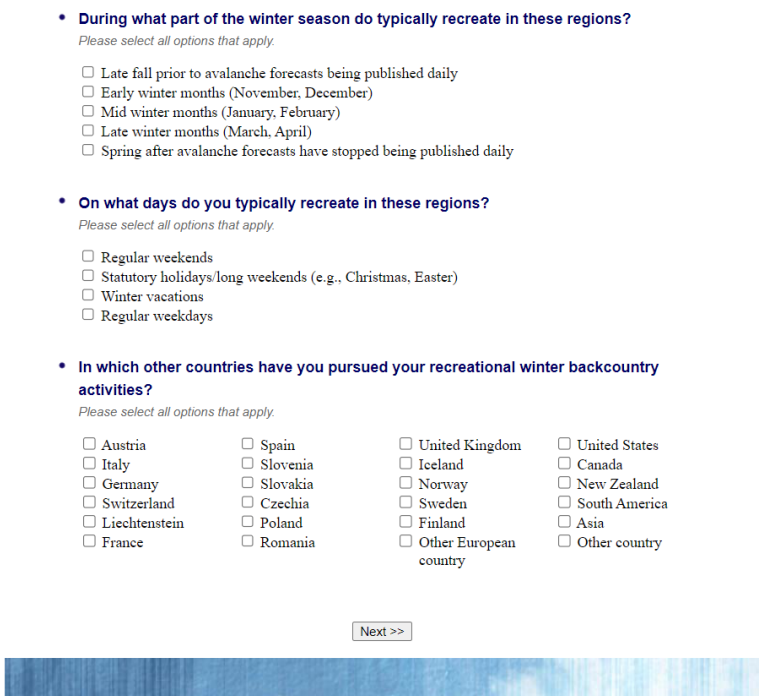


Figure A.4. Winter backcountry activities page of sign-up survey (Euregio version, English) (1 of 2)



- **During what part of the winter season do typically recreate in these regions?**

Please select all options that apply.

- ☐ Late fall prior to avalanche forecasts being published daily
- ☐ Early winter months (November, December)
- ☐ Mid winter months (January, February)
- ☐ Late winter months (March, April)
- ☐ Spring after avalanche forecasts have stopped being published daily

- **On what days do you typically recreate in these regions?**

Please select all options that apply.

- ☐ Regular weekends
- ☐ Statutory holidays/long weekends (e.g., Christmas, Easter)
- ☐ Winter vacations
- ☐ Regular weekdays

- **In which other countries have you pursued your recreational winter backcountry activities?**

Please select all options that apply.

☐ Austria	☐ Spain	☐ United Kingdom	☐ United States
☐ Italy	☐ Slovenia	☐ Iceland	☐ Canada
☐ Germany	☐ Slovakia	☐ Norway	☐ New Zealand
☐ Switzerland	☐ Czechia	☐ Sweden	☐ South America
☐ Liechtenstein	☐ Poland	☐ Finland	☐ Asia
☐ France	☐ Romania	☐ Other European country	☐ Other country

Next >>

Figure A.5. Winter backcountry activities page of sign-up survey (Euregio version, English) (2 of 2)

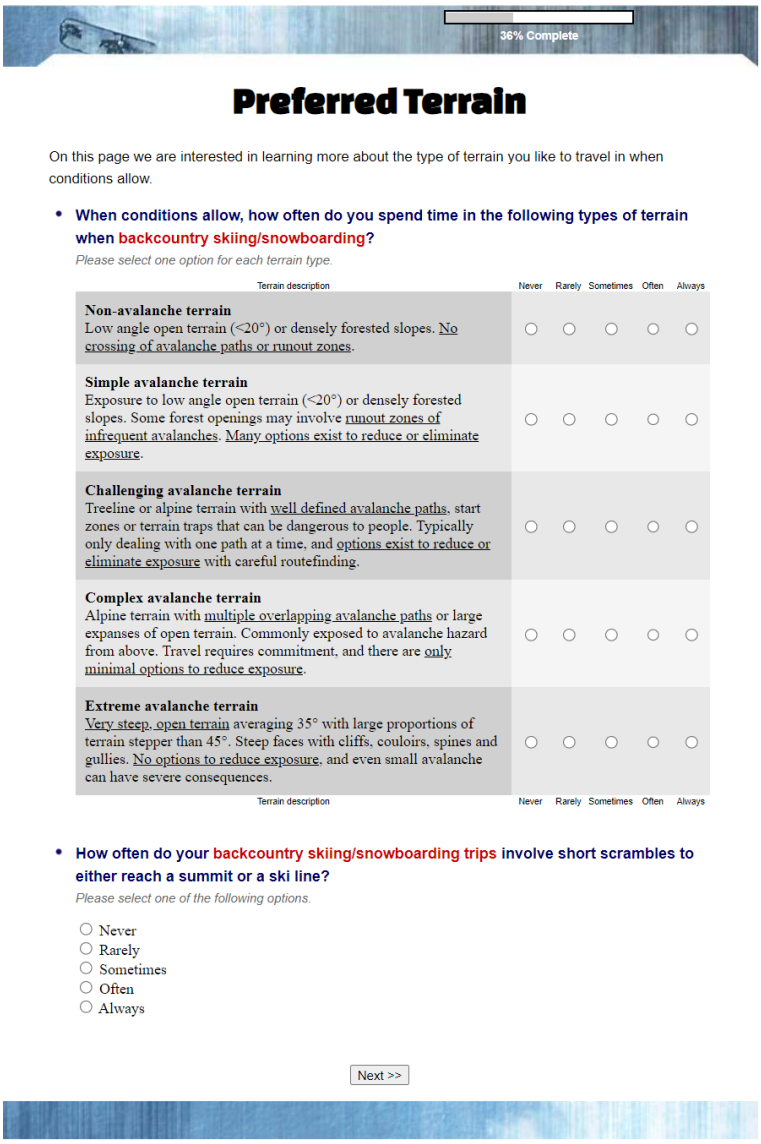


Figure A.6. Preferred terrain page of sign-up survey (Euregio version, English)

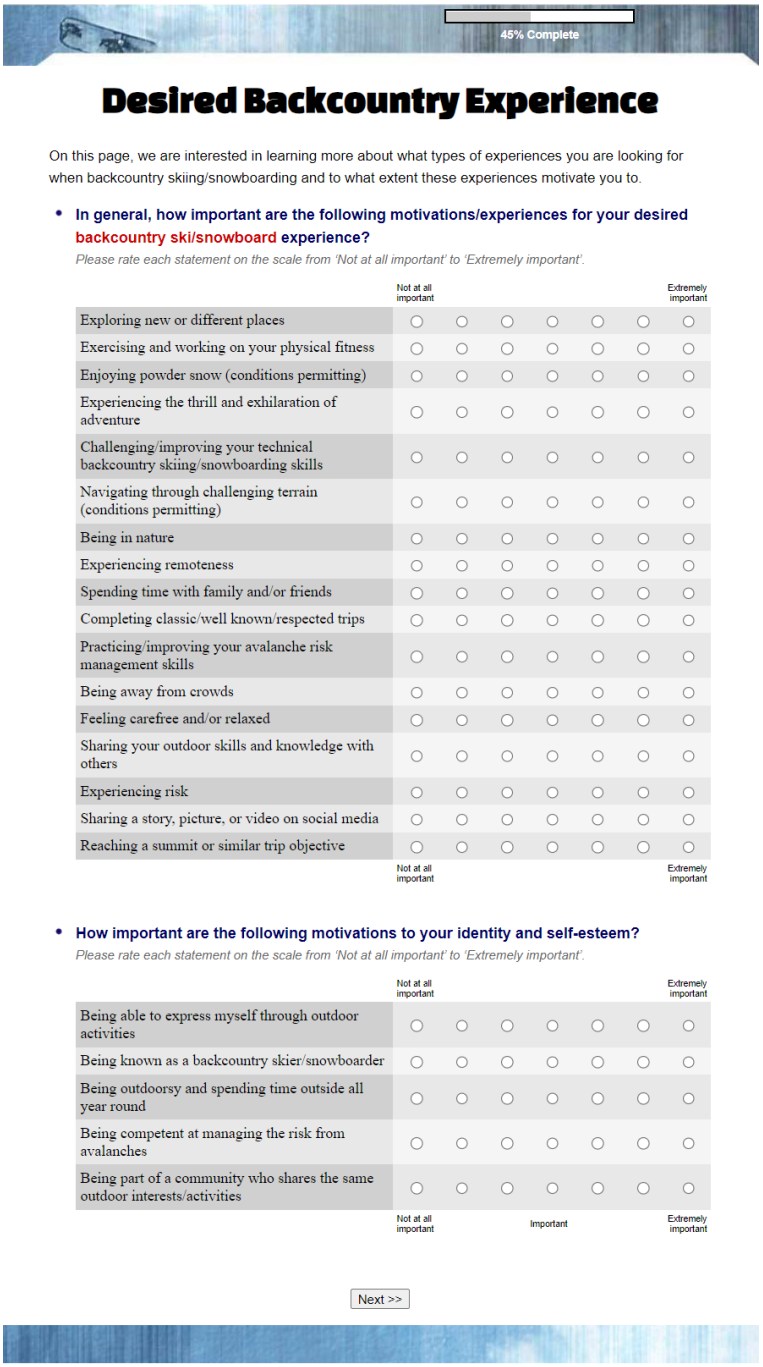


Figure A.7. Desired backcountry experience page of sign-up survey (Euregio version, English)

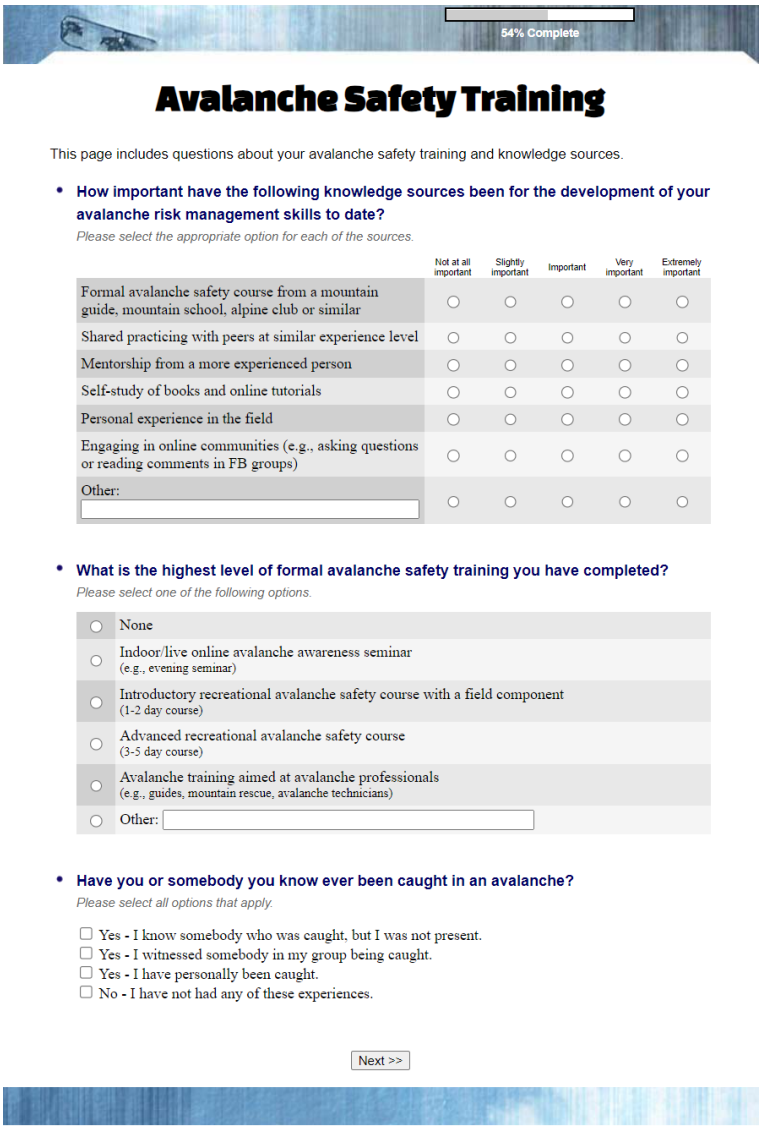


Figure A.8. Avalanche safety training page of sign-up survey (Euregio version, English)

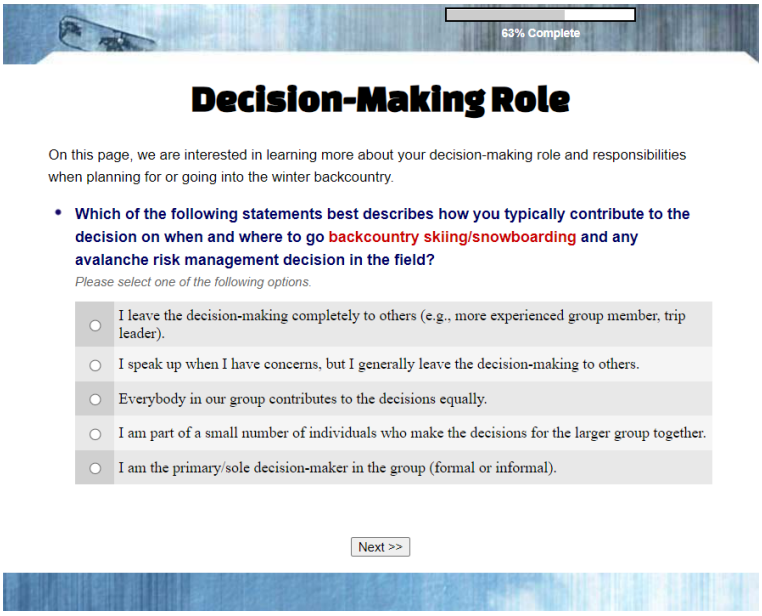


Figure A.9. Decision-making role page of sign-up survey (Euregio version, English)

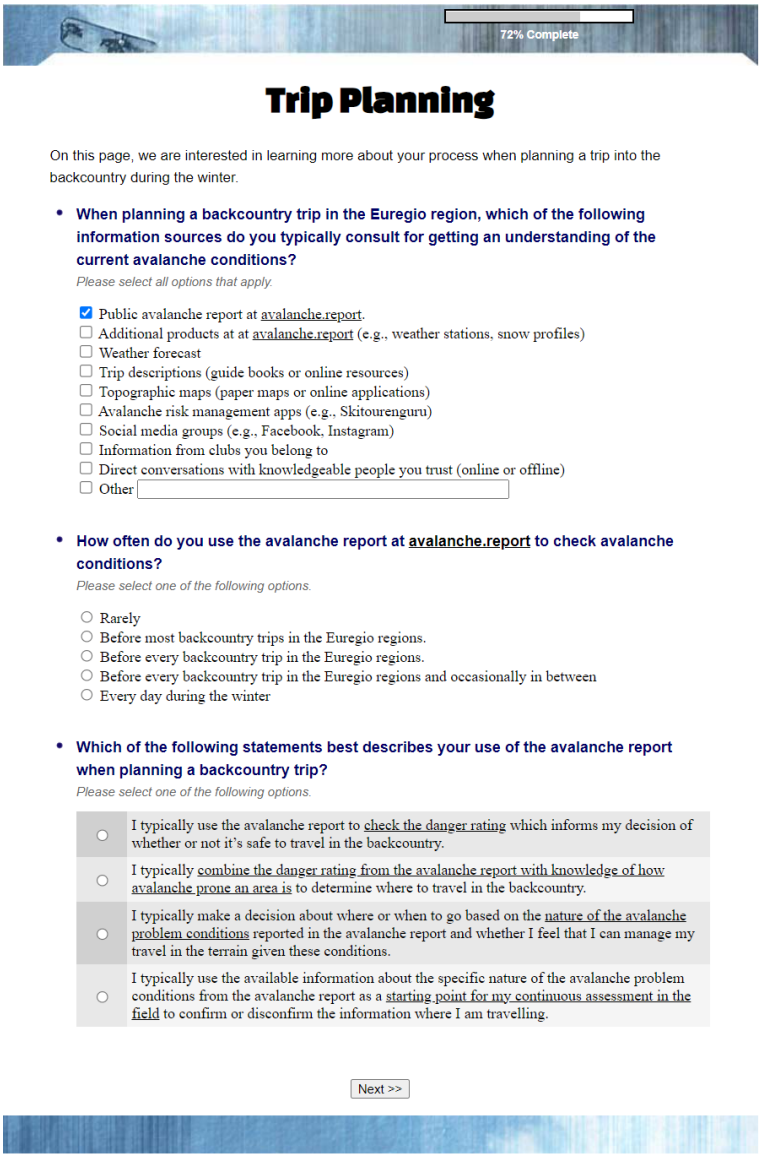


Figure A.10. Trip planning page of sign-up survey (Euregio version, English)

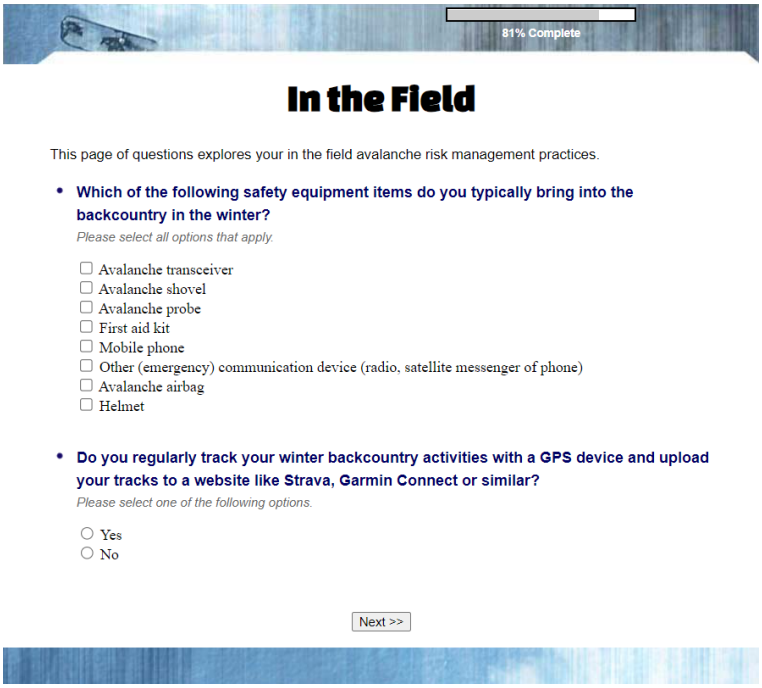


Figure A.11. In the field page of sign-up survey (Euregio version, English)

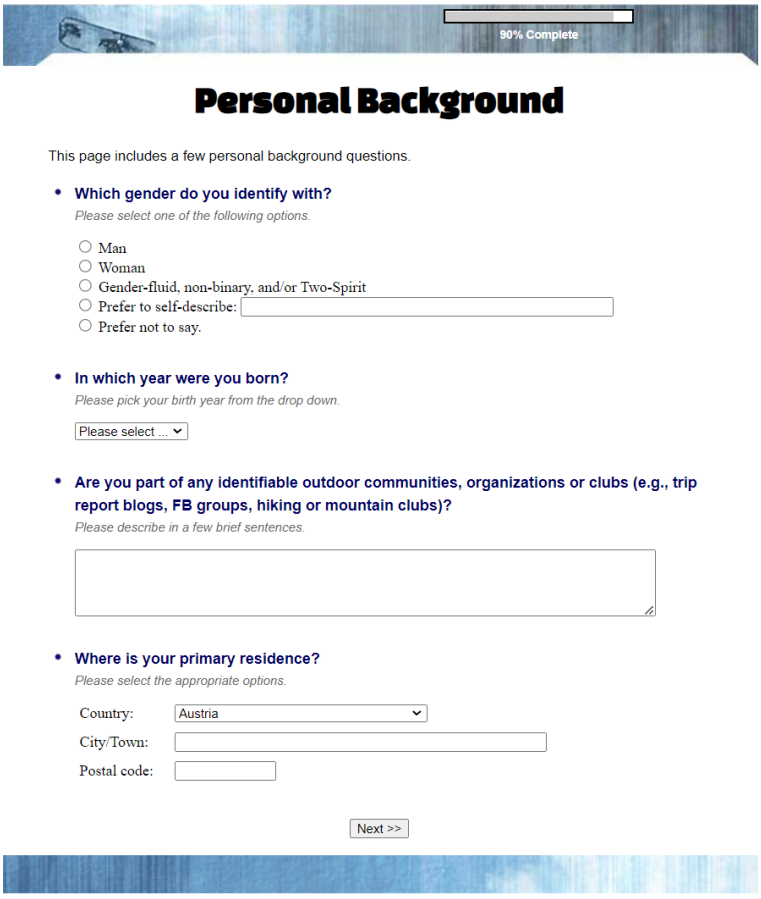


Figure A.12. Personal background page of sign-up survey (Euregio version, English)

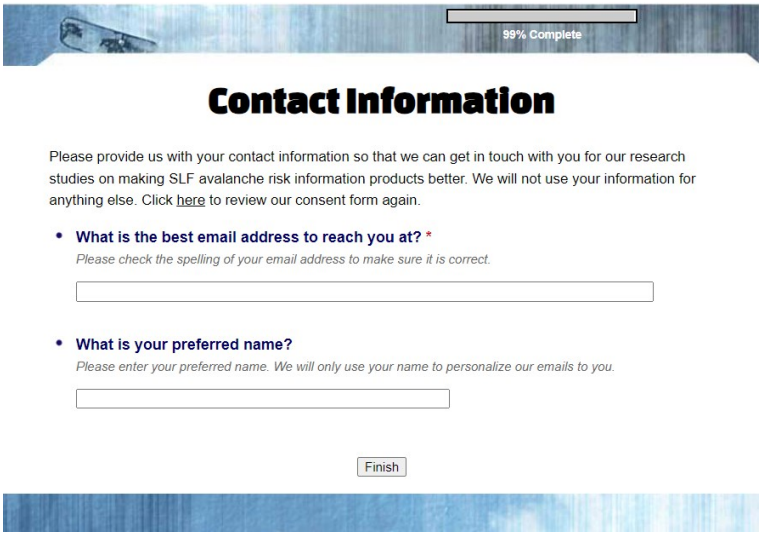


Figure A.13. Contact information page of sign-up survey (Euregio version, English)

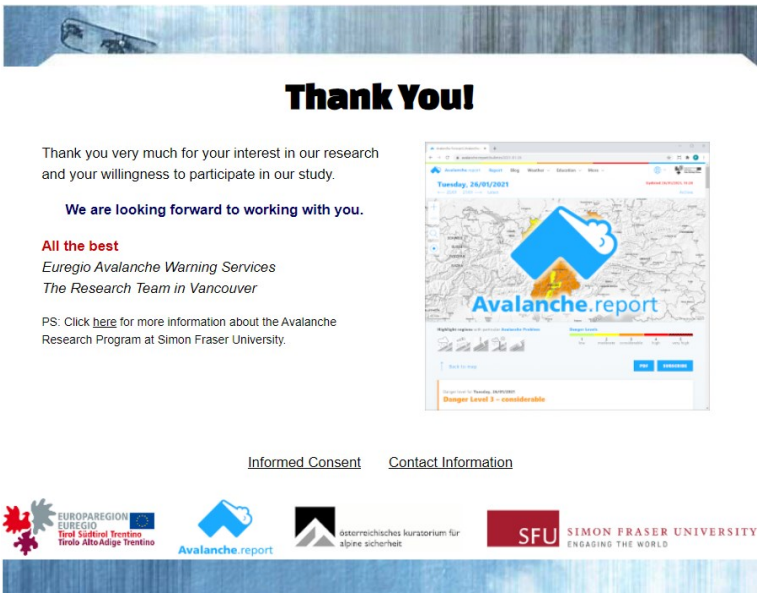


Figure A.14. Thanks you page of sign-up survey (Euregio version, English)

Appendix B. Motivation Cluster Solutions

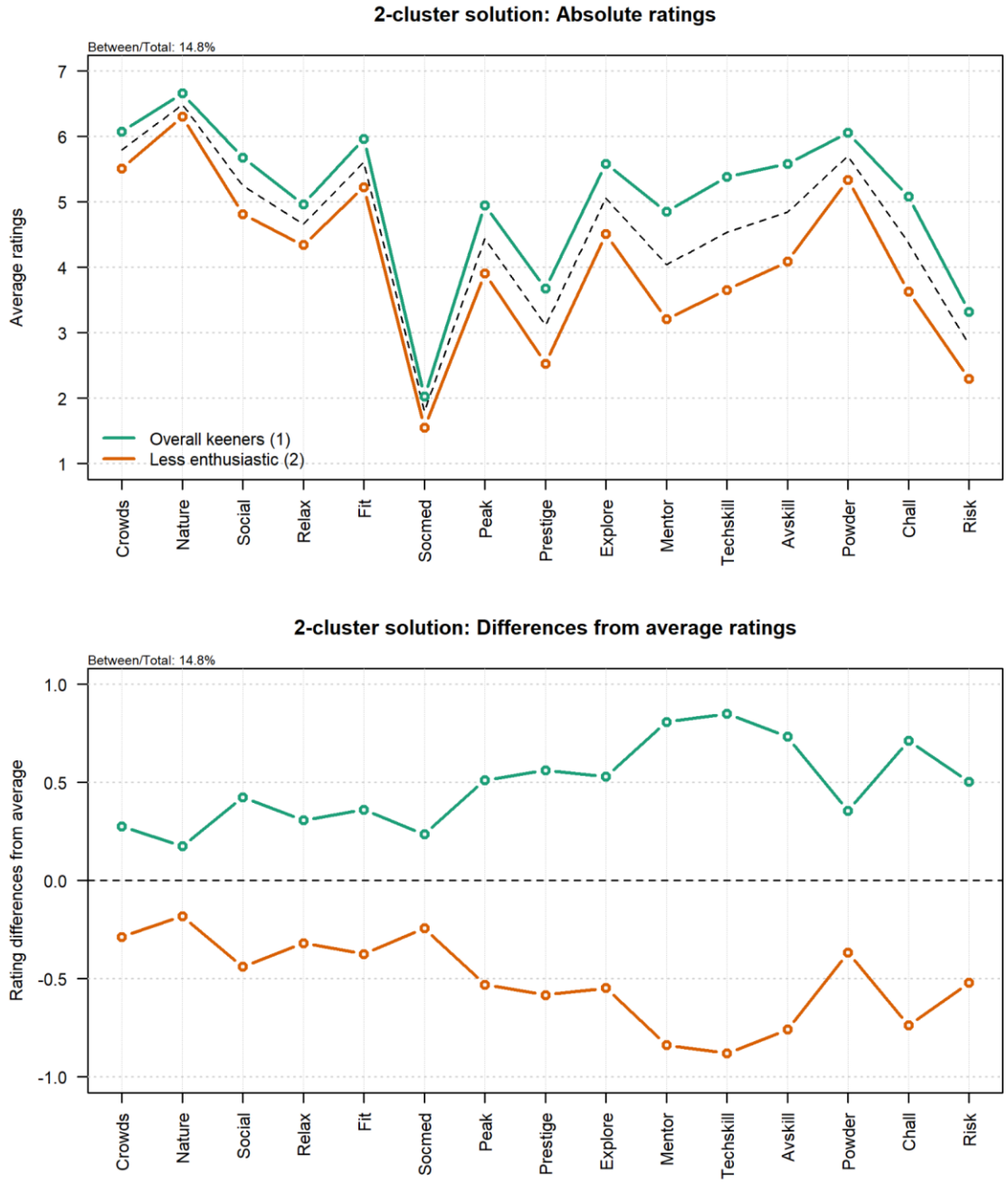


Figure B.1. **Motivation ratings of 2-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings.**

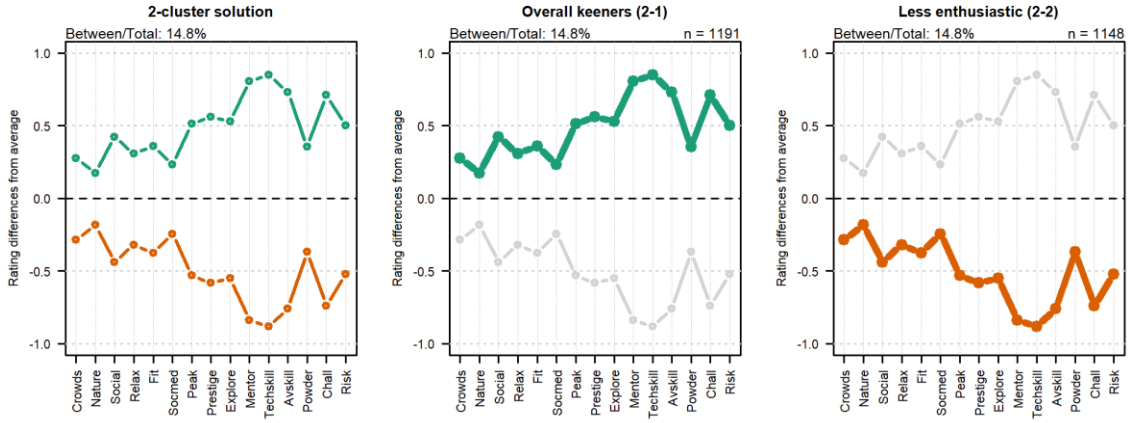


Figure B.2. Motivation ratings of 2-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.

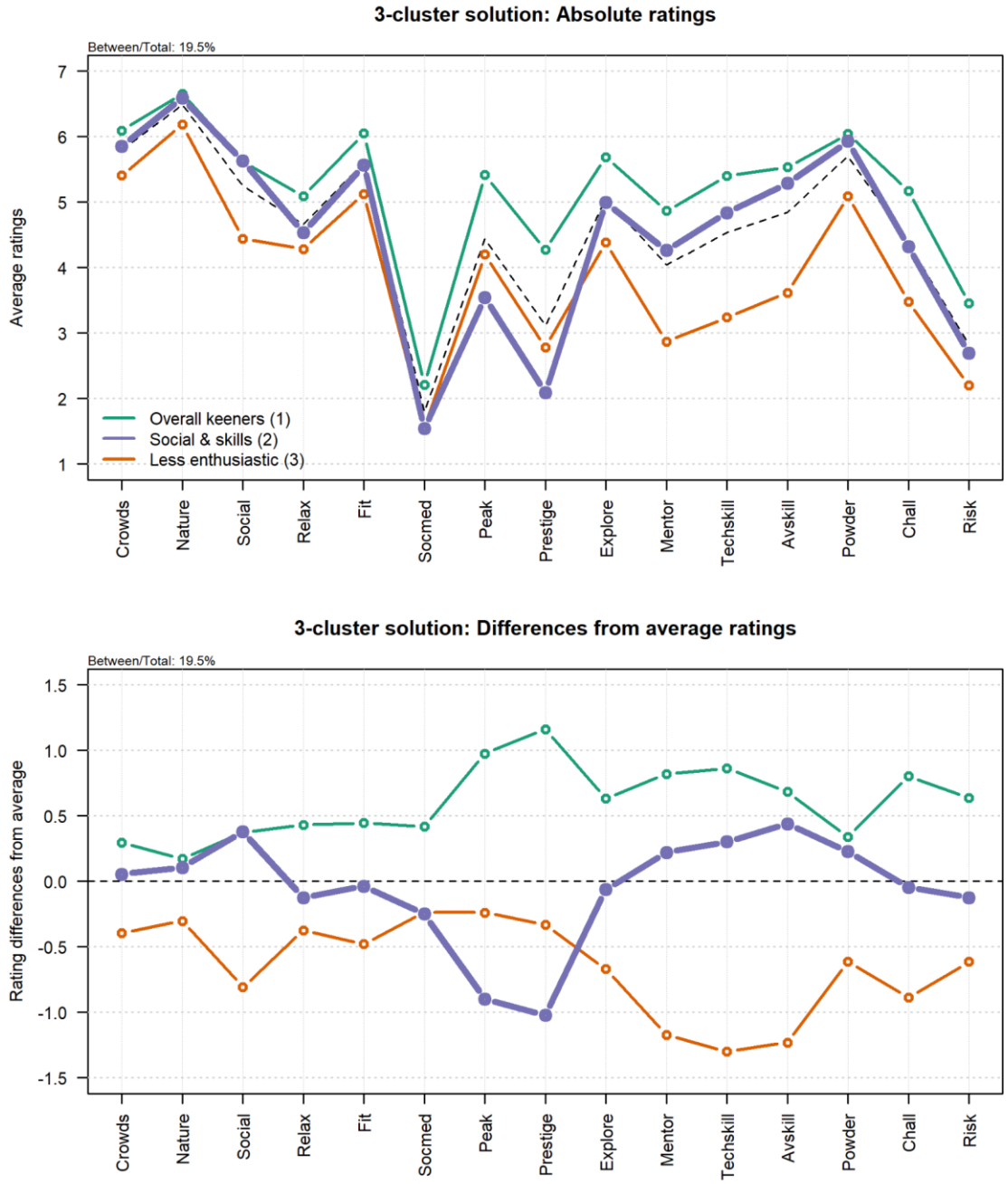


Figure B.3. **Motivation ratings of 3-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings. The newly added cluster is highlighted with a thicker line.**

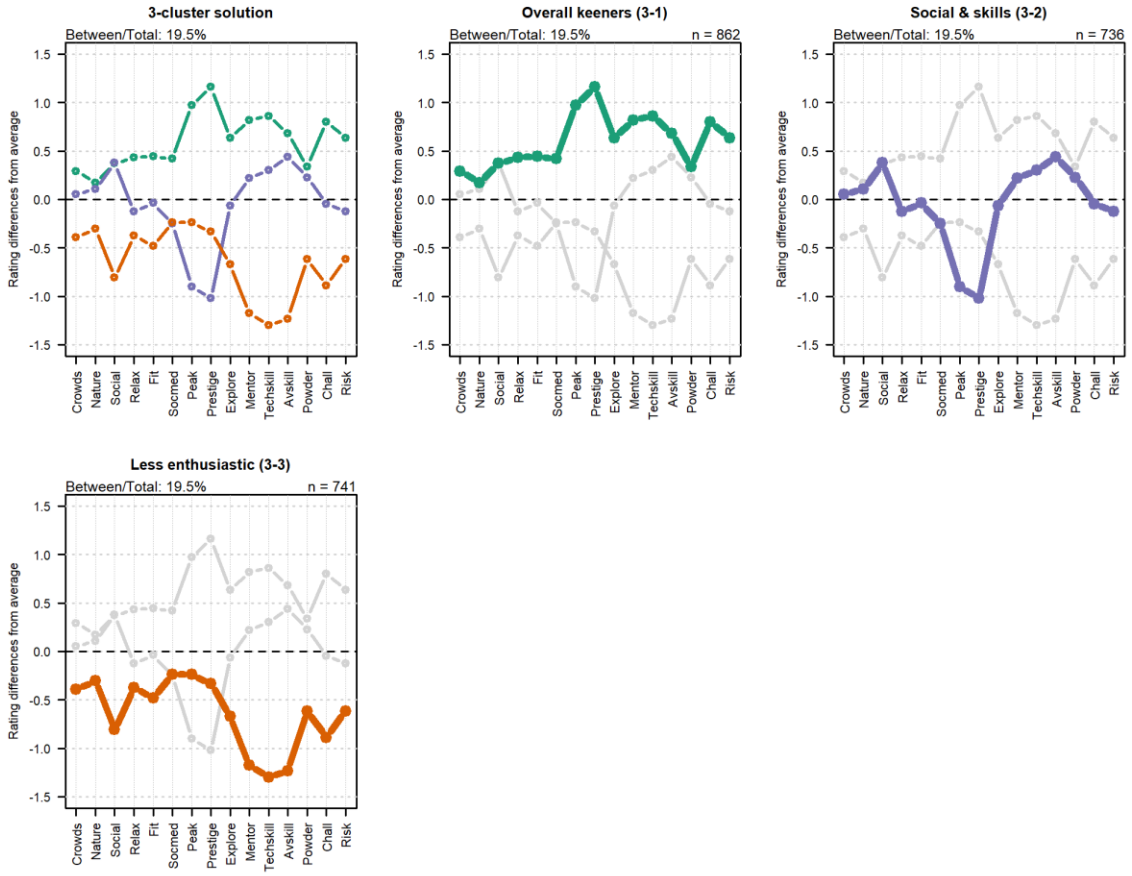


Figure B.4. **Motivation ratings of 3-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.**

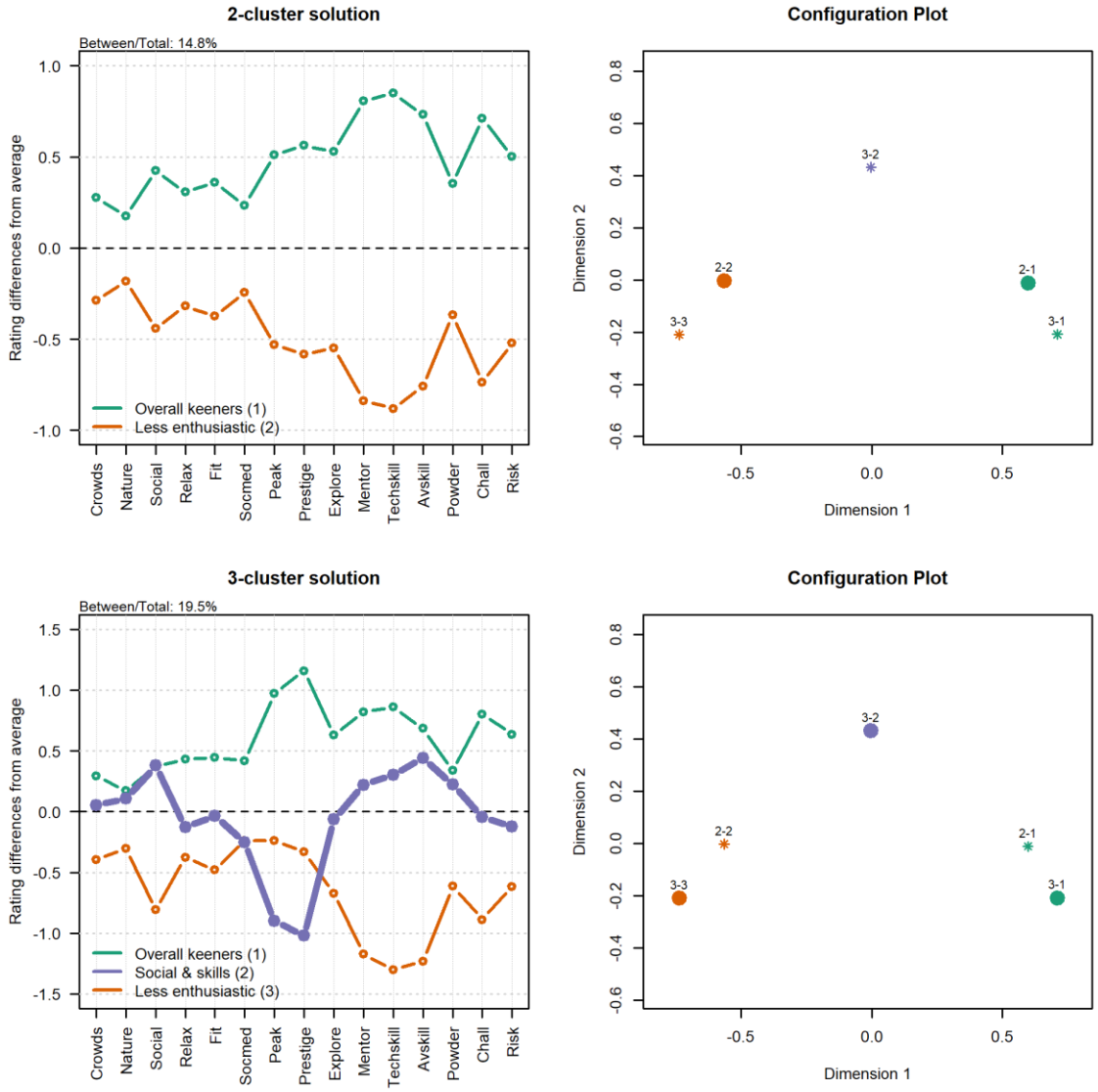


Figure B.5. Comparison of 2- and 3-cluster solutions. Left panels show differences from average ratings. Right panels show configuration plots with first two dimensions to illustrate proximities of the clusters of the two solutions.

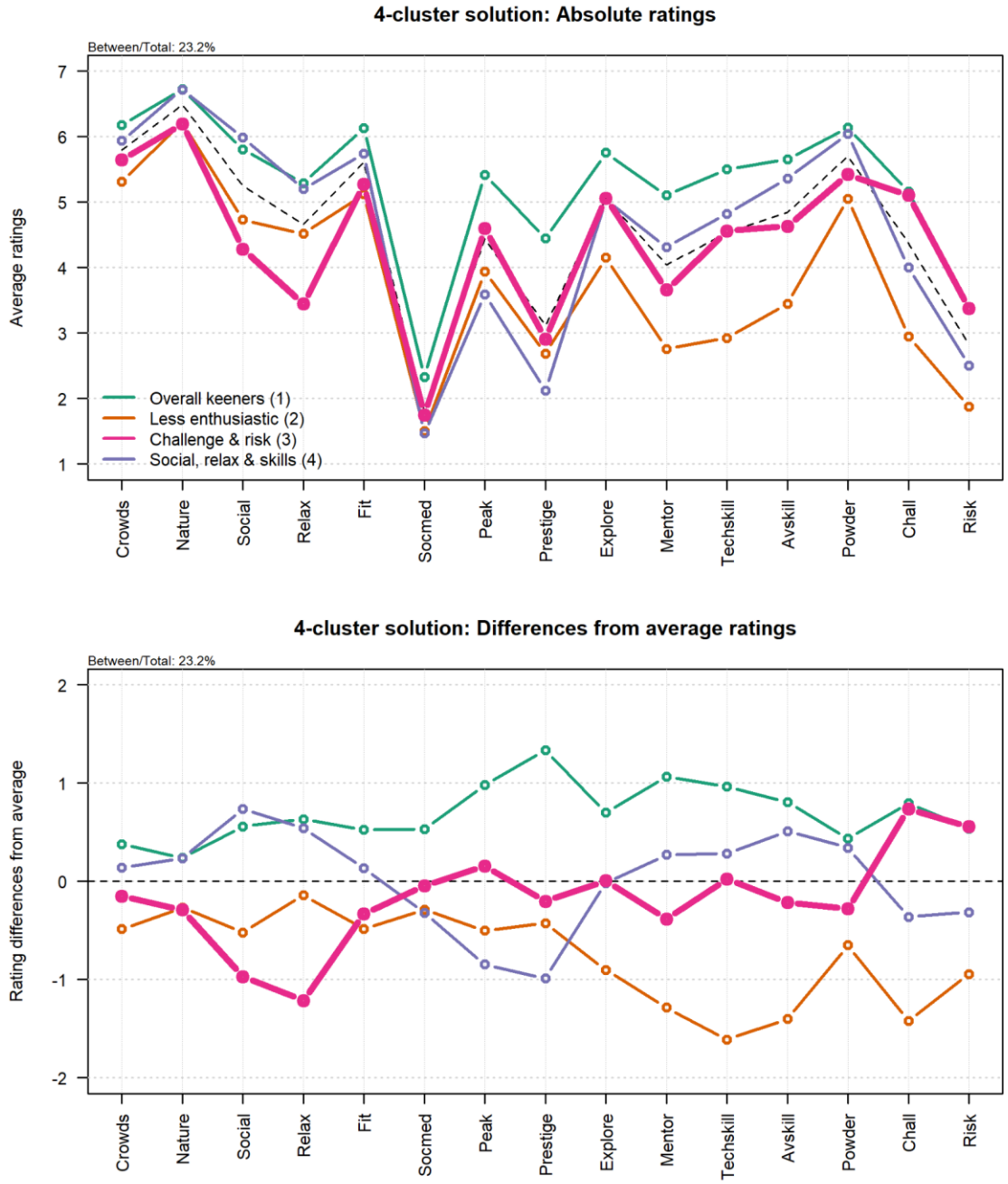


Figure B.6. **Motivation ratings of 4-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings. The newly added cluster is highlighted with a thicker line.**

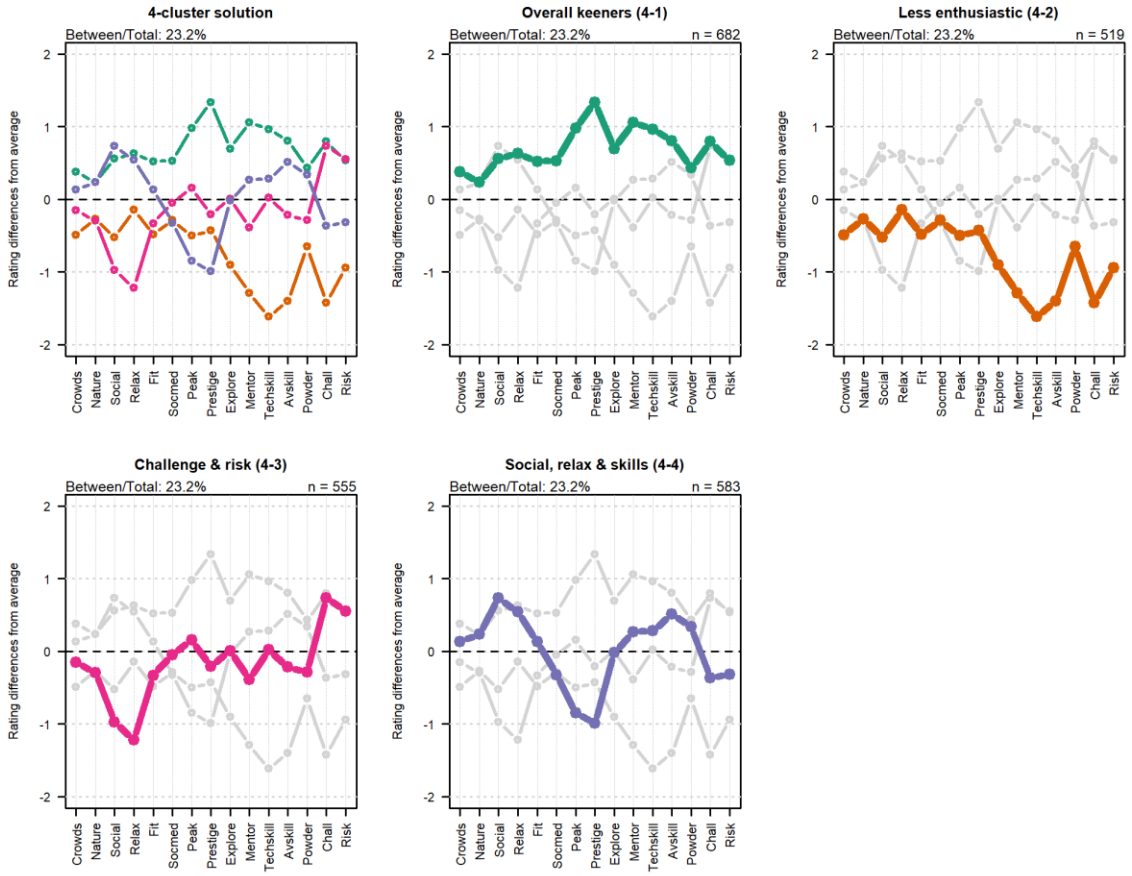


Figure B.7. **Motivation ratings of 4-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.**

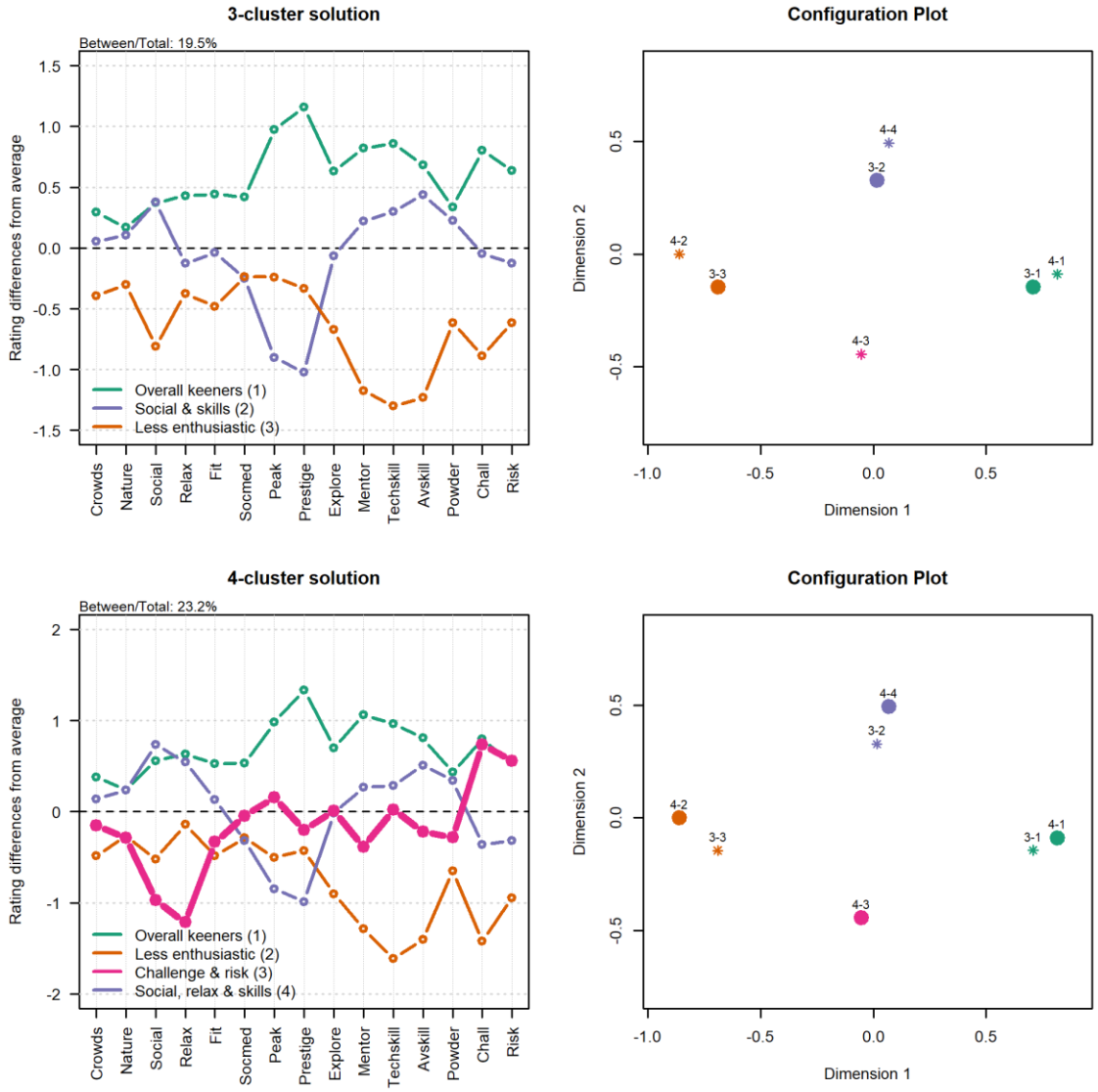


Figure B.8. Comparison of 3- and 4-cluster solutions. Left panels show differences from average ratings. Right panels show configuration plots with first two dimensions to illustrate proximities of the clusters of the two solutions.

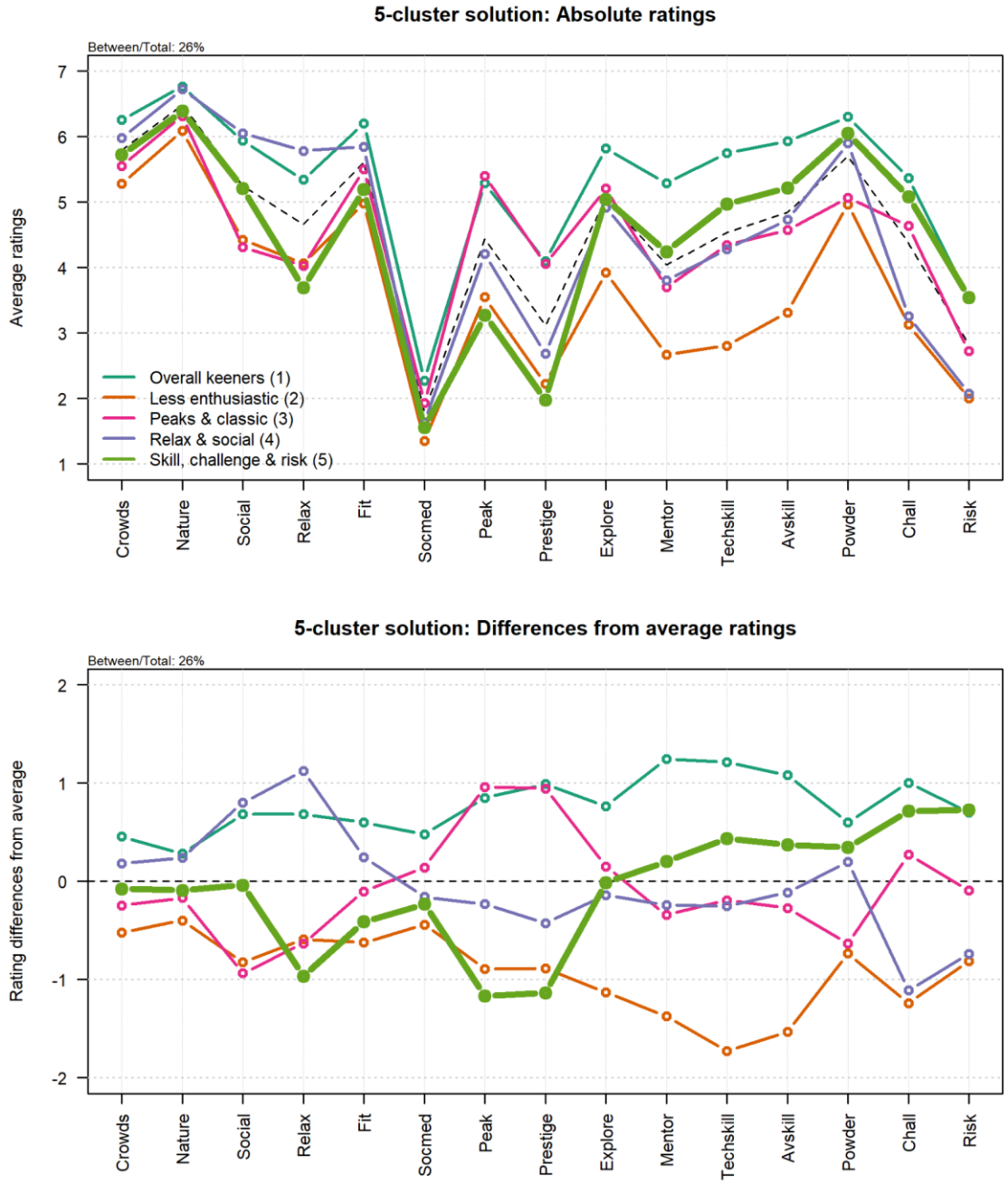


Figure B.9. **Motivation ratings of 5-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings. The newly added cluster is highlighted with a thicker line.**

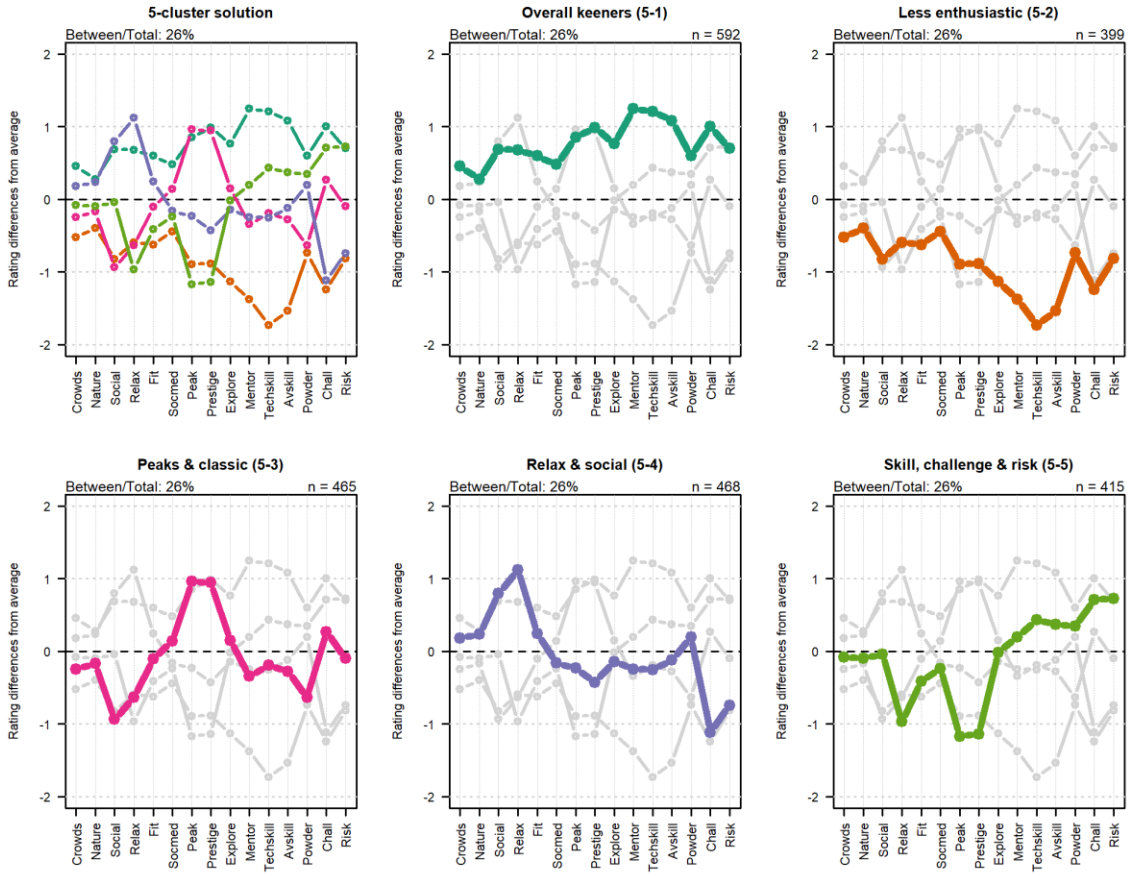


Figure B.10. Motivation ratings of 5-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.

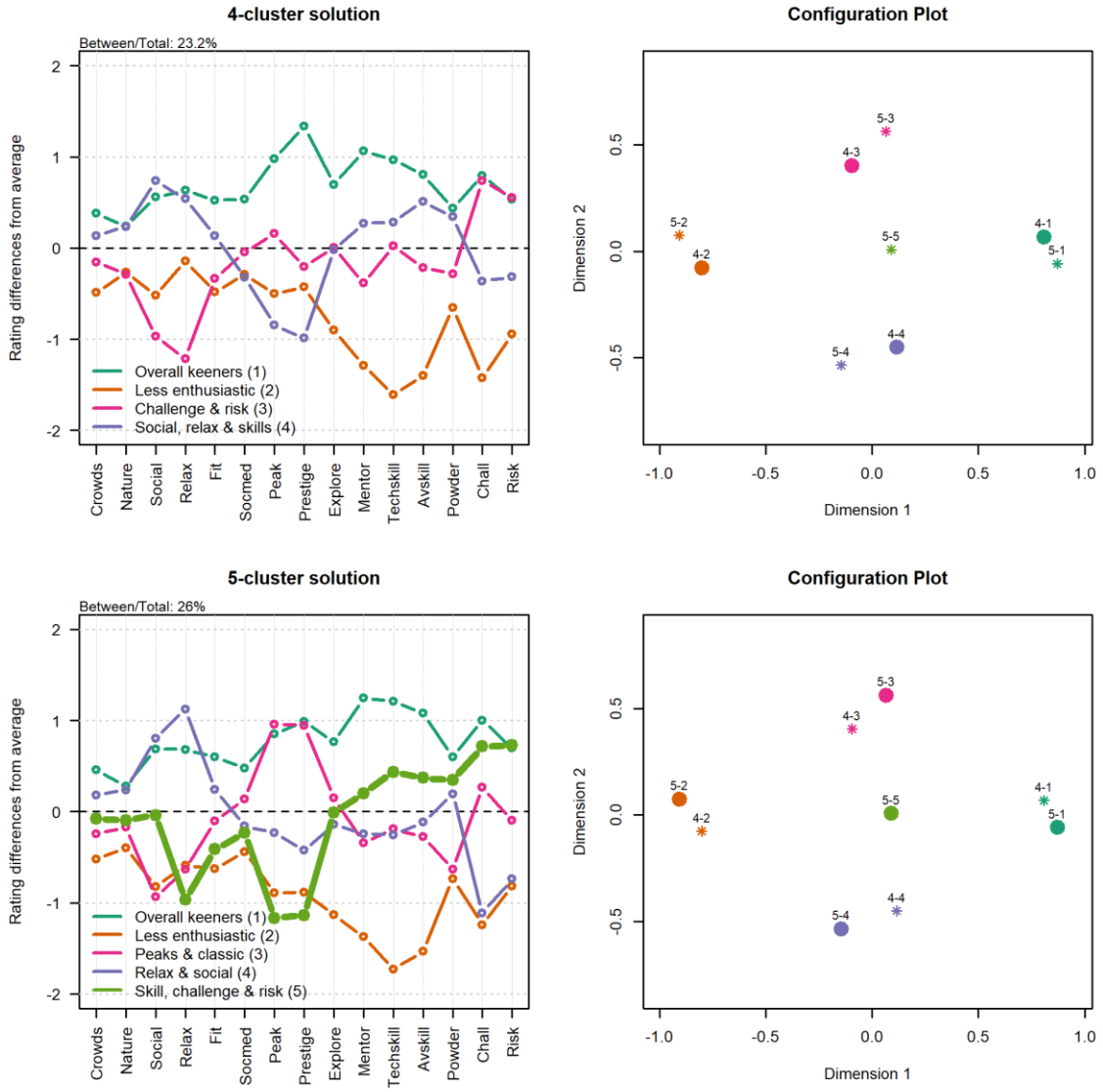


Figure B.11. Comparison of 4- and 5-cluster solutions. Left panels show differences from average ratings. Right panels show configuration plots with first two dimensions to illustrate proximities of the clusters of the two solutions.

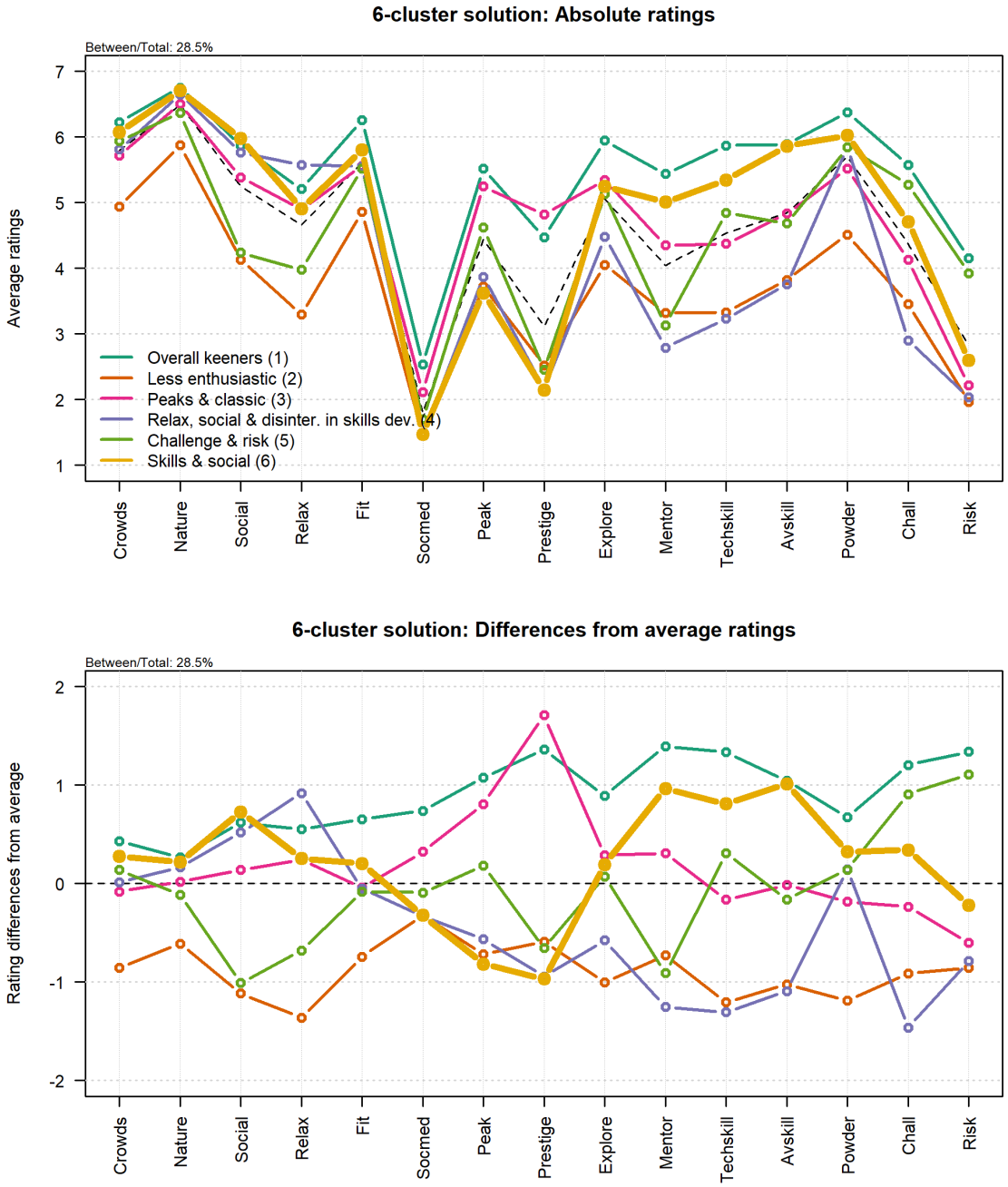


Figure B.12. Motivation ratings of 6-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings. The newly added cluster is highlighted with a thicker line.

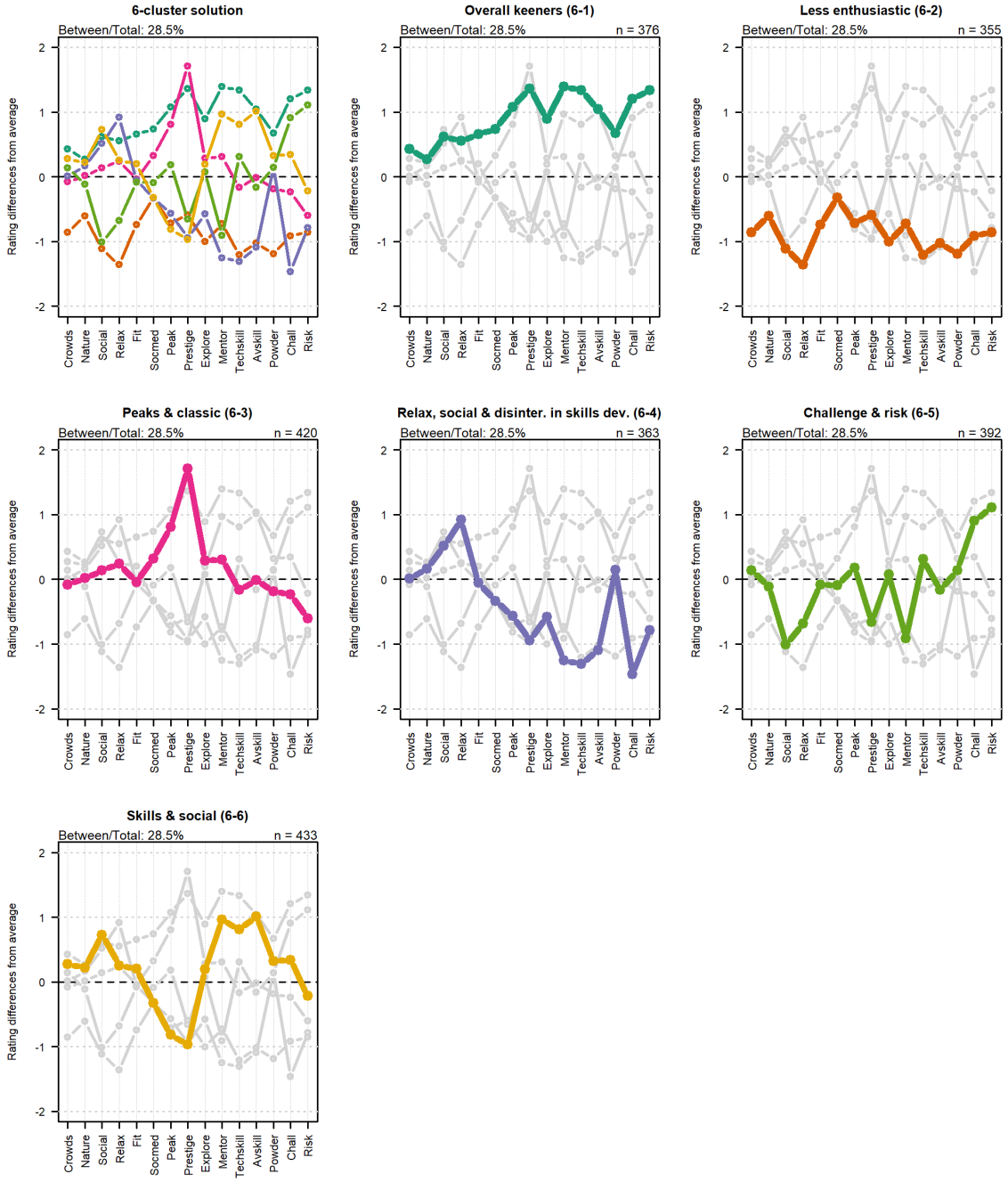


Figure B.13. Motivation ratings of 6-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.

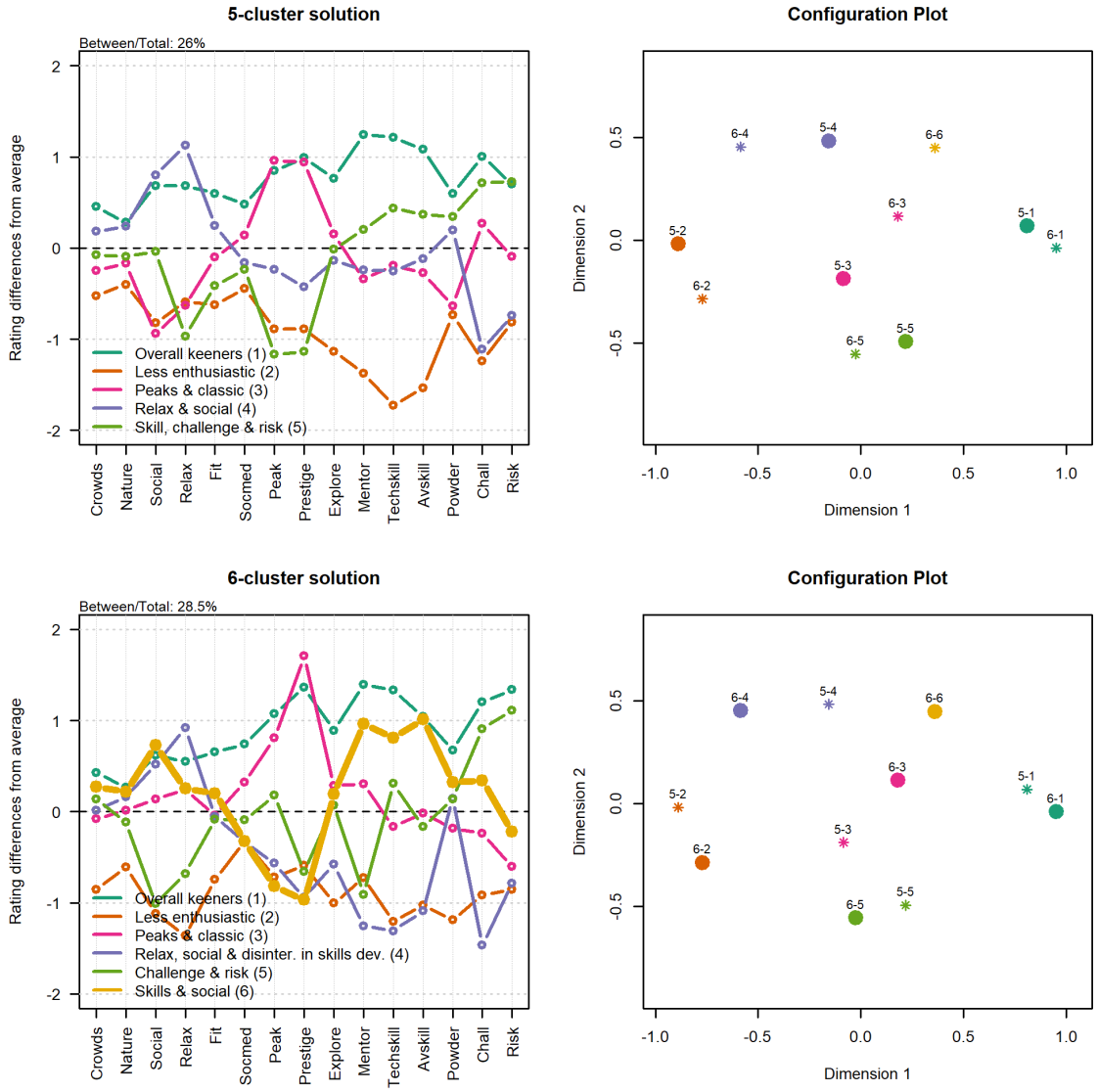


Figure B.14. Comparison of 5- and 6-cluster solutions. Left panels show differences from average ratings. Right panels show configuration plots with first two dimensions to illustrate proximities of the clusters of the two solutions.

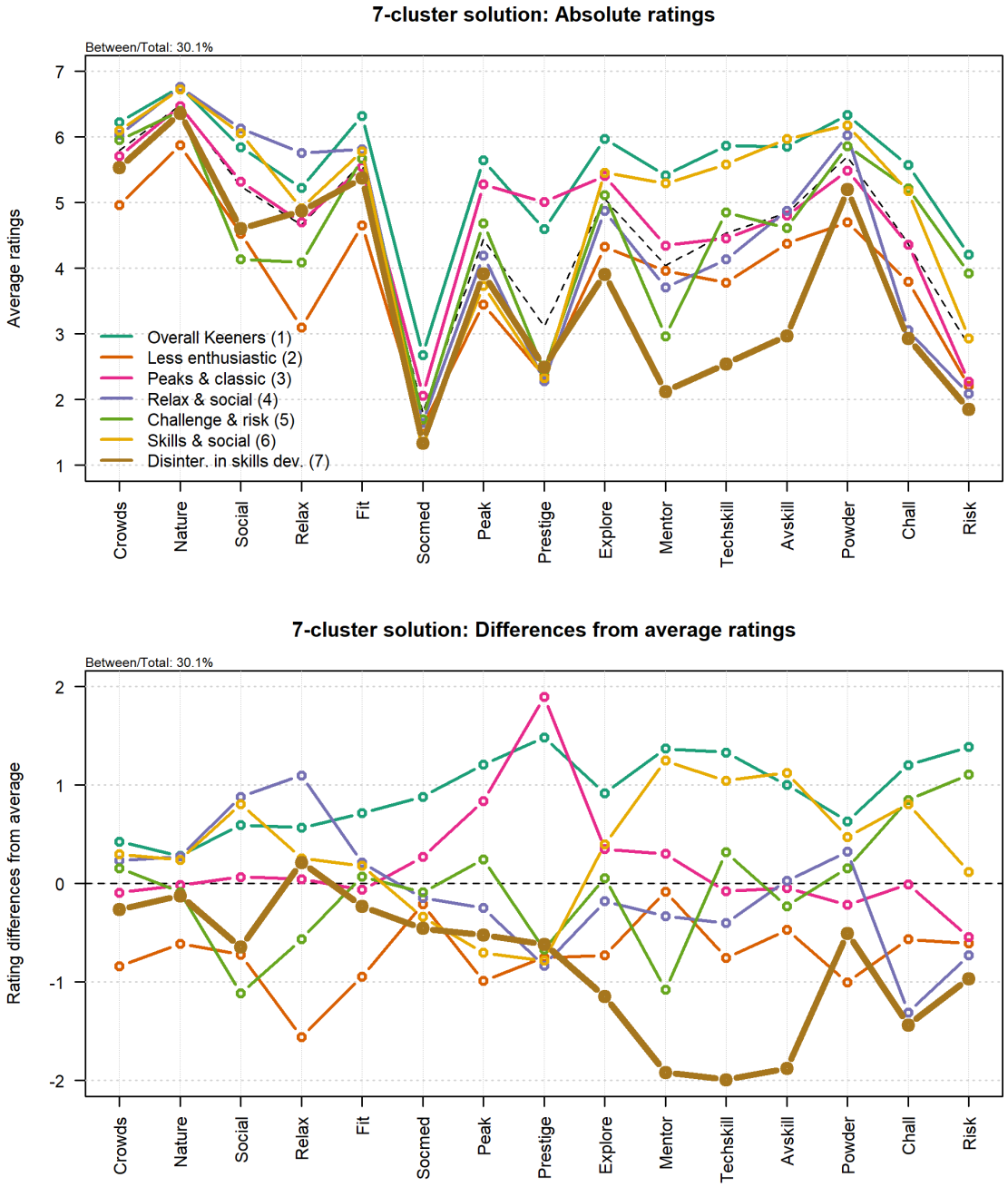


Figure B.15. Motivation ratings of 7-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings. The newly added cluster is highlighted with a thicker line.

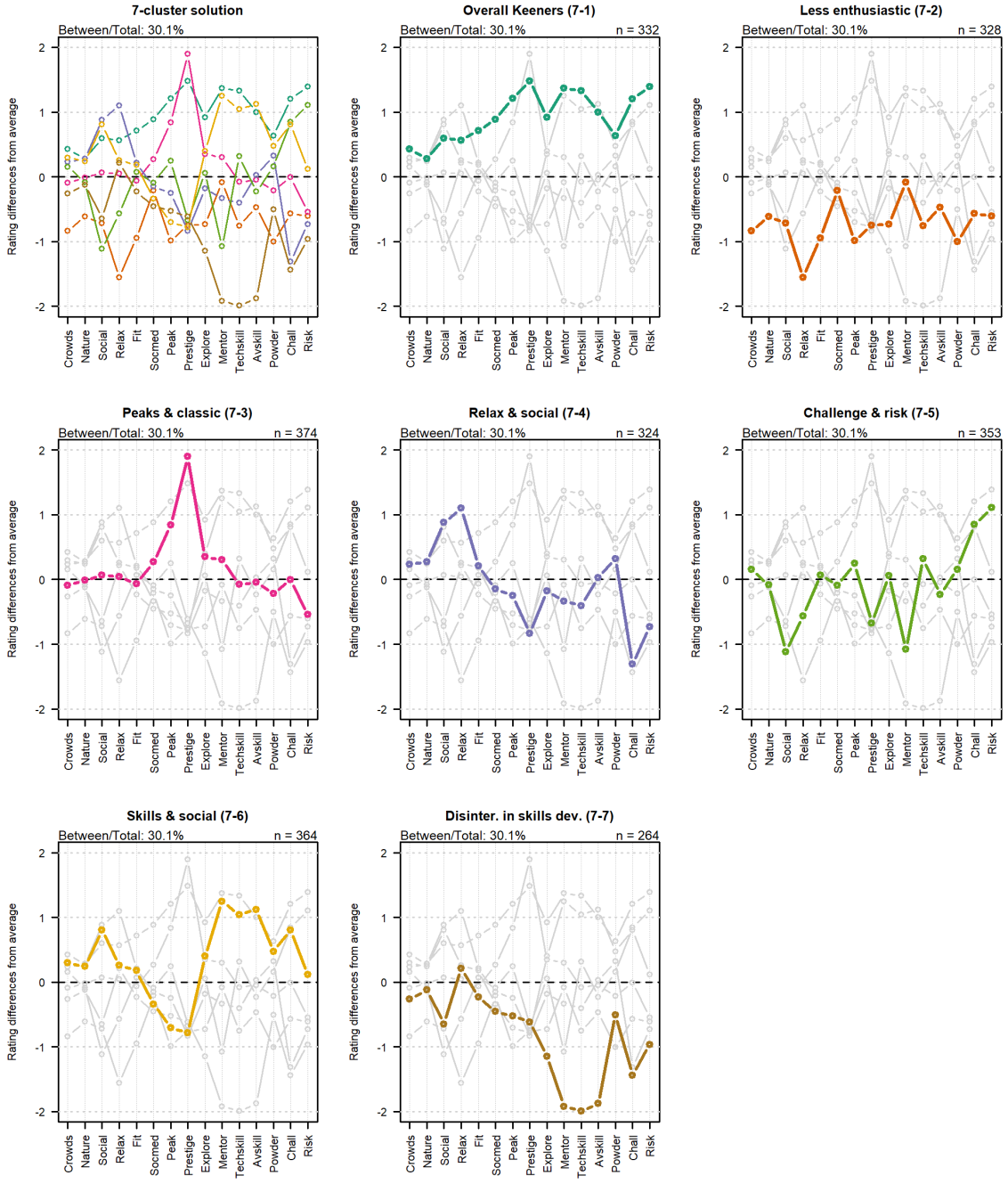


Figure B.16. Motivation ratings of 7-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.

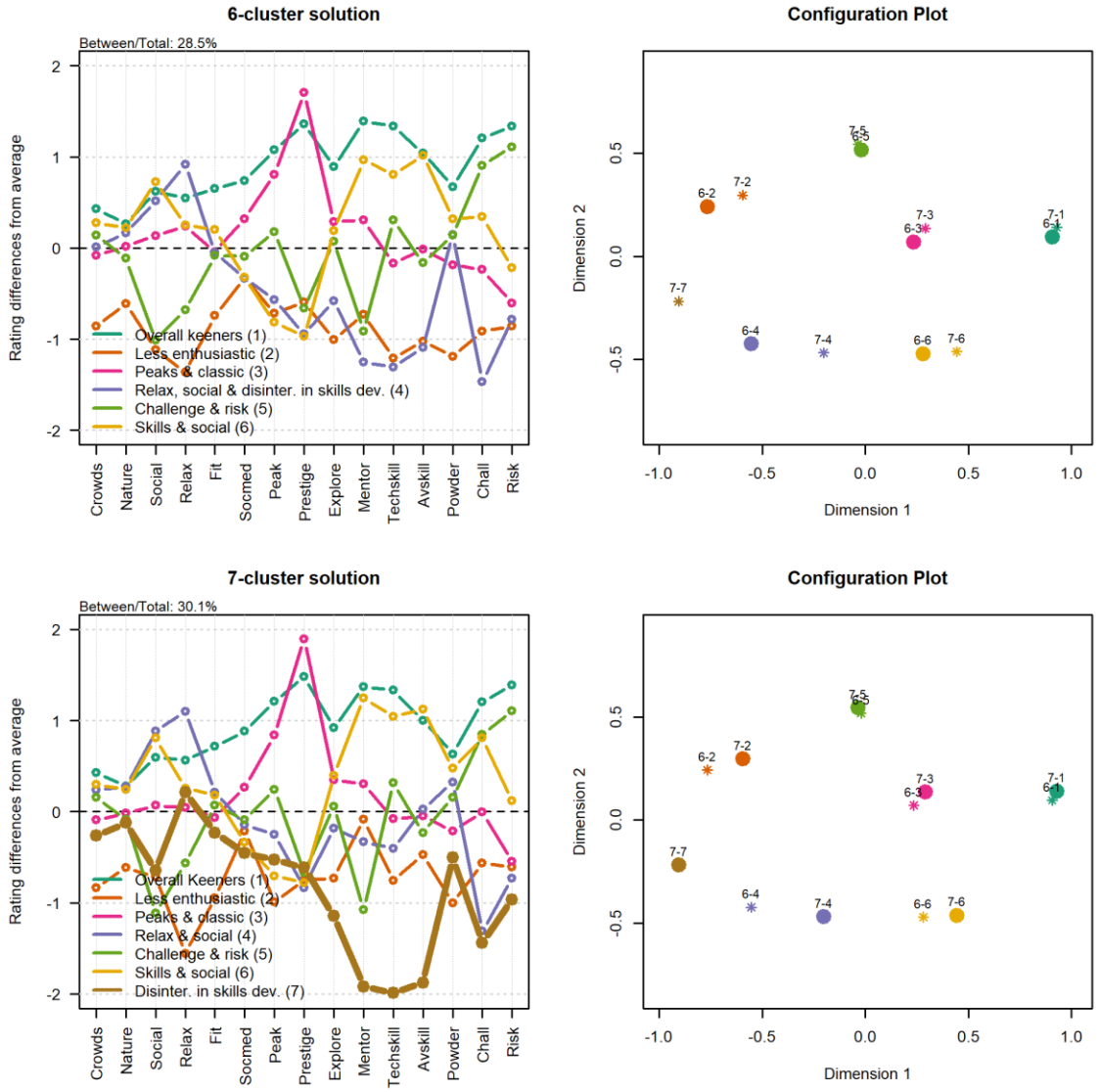


Figure B.17. Comparison of 6- and 7-cluster solutions. Left panels show differences from average ratings. Right panels show configuration plots with first two dimensions to illustrate proximities of the clusters of the two solutions.

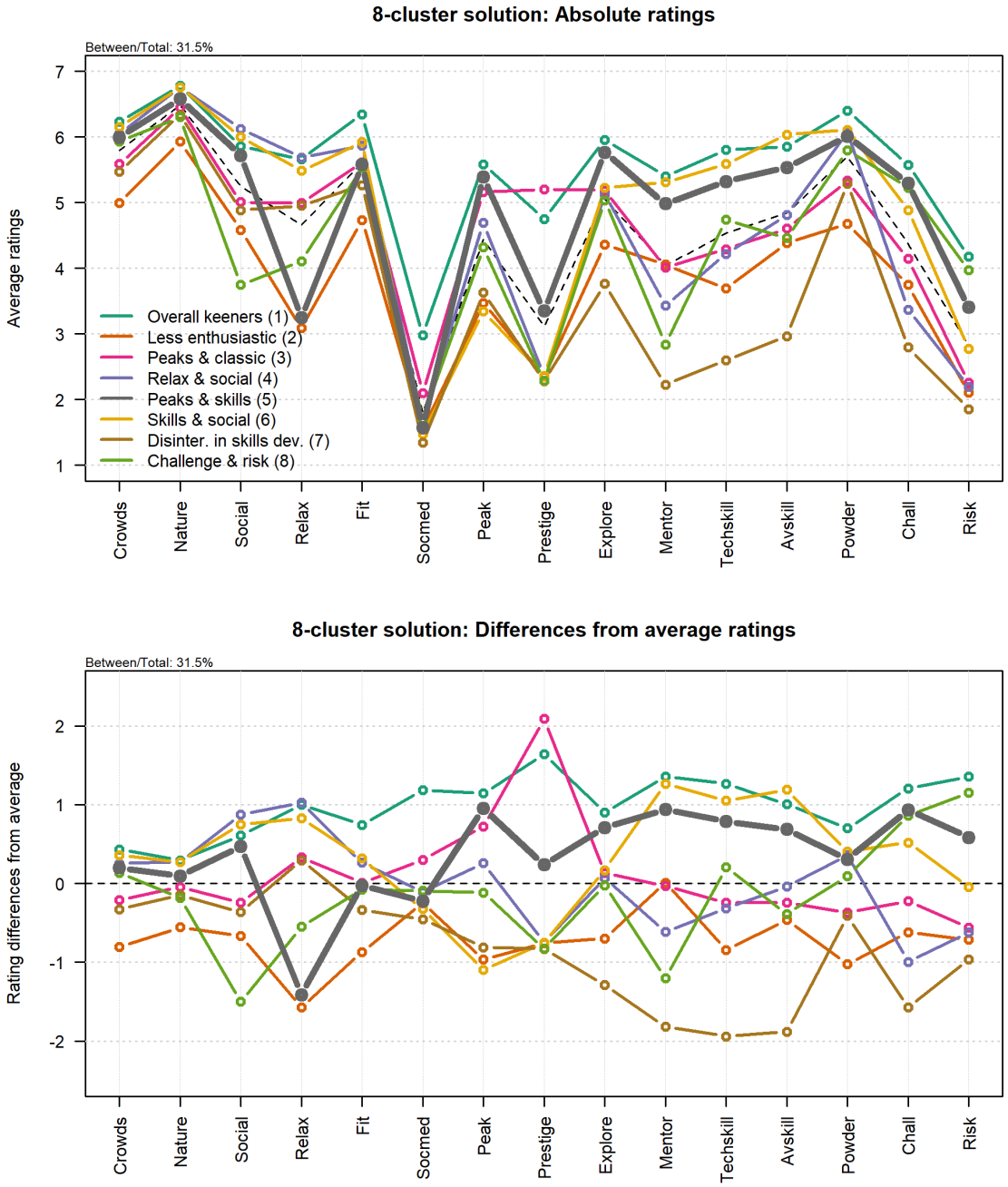


Figure B.18. Motivation ratings of 8-cluster solutions. Top panel shows absolute ratings. Dashed black line shows the average rating across the entire sample. Bottom panel shows differences from average ratings. The newly added cluster is highlighted with a thicker line.

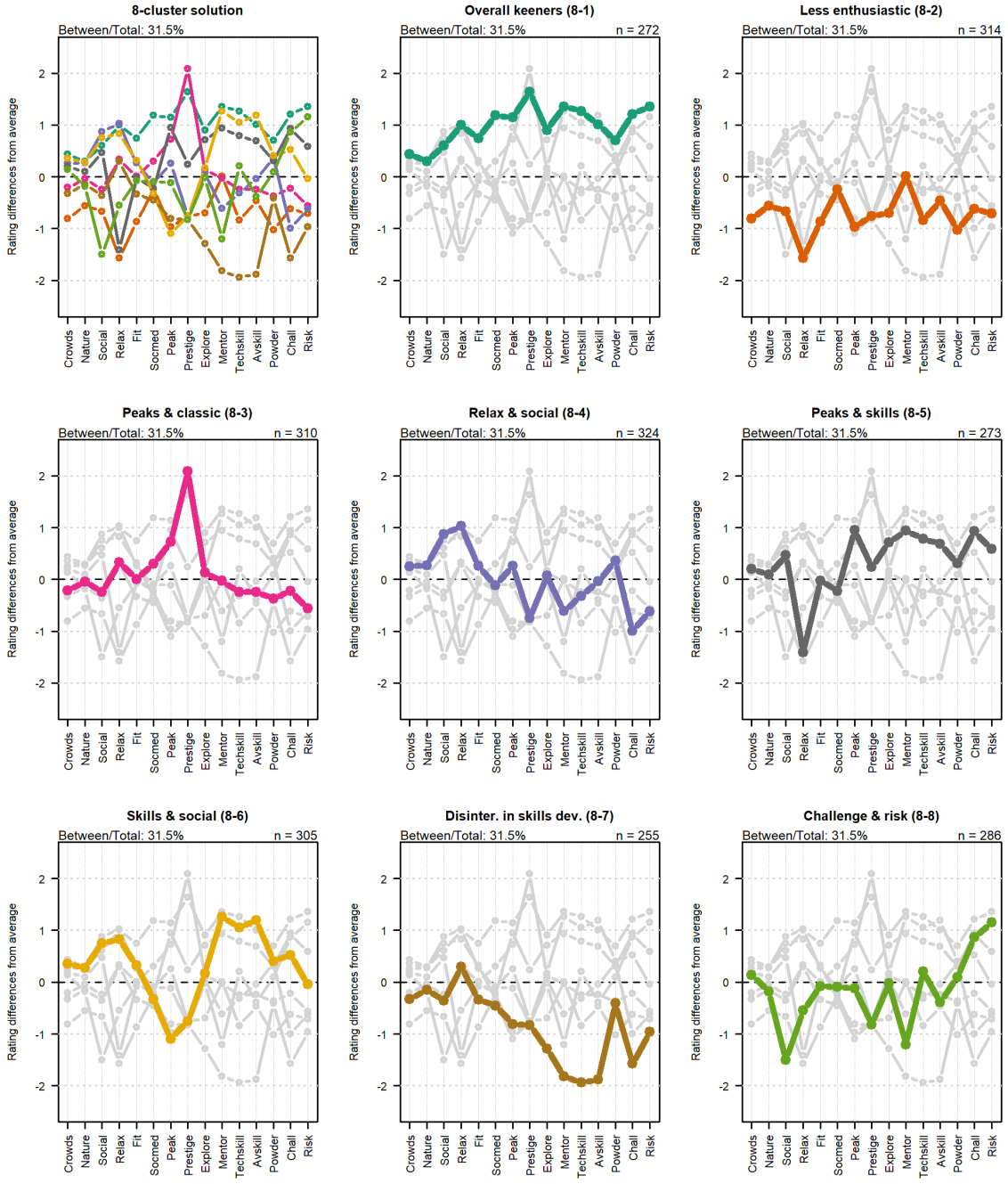


Figure B.19. Motivation ratings of 8-cluster solutions. All panels show differences from average ratings. Top left panel shows all clusters in a single chart. All other panels show the individual clusters.

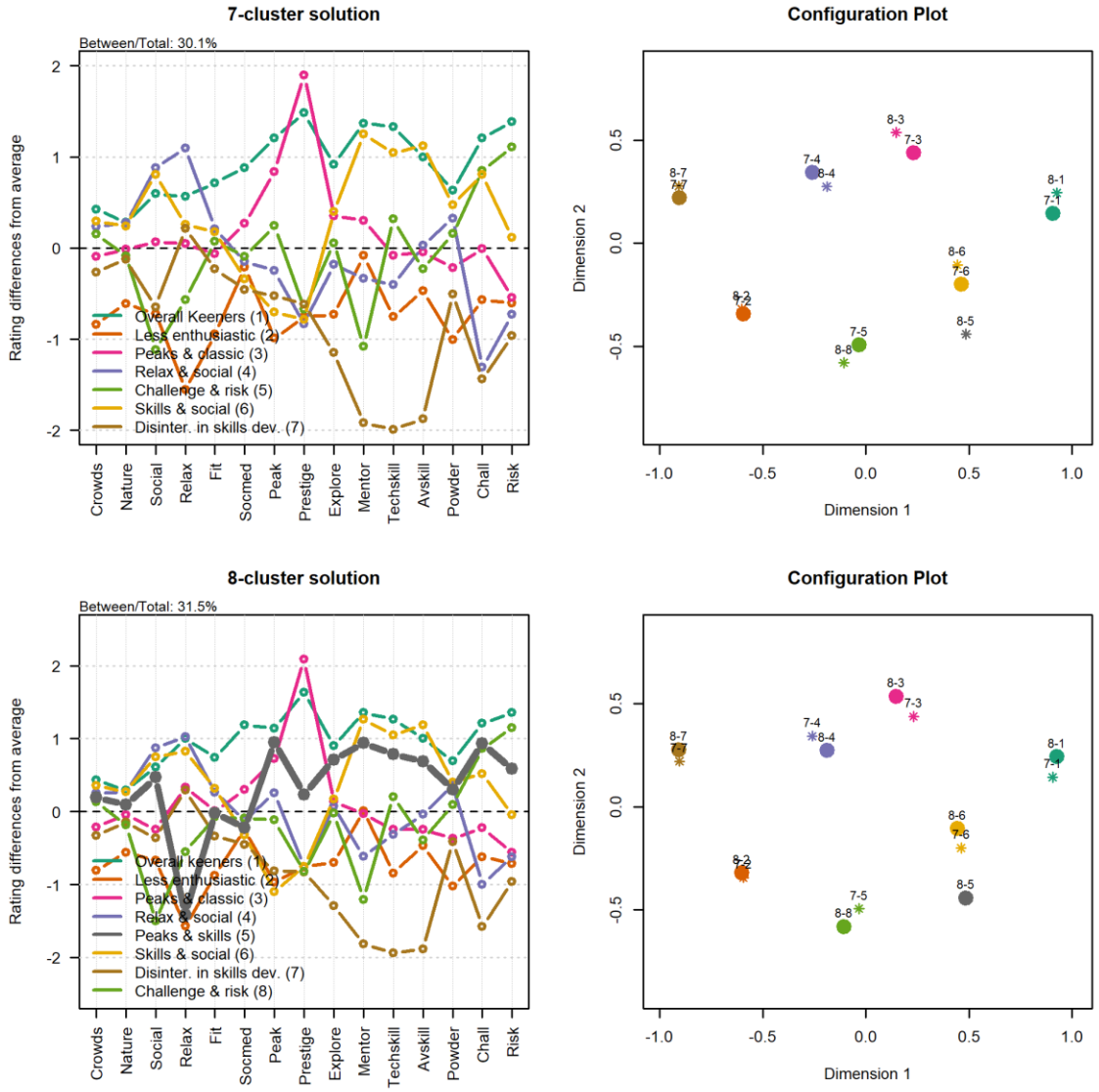


Figure B.20. Comparison of 7- and 8-cluster solutions. Left panels show differences from average ratings. Right panels show configuration plots with first two dimensions to illustrate proximities of the clusters of the two solutions.