TOWARD A CONCEPTUAL MODEL OF THE HUMAN PROBLEM IN AVALANCHE TERRAIN

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ABSTRACT: A historical lack of consensus surrounds the problem of humans in avalanche terrain. Research from a variety of fields - behavioral economics, social psychology, anthropology and public health, to name a few - offers insights into how and why professionals and recreationalists engage in practices that cause people to be involved in avalanche accidents. These ideas, however, fail to rise to the level of a cohesive and systematic framework for understanding and communicating about the *human problem*. Instead, ambiguity and varied understandings of the human problem remains. Individuals are largely left to interpret the science for themselves, hoping that this is sufficient to keep them safe. The avalanche industry has a model for understanding, communicating, and dealing with snow, weather, and terrain. We do not yet have an agreed upon conceptual model for the human problem in avalanche terrain. We argue that generating and reaching an agreed consensus is within reach. As such, we embarked on a qualitative research project focused on ascertaining common threads among professionals in the field regarding the problem of being human in and around avalanche terrain. Based on 14 expert interviews we generated a preliminary conceptual model that we would like to propose to the greater avalanche community. This paper outlines our research efforts and proposes a conceptual model we hope will be debated and discussed within the community as we work toward a consensus upon which we can build education, communication, and outreach efforts to help save lives in the future.

KEYWORDS: Human factor, conceptual model, framework, risk communication, common language

1. INTRODUCTION AND RATIONALE

To date, the field of avalanche sciences has yet to develop an agreed-upon language concerning the elements relevant to humans in avalanche terrain. Common language, we argue, underpins our ability to agree upon the problem, concentrate research appropriately, communicate the problems to the community, and deepen our capacity for addressing the problems therein. In (2000), McCammon presented the first attempt at a shared understanding through the application of heuristic traps to avalanche post-mortem analyses. Heuristics, popularized by Tversky and Kahneman (1974), are thinking short cuts by which individuals or groups can arrive at solutions or conclusions to complex problems. Much like heuristics are an avenue to process complex information quickly, conceptual models are useful in distilling the important pieces of data amidst an avalanche of information.

Since Roger Atkins in (2004) introduced a conceptual model for avalanche problems, the avalanche science community has developed a technical vocabulary to describe and communicate these issues. European avalanche warning services transitioned from communicating “danger patterns” to using “avalanche problems” in 2015 (Mair and Nairz, 2018). This vocabulary helps both experts and recreational users identify and ideally avoid avalanche problems by assessing weak layers, wind effects, and temperature impacts on snowpack. The model prompts four key questions to evaluate hazards: (1) *What* type of avalanche problem(s) is relevant? (2) *where* in the terrain are the problem(s) located? (3) *what* is the likelihood of an avalanche occurring? and (4) *what* is the potential size of the occurring avalanche(s)?.

This conceptual model has helped us address the objective and observable patterns of snow, weather, and terrain. However, the most complex, unstable and unpredictable factor of the equation remains unaddressed – the human. The role of the human has long been identified as important, and researchers have developed and offered methodological and analytical tools to grasp some of the (mal)functions of the human cognitive rationality in avalanche terrain. First and foremost, the acronym of FACETS and identification of the heuristic traps (McGammon, 2002; 2009), which has been revised throughout the years, fast-tracked us towards an understanding of human decision-making. That said, we still lack a robust, agreed-upon, inclusive framework for communicating about, addressing, and mitigating the ambiguous problem of the human in avalanche terrain.

Despite debate around the "human factor" in avalanche incidents, there seems to be a growing consensus on the need for a common language to effec-

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tively communicate risks. Recognizing the importance of understanding human behavior in avalanche safety, we initiated a qualitative research project to dial in that understanding, starting with the research question:

How should the avalanche science community conceptualize, frame, and communicate the "human factor" problem to effectively address the challenges it presents?

This project aims to provide foundational insights for a conceptual model that addresses human factors, enhancing communication and safety practices in avalanche-prone environments. The result, we hope, can be applied in fruitfulness by the greater avalanche community as an agreed upon common language.

2. METHOD

First, as a step towards our objectives, we carried out 14 semi-structured expert interviews with people from various disciplines within the avalanche and snow community. Participants included professional skiers and snowmobilers, avalanche forecasters, educators, influencers, and researchers from across the world. We inquired about their perceptions of the challenges related to humans navigating snowy mountainous areas prone to avalanches, how they would characterize or define these challenges, and if they could think of potential solutions or improvements to work against these challenges. To minimize the influence of the researchers' preconceptions on the interview data and analysis, interviews were conducted and analyzed by two research assistants. The audio files were auto transcribed (google meets), quality checked and edited by the research assistants.

2.1 Ethics

All participants were presented with an information letter describing the project and their rights and provided written consent to the study. Interviews were recorded, transcribed, anonymized and stored at a decrypted online server certified for patient data handling.

2.2 Participant recruitment and representation

Participants were strategically sampled by the researchers through their extensive personal and professional networks within the snow and avalanche community. This network includes educators, researchers, forecasters, guides, patrollers, influencers, and scientists worldwide. The participants represented key regions of winter and avalanche activity, including North America, the European Alps, and the Nordics. We reached out via email to 28 individuals, inviting them to participate in semi-structured interviews about human challenges in avalanche terrain. Out of these, 15 agreed, though scheduling conflicts reduced the final number to 14 interviews.

2.3 Analysis

Interviews were read and initially coded with the help of ChatUiT (an open-source frontend for GPT-3.5/4 by UiT The Arctic University of Norway (2023)). Researchers met face-to-face online to discuss emerging themes (see Figure 1). Analysis happened in two steps, inspired by Srivastava and Hopwood (2009). (1) Iteratively, we focused on identifying emerging patterns, commonalities and discrepancies among the responses in the first stage. We looked for recurring themes across the interviewees to pinpoint areas of consensus. Subsequently, we made a thematic map and outlined an analytical process to identify (what we think are) the foundational principles, creating a typology of the human-related problems. (2) We discussed and analyzed these themes for underlying patterns and emerging problems within the context of sense- and decision-making in wicked learning environments. This approach established the foundational framework for the relevant theories used to interpret the empirical findings. Looking through a relational ontology lens (Lange, 2018), we organized the types of problems in two overarching categories: human-human relations and human-nature relations.

3. RESULTS

We identified the following themes during the first stage of analysis. See Figure 1.

3.1 Description of themes

Underestimation of risk

In avalanche terrain, humans tend to underestimate the uncertainty of the natural environments and the unpredictability of events. Judgment, preconceived notions, biases, goals, and desires all influence our perception of risk.

Imperfect decision-making

The act of making a decision is a three-part process involving assessing relevant information, being motivated to make a decision, and applying the relevant information to the decision to be made. Decision-making can be understood as a series of processes, each lending itself to numerous pitfalls that may lead to an imperfect choice.

Unpredictability and uncertainty

There are several dynamic and shifting elements, both in the nature of the environment and in the interrelations between humans. Further, we cannot possibly know all that there is to know. We are left to

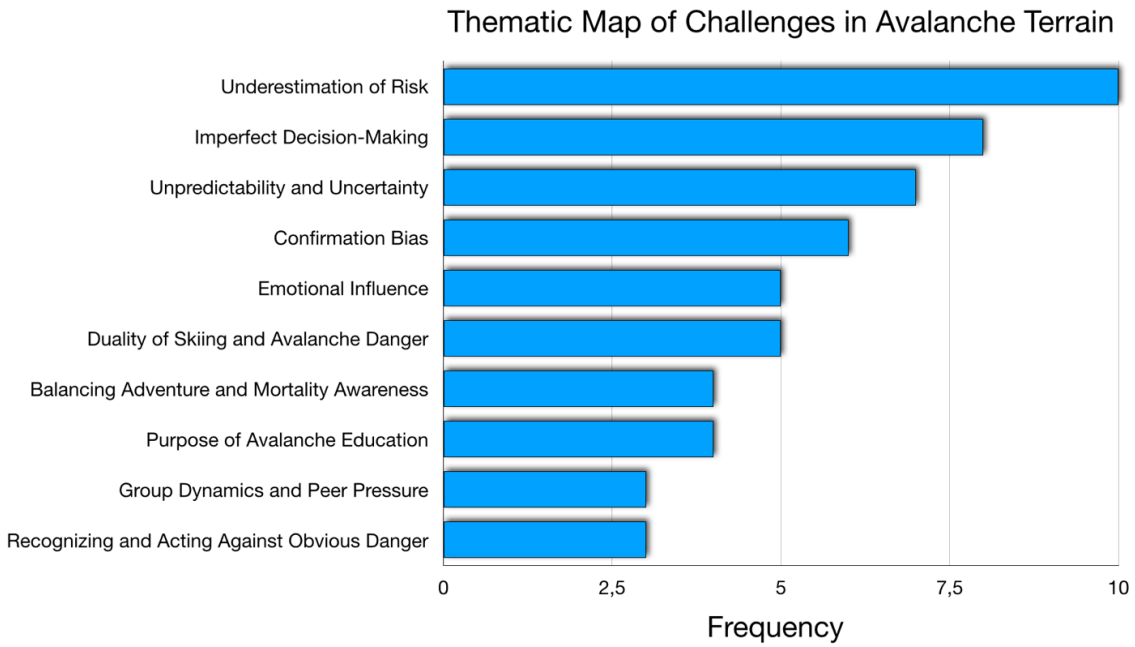

Figure 1. Map of emerging themes indicating the issues of the human problem by mention frequency by participants.

navigate a world filled with uncertainty and unpredictability.

Confirmation bias

Humans tend to gather, seek out, and attend to information that confirms their beliefs and favors what they think (and often want) to be true, whilst discrediting the information that goes against these beliefs.

Emotional influence

Humans are emotional beings; skiing is a sensuous activity, the objective of which is often rooted in a desired emotional outcome. How we think and feel about ourselves, others, and nature influences how we perceive and behave in avalanche terrain, as well as generally in life.

Duality of skiing and avalanche danger

There are “good” things and there are “bad” things related to sliding on snow. Engaging in the act of enjoying avalanche terrain requires one to maneuver this duality between the pure joy and the mortal reality backdrop.

Balancing adventure and morality awareness

To travel in avalanche terrain is to experience adventure. With it comes ethical responsibility. There, we move in terrain and make decisions that can impact more than just ourselves.

Purpose of avalanche education

Behavior is shaped through knowledge, experience, and education. Partaking in courses, one can learn navigation skills, tools, mitigation efforts toward safe travel. Avalanche education – for many the first step towards avalanche terrain – is an important arena whereas the purpose and outcome are important.

Group dynamics and peer pressure

Most people go backcountry skiing in groups with peers. We are affected and influenced by the perceptions of the people we go touring with, just as they are influenced and affected by their perceptions of us. Skiers are social beings, and the interrelation aspects of a group activity will influence our behavior.

Recognizing and acting against obvious danger

Nature reveals a lot of information and signs for humans to pick up about the dangers and uncertainties that nature can pose. The importance of recognizing the dangers one can encounter and to act against the obvious dangers are demanding but essential tasks.

3.2 *Identifying underlying patterns and outlining a conceptual model*

Our analysis, informed by our data and combined with the extensive work of many predecessors, leads us to the following preliminary findings:

There are significant human-related problems when it comes to travel in avalanche prone terrain. The problems can be divided into two main categories (see Table 1). The first is a problem between humans and nature. Specifically, humans often fail to accurately gather, perceive or interpret the signals from nature that could indicate potential avalanche-triggering conditions (i.e. perceptual- or sense-making disturbances, or lack of mechanical feedback from the snowpack).

The second issue pertains to the relational dynamics between humans and is thus a human-human problem. This can occur within a particular group, where communication breakdowns or unresolved misunderstandings happen, or between different groups,

Problems/ Relations	Human-Human (HH)	Human-Nature (HN)
Over-/Under-estimation	We overestimate our ability to manage wicked environments (Jenkins, 2012), the certainty of our predictions, and fail to adequately communicate the danger to others (Milch et.al, 2019). Biases, such optimism bias (Bass, 2020), preclude us from acknowledging that danger applies to us.	We tend to underestimate the uncertainty and unpredictability of the natural environment (Kates and Clark, 1996).
Perception	We can perceive biases in others better than in ourselves (Kahneman and Tversky, 1973).	We are rarely capable of perceiving the world as it is, but as we as observers and dwellers perceive it (Gibson, 1994).
Fallibility	The mind is an inaccurate instrument for measurement (Kahneman et.al, 2021) and yet it is the tool we filter everything through.	The mind is an inaccurate instrument for measurement and yet it is the tool we filter everything through.
Uncertainty	Doubt is not a pleasant condition, but certainty is an absurd one (Kahneman & Tversky, 1982). .	Avalanche terrain is a wicked learning environment (Hogarth, 2015; Jamieson et. al, 2015).
Motivation (drive / desire)	We have conscious and unconscious drives and desires that can impact our perception (Balcetis and Dunning, 2006), rational thought (Dunning and Balcetis, 2013) and behaviors (Döring, 2007).	Our desires and drives can impact our perception of the natural world.
Emotion	How we think and feel influences how we perceive (DeSteno et. al, 2000), behave, communicate, and influence others.	How we think and feel about nature influences our perceptions, behaviors, and thoughts (Zadra and Clore, 2011).
Peer-influence	We are affected by others' perceptions of us and others by our perceptions of them (Ferguson and Bargh, 2004).	Our perception of the omnipotent audience impacts our behaviors in the mountains.

Table 1. Identifying underlying patterns within human-human and human-nature relations. For a more comprehensive and hands-on version of the matrix, where we also suggest how one can address these underlying patterns in the backcountry see Boilen et al., (2024).

such as when a member of the public (e.g. a recreational skier) misinterprets data information presented by professionals (e.g. forecasters). Additionally, there can also be a lack of communication about concerns, recognized dangers or warning signs among group members, even when these are present and recognized by the members, due to social struggles and intersocial aspects.

The map of emerging themes is the foundation for the conceptual framework model that we suggest. Here, we work with a twofold understanding of the problems we have identified (human-nature and human-human). The twofold dimensionality of the problems is part of what makes this task complex but ultimately seems like the most comprehensive and accurate.

4. DISCUSSION AND A WAY FORWARD

Agreeing on a common technical language has many benefits but does not come without its challenges (see Table 2). On the one hand, the use of an agreed-upon language is considered essential for clear and efficient communication, consistency, and knowledge transfer within technical and scientific communities. On the other hand, it has also been argued that with thought and language we close the openness of the world (Law, 2004) and that our knowledge and perception of reality are filtered through linguistic and conceptual frameworks, which create a "closure" around phenomena, enabling us to interpret and make sense of them (Lawson, 2001). Agreeing on one single lens and one common way to understand phenomena may thus lead to inflexibility, exclusion and resistance to change. As the Challenger (1986) and Columbia (2003) shuttle tragedies effectively demonstrate, considering a common agreed on language to be definitive when in reality it is ambiguous and context-dependent may even lead to disaster (Dombrowski, 2005).

We therefore suggest that in creating a conceptual model it is important to balance standardization with flexibility to ensure that the language can evolve with new advancements and remain inclusive. While an

Benefits	Challenges
Improved communication **Clarity:** A shared technical language reduces ambiguity, making it easier for people to understand each other clearly. **Efficiency:** Streamlines communication, allowing for quicker and more precise exchanges of ideas. **Collaboration:** Facilitates collaboration among individuals and teams, particularly those from different disciplines or geographic regions.	**Inflexibility** **Rigidity:** Can lead to a rigid framework that may stifle creativity and limit the expression of new ideas. **Adaptation:** New concepts or technologies may struggle to be integrated into the established language.
Consistency **Standardization:** Promotes consistency in documentation, instructions, and reports, making them easier to follow and maintain. **Quality control:** Ensures that everyone adheres to the same standards, improving the quality and reliability of work.	**Complexity** **Learning curve:** Can be difficult for newcomers to learn, creating a barrier to entry for those new to the field. **Over-specialization:** May become overly complex and specialized, making it harder for non-experts to understand.
Knowledge transfer **Training and education:** Simplifies the training process as everyone is taught the same terminology and concepts. **Documentation:** Makes it easier to create and use documentation, manuals, and guides that are universally understood.	**Exclusion** **Barrier to entry:** May exclude those who are not familiar with the technical language, such as newcomers, professionals from other fields, or the general public. **Communication gap:** Can create a communication gap between experts and non-experts, leading to misunderstandings and misinterpretations.
Innovation and research **Cross-disciplinary work:** Encourages interdisciplinary research and innovation by providing a common language for scientists and engineers from different fields. **Accessibility:** Makes it easier to access and understand research findings, fostering further advancements.	**Evolution** **Resistance to change:** Established terminologies can be resistant to change, even when new and better concepts are developed. **Lagging behind:** The technical language might not keep pace with rapid advancements in technology and research, becoming outdated.

Table 2. Summarizing benefits and challenges of creating a common language and agreed upon conceptual model.

agreed-upon technical language can offer benefits, its implementation and use must be carefully considered to avoid potential pitfalls. Efforts should be made to bridge the communication gap between experts and non-experts to ensure broader understanding and collaboration.

Acknowledging the intricate nature of the issue, we propose that our conceptual framework parallels our established understanding of snow, weather, and terrain-related issues.

The next step is for interested parties and stakeholders to come to the table with concerns, adjustments, and considerations so that we might, at some point in the not-so-distant future come to a place where we can stop arguing about whether or not there is a human problem or what these human problems are, and start researching them, educating our community about them, and developing strategies to mitigate them as best we can.

5. CONCLUSION

We propose this conceptual model as an initial move towards developing a standardized language for discussing challenges related to humans traveling in and around avalanche-prone terrain. It is vital for our field to adopt a shared understanding, a common vocabulary, and a structured approach to enhance decision-making and improve safety in mountainous environments. The challenge is to do so in a thoughtful, scientifically rigorous, and unified way so we can minimize the drawbacks and boost the benefits of agreeing on a common language.

We offer this conceptual framework as an imperfect, but empirically grounded starting point and model through which we can, hopefully, reduce human-involved avalanches through targeted research, a common language, and directed educational aims.

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