ON THE INTERFACE OF THE SNOW AND HUMAN SCIENCES

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"Oddities explain it – oddities of terrain and oddities of psychology, although oddities of psychology aren't usually as odd as they first seem. What is really odd is how the terrain and the psychology came together in odd ways."

- Norman Maclean*, Young Men and Fire*

INTRODUCTION

Why would a cognitive and behavioral scientist be interested in avalanches? At the professional level, the answer is straightforward. As Dale Atkins (2000) inferred: "The literature and basic research shows avalanche accidents are not a terrain, weather, or snowpack problem; avalanche accidents are a human problem;" or, as David McClung (2002) argued: "Since most avalanche accidents result from human errors, no description of avalanche forecasting is complete unless the human component is addressed." I've spend much of my own research career studying "human problems" pertaining to attention and perception. As many have realized, the cognitive and behavioral sciences have the potential to help us understand some human decision making patterns that contribute to avalanche accidents, like these academic disciplines have with human problems and errors – or "human factors" – in medicine, aviation, finance, and other areas.

Over the last few decades snow scientists and avalanche forecasters have begun to turn to literature and theory in psychology and related academic disciplines for ideas to better explain avalanche accidents (e.g., Atkins, 2000; Fredston, Fesler, & Tremper, 1994; McCammon, 2002; McClung, 2002). But true interdisciplinary projects ought to have researchers crossing disciplinary boundaries from all directions; just as snow scientists have turned to the human sciences for answers, scientists who specialize in studying mental and behavioral phenomena should also contribute to this discourse. I hope this project serves that aim, even if only as a first step. The appeal of decision science approaches has surged in several academic disciplines recently, as has the popularity of winter recreation in avalanche terrain. It seems past due that cognitive and behavioral scientists moved to thinking about, and perhaps conducting future research projects on, human-avalanche interactions.

My motivation for conducting this project was, of course, also personal. I live in Salt Lake City, Utah, and spend much time during the winter and spring months skiing and mountaineering in avalanche terrain. Some of the questions I want to ask stem from recollection and reflection on my own training, which has, for the past twenty years, consisted of taking avalanche and glacier travel courses, reading many books on the topic, as well as attaining knowledge informally, through experience and through conversations with experienced backcountry partners. I remember much of that training has been focused on physical factors such as snow crystal bonding, snowpack morphology, terrain, and weather, as well as rescue techniques. Relatively little of my training – at least formally – has been directed toward improving decision making in avalanche terrain. The first part of this project examines this potential bias in avalanche education through a textual analysis of popular avalanche books, and discusses potential implications of this pattern.

I've also had several friends and acquaintances, and friends of friends and acquaintances, involved in avalanche accidents. A surprising number of those affected were experts, or at least were travelling with experts at the time of the accident. Others have observed similar phenomena. This project also address the cognitive science of expertise, examining how thought and behavioral patterns change as novices and intermediates gain experience and begin to think and behave like experts. While there is a well-developed literature in cognitive science on expertise, relatively little of it has been specifically applied, at least by cognitive scientists themselves, to decision making in avalanche terrain.

Finally, I wish to conclude this presentation by looking toward what can be done. Work by cognitive scientists, including, for example, the much-cited decision making biases and heuristics famously described by Kahneman and Tvsersky (1979; see also McCammon, 2002; Tversky & Kahneman, 1975) are descriptive of how humans, on average, typically make decisions. They often offer little instruction, other than through the mathematical optimums used in comparison to actual, observed behavior, about how humans *ought* to make decisions. This point brings me back to a conversation I

had with a respected avalanche forecaster, educator, and author several years ago who said (and I paraphrase here, from memory): "We can provide people with the best information available. But we can't make them use it." And observations, in fact, show that humans will *not* optimally use information that is gathered from, say, online advisories or snowpits. As McCammon (2009) has pointed out, our increase in knowledge about human errors in avalanche terrain has not been paralleled by comparable knowledge increase of how to avoid such errors. In our conclusion we briefly explore ways in to possibly alleviate this human problem through education. What are the best practices educate backcountry travelers – travelers we know are likely flawed in decision making behavior – to make better judgments and decisions?

ANALYSIS OF AVALANCHE TEXTS

Text Selection and Method

The hypothesis that avalanche education was biased toward snow science over human and decision science came from my personal experiences. To ground that theory, we decided to analyze the content of popular avalanche textbooks.[1] Twelve books were selected to be analyzed as a representative sample of the snow safety education resources currently being used by the general public. A number of factors were considered in choosing the books including Amazon's "Best Sellers Rank," which serves as an indicator of how well an item currently selling. The ratings and number of reviews written about the books on popular websites such as Goodreads and Amazon were also taken into account to ensure the most widely used books were selected. While the selection of texts was informal and used mixed methods, the list of texts was selected before content was analyzed, and we feel our sample constitutes a representative sample of the relevant and popular literature. The selection criteria centered on the *popularity* of the books, as opposed to their quality or other characteristics, as we wanted our results to be reflective of what typical backcountry recreational travelers are reading. The list of textbooks used can be found Table 1, below.

After identifying the books to be analyzed, we examined their content, quantifying the number of pages devoted toward snow or physical sciences versus those devoted toward psychological, behavioral, or decision (i.e., "human") sciences. The former "snow science" category included content devoted toward crystal bonding, snowpack formation and morphology, terrain and weather, and avalanche formation and mechanics, while the latter "human" category included pages that discussed human factors, hazard evaluation, decision making, and related topics. Early in our analysis, it became clear that the two categories we conceptualized were not mutually exclusive. As Maclean notes, albeit in a book about fire not snow, "the terrain and the psychology came together in odd ways." This interaction is important, and will be revisited. Based on this intersection, we created a "mixed" category to assign sections in which the physical and human sciences could not be clearly delineated. This category typically included content describing route finding and rescue techniques.

Results of this blunt methodology indicate that, at least as measured by the content of popular avalanche books, avalanche education is strongly weighted toward explaining the snow sciences, as opposed to the human ones (see Figure 1). While our method was primitive, minor alterations to our textbook selection or categorization scheme would, of course, alter the data slightly, but the overall pattern is clear and would, we think, remain largely unchanged: almost 90% of content in these texts is devoted to snow science, despite avalanche accidents being increasingly described as a "human problem," and despite increased calls for the human component of accidents to be addressed.

Discussion of Results

This pattern of education has consequences for actual human behavior in avalanche terrain. As backcountry travelers gain more experience, they likely seek more education through both coursework and through reading. These data suggest that, at least from popular reading material, knowledge, and expertise of snow properties will likely be acquired faster than

[1] An obvious future step will be to analyze the content of avalanche courses, which may show a similar bias; however, given that this initial project was conducted during the late spring and summer months in North America, courses were not available to be observed.

knowledge of decision making.[2] This pattern could lead to a situation in which experts in analyzing snow pit data remain at an intermediate (or even novice) level of decision making based on the information gathered from observations of snowpack and snowpits (or, for that matter, of weather and snowfall information in avalanche forecasts). This problem is likely compounded by the realities of the state of the sport of present-day backcountry recreation, where advances in equipment, popularity, and fitness and training, as well as the effects of new media, has lead to both a faster learning curve toward expertise, as well as increased risk taking behavior (see Figure 2).

It is likely the case that the modern backcountry traveler's self-assessed competence, and their related risk-taking behavior, is more closely linked to their snow science knowledge; that is, the number of avalanche courses taken and avalanche books read, than it is their decision making competence (see also, Ebert, 2015). Yet the risk of being involved in an avalanche accident may be better predicted by the difference between decision making expertise and risk-taking behavior than it is by the difference between snow science expertise and risk taking behavior. We should not only ask why recreationalists travelled to a slope with limited snowpack knowledge, but also why they did so with limited decision making knowledge.

CONCLUSIONS AND RECOMMENDATIONS

The hypothetical knowledge growth curves depicted in Figure 2 are obviously only theoretical. Knowledge growth is unlikely to be a linear function; in fact, it is likely asymptotic, with more knowledge gained during the earlier stages of learning (see, for example, Mayer [2011] for discussion of Ebbinghaus's famous "learning curve" from early cognitive science research). Moreover, quantifying knowledge level is a notoriously difficult task and studying human errors in the field is both empirically and ethically problematic when "the field" encompasses avalanche terrain. However, the overall trend described here fits a well-known pattern in which the growth of confidence outpaces the growth of competence. This particularly explains the confidence-competence distinction in light of the hindsight and confirmation biases (e.g., Blank & Nestler, 2007) in which perceptions of risk are constructed *post hoc* (McCammon, 2009; see also, Dekker, 2006), after many incident-free excursions into the backcountry and after the recreational traveler in avalanche terrain has read several (or many) books and taken courses.

Moreover, human judgment and decision making in avalanche terrain must be considered in light of the limitations of transferring skill and expertise across domains. For example, although working with simple cognitive tasks known as the digit- and letter-span, Chase and Ericsson (1982), concluded that a participant's expertise in remembering strings of numerical digits did not transfer to corresponding expertise in remembering strings of letters. Although we should be rightfully cautious in extending the results from behavior in psychology laboratories to behavior on mountain slopes, the evidence from cognitive science for the narrow transfer of skill ought to be read to suggest that expertise in evaluating snowpack stability cannot be safely extended to equal to expertise in making decisions. Although the trajectory (and shape) of the lines in Figure 2 are only hypothetical, the fact that their slopes diverge, and likely diverge greatly, seems strongly supported by evidence from cognitive science. Experts in snow science are not necessarily experts in decision making, and based on our preliminary data, more attention in avalanche books, if not also in avalanche courses[3], should be devoted to education and training in decision making. Finally, this project was not intended to be, nor should it be interpreted as, a disparaging critique of the existing avalanche literature. The knowledge conveyed in these works is, of course, highly useful in keeping travelers safe in avalanche terrain. It should, rather, be interpreted as call for both avalanche

[2] The assumption that a page of snow science leads to the same amount of knowledge growth as a page of decision science, is of course an oversimplification. It may very well be the case that learning how to make decisions requires more training than learning how to analyze snow pit or avalanche forecast data, as emotions and many other "human factors" must be overcome.

[3] Although it has been too long since I have personally taken or observed a formal avalanche course, informed students, friends, and partners have informed me that more time is being devoted to human factors and decision making skills in such courses.

professionals and cognitive and behavioral scientists to focus more attention, and more research, on human factors and decision making processes in avalanche terrain. While the trend has seen an increase in such work in recent decades, our project shows we still have a long way to go.

CONFLICT OF INTEREST

The creation of this document was not supported financially or materially by the ISSW. None of the authors benefit financially from the production or sale of ISSW proceedings nor have they received any related grants or patents.

ACKNOWLEDGEMENTS

This project was graciously supported by the Institute for Mountain Research at Westminster College (http://westminstercollege.edu/imr/) in Salt Lake City, UT.

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McClung, D. M., 2002: The elements of applied avalanche forecasting, Part I: The human issues. *Natural Hazards*, *26*(2), 111-129.

McClung, D., & Schaerer, P. A., 2006: *The avalanche handbook*. Mountaineers Books.

Moynier, J., 2006: *Avalanche aware: The essential guide to avalanche safety*. Morris.

O'Bannon, A., & Clelland, M., 2012: *Allen & Mike's Avalanche Book: A Guide to Staying Safe in Avalanche Terrain*. Globe Pequot.

Tremper, B., 2011: *Staying alive in avalanche terrain*. Mountaineers Books.

Tremper, B., 2013: *Avalanche essentials: A step-by-step system for safety and survival*. Mountaineers Books.

Tremper, B., 2014: Avalanche pocket guide: A field reference. Mountaineers Books.

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Volken, M., Schell, S., & Wheeler, M., 2007: *Backcountry skiing: Skills for ski touring and ski mountaineering*. The Mountaineers Books.

Table 1. Avalanche books used in our sample.

Book Title	Author	Year of Publication
Staying Alive in Avalanche Terrain	B. Tremper	2008
Backcountry Skiing: Skills for Ski Touring and Ski Mountaineering[ŦŦ]	M. Volken, S. Schell, & M. Wheeler	2007
Snow Sense: A Guide to Evaluating Snow Avalanche Hazard	J. Fredston & D. Fesler	2011
Allen & Mike's Avalanche Book: A Guide To Staying Safe In Avalanche Terrain	M. Clelland & A. O'Bannon	2012
Avalanche Essentials: A Step by Step System For Safety and Survival	B. Tremper	2013
Avalanche Pocket Guide: A Field Reference	B. Tremper	2014
The Avalanche Handbook	D. McClung & P. Schaerer	2006
ABCs of Avalanche Safety	S. Ferguson & E. LaChapelle	2003
Avalanche Aware: The Essential Guide To Avalanche Safety	J. Moynier	2006
Backcountry Avalanche Awareness	B. Jamieson	2001
Backcountry Avalanche Safety: Skiers, Climbers, Boarders, Snowshoers	T. Daffern	2009
Avalanche Safety for Skiers & Climbers	T. Daffern	1999

[ŦŦ]Only 65 (of 339) pages deal with avalanches. As such, only these pages are included in the analyses.

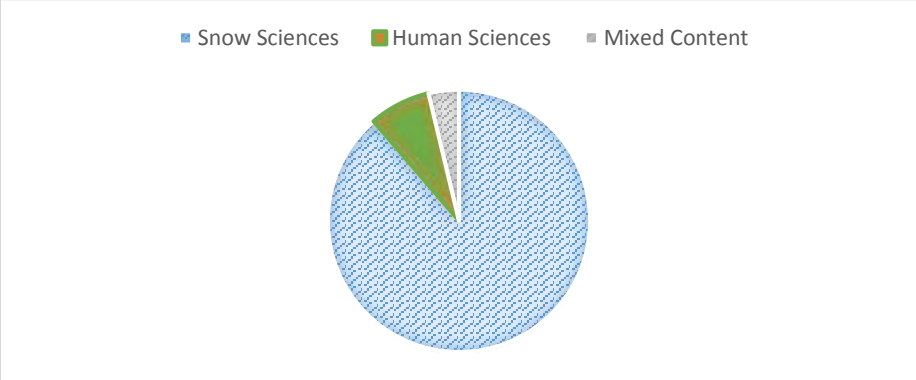

Figure 1. Percentage of pages of popular avalanche texts devoted to snow sciences (88.7%), human sciences (7.6%), and mixed content (3.7%).

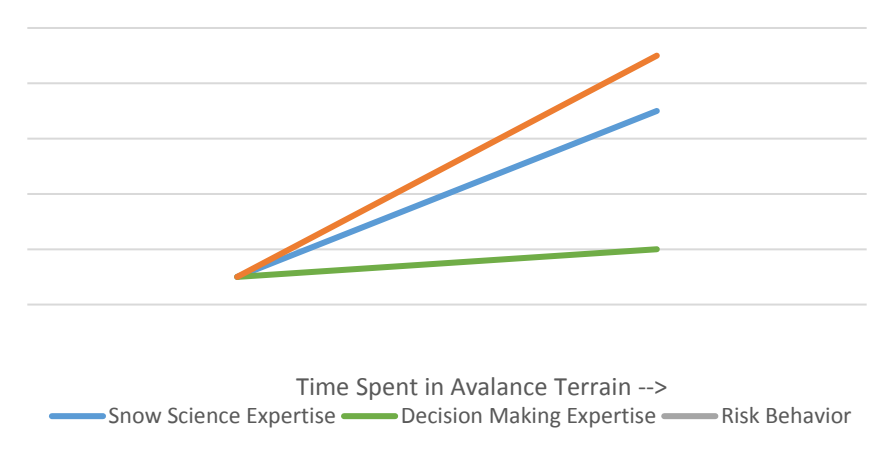

Figure 2. Hypothetical development in snow science, decision making skill, and risk behavior.