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Evidence of heuristic traps in recreational avalanche accidents

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Abstract: Even though people are capable of making decisions in a thorough and methodical way, it appears that most of the time they don't. A growing body of research suggests that people unconsciously use simple rules of thumb, or heuristics, to navigate the routine complexities of modern life. In this paper, I examine evidence that four of these heuristics – familiarity, social proof, commitment and scarcity – have influenced the decisions of avalanche victims. Using a quantitative method to define the level of hazard exposure in 598 avalanche accidents in the United States, I compare the behavior of the victims when heuristic cues were present to their behavior when these cues were absent. Key findings of this study include: 1) evidence that social proof, commitment, and scarcity traps were significant in many accidents, 2) evidence that group size influenced susceptibility to certain heuristic traps, and 3) evidence that the level of avalanche training in victims influenced their susceptibility to heuristic traps. These findings strongly support the idea that tools for managing heuristic traps are essential for effective avalanche education.

Keywords: avalanche accidents, avalanche education, decision making, heuristics, human factors

1. Introduction

When most of us think of decision making, we imagine a process where we review relevant information, weigh alternatives, then decide. There's no doubt that we are capable of making *some* decisions this way, but the method requires time and mental energy – resources that are in short supply in a busy and complex world. In a typical day we make hundreds of decisions, both large and small, and we must make them efficiently.

To balance our constant need to make good decisions against our need to make them quickly, we often use simple rules of thumb, or heuristics. Heuristics give quick results because they rely on only one or two key pieces of evidence, and though they are not always right they work often enough to guide us through routine but complex tasks such as driving or shopping (Gigerenzer et al, 1999). Because we use them so often, heuristics tend to operate at the threshold of our consciousness, a fact that has been relentlessly exploited by countless advertising and marketing campaigns (see, for example, Cialdini, 2001).

In order for heuristic decision making to work in high-risk situations, the cues we rely on must be relevant to the actual hazard. If, out of unconscious habit, we choose the wrong cues our decisions can be catastrophically wrong. This mismatch, where we base decisions on familiar but inappropriate cues, is known as a heuristic trap.

Heuristic traps have long been implicated in avalanche accidents. Among others, Smutek (1980) and Fredston and Fesler (1994) have noted the presence of heuristic mismatches in avalanche accidents involving victims with and without avalanche training. In a review of 41 avalanche accidents involving avalanche-aware victims, Atkins (2001) found that 34 accidents (83%) were due to decision-making errors rather than subtleties of the terrain or snowpack. These and other results have fostered a growing emphasis on decision-making skills and human factors in avalanche education (see, for example, Tremper, 2001).

In this paper, I present evidence that four heuristic traps – familiarity, social proof, commitment and scarcity – have played key roles in recreational avalanche accidents. For each trap, I examine its statistical significance, the influences of group size and level of avalanche training, and how reliable or unreliable the underlying heuristic might be for making decisions in avalanche terrain. Data for this study came from accident records maintained by the Colorado Avalanche Information Center, published accounts in the *Snowy Torrents* (Williams and Armstrong, 1984; Logan and Atkins, 1996), and various internet and newspaper resources. Over the course of the study, I reviewed 622 recreational avalanche incidents involving 1180 individuals in the United States between 1972 and 2001.

2. Methods: Quantifying decision making in avalanche terrain

In order to examine the effects of heuristic traps in avalanche accidents, I used a simple quantitative approach described in an earlier study (McCammon, 2001). Each accident was assigned a *hazard score* equal to the sum of the number of hazard indicators present at the time of the accident (Table A1). In effect, the hazard score approximated the level of avalanche risk that the victims had exposed themselves to at the time of the accident. To minimize reporting

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biases, I chose indicators that would have been apparent at the time to any observant individual with avalanche awareness. In some cases, hazard indicators were reported by the rescue party or accident investigators rather than the victims themselves, further reducing (though not entirely eliminating) reporting biases. To minimize documentation biases and to remove any organizational influences, I considered only recreational accidents. Accidents that occurred during commercially guided trips, club outings, in work settings or on highways were not included in the study. I also omitted incidents where none of the hazard indicators were known (24 cases). There were no accidents where all of the hazard indicators were known to be absent (hazard score = 0).

Figure 1 shows the base rates of hazard scores for the accidents in this study. Consistent with the observations of many avalanche investigators, most accidents happened when there were several obvious clues to the hazard (median hazard score = 3). Because hazard indicators are probably under-reported, actual hazard scores in recreational accidents will be somewhat higher to the (presently unknown) degree that under reporting is present.

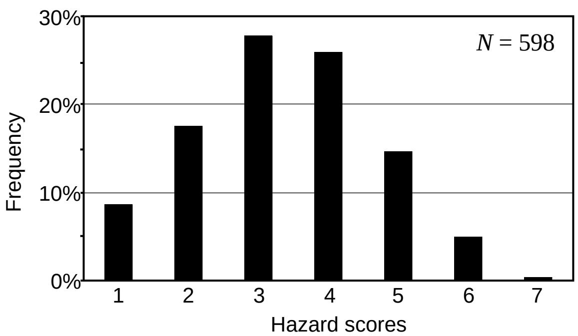

Figure 1. Hazard scores of recreational avalanche accidents in the United States, 1972 – 2001.

To asses the effects of avalanche training on hazard scores, I assigned each accident party to a training category based on the reported training of the most trained person in the party. Definitions of training levels appear in Table A2. If the training level of the victim(s) was unknown, I assigned a training category based on their apparent awareness of the hazard and their group management precautions when both of these were known. To avoid deliberately linking training with hazard scores, I did not consider terrain management precautions to be a training discriminator. In 431 cases, the level of training was reported or could be inferred from the accident accounts.

To assess the effects of group size on hazard scores, I counted only those group members who were present at the time of the accident. If multiple groups were present during the accident, I assigned group size based on the single largest group involved. Group size was known or could be inferred in 575 cases.

In comparing hazard scores among the various heuristic conditions, I used parametric methods (ANOVA, *t*-test) within each analysis category whenever possible due to the greater statistical power of these tests. I judged a parametric test to be a valid choice based on sample size and variance requirements, along with distribution normality as determined by 95% compliance with normal kurtosis and symmetry. In cases where these conditions were not met, I used nonparametric methods as noted in the text. When *p*-values are less than 0.05 (95% significance level) they appear in **bold**.

3. Results: Decisions of avalanche victims

Once I had assigned a hazard score to each avalanche accident, I could assess the effects of various heuristic cues by comparing hazard scores when the cues were present and when they were not. I began the analysis by computing the hazard-score base rates for different group sizes and different levels of training.

3.1 Group size and training

Group size and hazard score were known in 557 accidents; Figure 2 shows the variation of hazard score by group size. Because of limited sample size, I combined hazard scores for groups of eight to ten people and groups larger than ten. Here, the mean and standard deviation are valid parameters since each distribution satisfies kurtosis and symmetry constraints for normality. Since the variances for the distributions differed differed by more than 10%, a parametric ANOVA was not a valid test for significance. Instead,

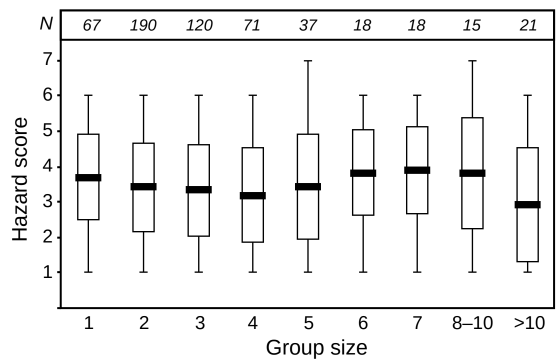

Figure 2. Hazard scores for group sizes in avalanche accidents. Boxes indicate ±1 standard deviation about the mean (dark line) and whiskers indicate the range. N is the sample size.

I used the non-parametric Kruskal-Wallis or *H*-test, which showed that the probability of the distributions being different was greater than 98% (p_{KW} = **0.018**). In other words, people travelling alone and in groups of six to ten appeared to expose themselves to significantly more hazard than groups of four or groups of more than ten. Unfortunately, a subsequent test to identify the exact differences between hazard scores (the Nemenyi-Dunn non-parametric multiple comparison test) lacked the statistical power to draw any further conclusions about these differences ($p_{ND} > 0.42$).

Training and hazard score were known in 424 accidents. A non-parametric analysis of variance test showed no significant difference in hazard scores among different levels of training ($p_{KW} = 0.29$). This finding agreed with my earlier study (McCammon, 2001) with the exception of the absence of a slight rise in hazard score among victims with basic avalanche training. This difference is most likely due to the fact that the behavior-based definitions of training categories used in this study incorporated some of the mitigation factors identified in the earlier study.

3.2 The familiarity heuristic

The familiarity heuristic is the tendency to believe that our behavior is correct to the extent that we have have done it before. In essence, this heuristic amounts to a kind of mental habit where our past actions are proof that a particular behavior is appropriate. For example, when we drive to work each day, we generally don't review the pros and cons of all possible routes; we simply take the most familiar one.

The familiarity heuristic is especially powerful because it is simple and it frees us from having to go through the same time-consuming decision processes again and again, only to arrive at what is usually the same conclusion. People unconsciously use this heuristic dozens of times each day, so it's no surprise that it is routinely exploited in the advertising and retail industries (Underhill, 1999).

To evaluate the possible influence of the familiarity heuristic in avalanche accidents, I rated each group's familiarity with the accident site where their familiarity was reported (377 cases). Most accidents (69%) occurred on slopes that were very familiar to the victims. Fewer accidents occurred on slopes that were somewhat familiar (13%) and unfamiliar (18%) to the victim. In the subsequent analysis, I made comparisons only between the "very familiar" and "unfamiliar" categories. Hazard scores of all groups showed only mild sensitivity to familiarity cues (Table 1), while groups of one to four showed little to no sensitivity. Groups of more than four people were not analyzed due to insufficient data.

Category	N_p	N_a	*test*	*p*
all accidents:	211	56	*t*	0.12
group size:				
1	23	8	*t*	0.21
2	55	26	*t*	0.13
3	43	11	*t*	0.39
4	24	6	*t*	0.88
>4	insufficient data		-	-
training:				
none	45	23	*KW*	0.46
awareness	41	10	*KW*	0.85
basic	54	9	*KW*	0.79
advanced	36	11	*KW*	**0.24E-2**

Table 1.Comparison between accidents where terrain familiarity cues were present (p) and absent(a). Significance is greatest in groups with advanced training.

The lowest levels of avalanche training showed no sensitivity to familiarity cues. This result is reasonable since untrained victims lacked the knowledge to reduce their exposure to avalanche hazard, regardless of whether they were in familiar or unfamiliar terrain. At the highest level of training, familiarity with the

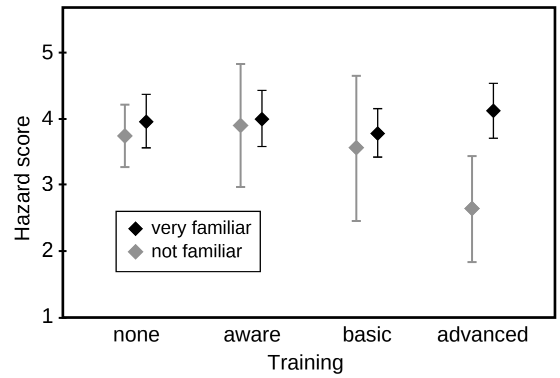

Figure 3. Comparison of hazard scores by training in familiar and unfamiliar terrain, showing the 95% confidence interval about each mean.

slope corresponded to a significant increase in hazard score. At the 95% confidence level, hazard score increased by 1.5 ± 0.8 hazard indicators (Figure 3). In unfamiliar terrain, people with advanced avalanche knowledge appeared to use their risk-reduction skills to their advantage. But in familiar terrain, these groups exposed themselves to the same level of hazard as other groups with less or no training (p_{KW} = 0.76 for all groups in familiar terrain). It thus appears that, in victims with advanced training, familiarity with a slope tended to negate the benefits of knowledge and experience.

The familiarity heuristic is fairly reliable in everyday decisions, but how well does it work in avalanche terrain? We can make a preliminary estimate from some simple observations. First, most accidents happen on slopes that are familiar to the victims. While it's likely that people tend to recreate more often on slopes they are familiar with, the high percentage of accidents on familiar slopes suggests that familiarity alone does not correspond to a substantially lower incidence of triggering an avalanche. Second, a comparison of familiarity cues with the posted avalanche hazard shows no preference among avalanche victims for familiar slopes during times of lower hazard (p_{KW} = 0.55). In other words, it appears unlikely that the familiarity heuristic is linked to some third factor that substantially reduces avalanching.

One possible factor in favor of the familiarity heuristic is the process of skier stabilization, where constant use of a backcountry slope throughout a season tends to reduce the likelihood of avalanches. While anecdotal evidence and preliminary studies indicate that the effect can be significant on heavily used slopes (McCammon, 1999), little work has been done in this area. As a result, there is little hard evidence that the familiarity heuristic is reliable in avalanche terrain.

3.3 The social proof heuristic

The social proof heuristic is the tendency to believe that a behavior is correct to the extent that other people are engaged in it. Cialdini (2001) provides a comprehensive review of research supporting the idea that others' behavior and even mere presence has a powerful influence on our decisions. In general, we rely on the social proof heuristic most when we are uncertain and when others similar to ourselves are engaged in an activity. Tremper (2001) considers this heuristic to be one of the major causes of avalanche accidents.

To evaluate the possible influence of the social proof heuristic in avalanche accidents, I compared the hazard scores of accidents where the victims had met others similar to themselves to the hazard scores of accidents where the victim(s) had met no one (Table 2). The difference between these two conditions is significant; victims that had met similar others prior to the accident exposed their group to more hazard factors than groups that had met no one.

Category	N_p	N_a	*test*	*p*
all accidents:	187	87	t	**0.034**
group size:				
1	21	17	*KW*	0.46
2	49	25	*KW*	0.92
3	34	19	*KW*	0.10
4	21	11	*KW*	**0.030**
5–10	36	12	*KW*	0.68
>10	insufficient data		-	-
training:				
none	53	19	*KW*	0.52
awareness	48	12	*KW*	0.10
basic	28	25	*KW*	**0.13E-3**
advanced	8	16	*KW*	**0.36E-2**

Table 2. Comparison between accidents where social proof cues were present (p) and absent (a). Significance is greatest in groups of three and four and at higher levels of training.

Groups of three and four people appeared to be sensitive to social proof cues. Because of limited sample sizes, I lumped together groups of five through ten people; this group did not show any sensitivity to social proof cues.

The largest increases in hazard exposure with social proof cues appeared in groups with basic and advanced avalanche training (Figure 4). For these victims, the mere presence of people outside the victims' group correlated with a significant increase in exposure to avalanche hazard. As with familiarity, this increase was easily sufficient to negate the risk-reduction benefits of avalanche training.

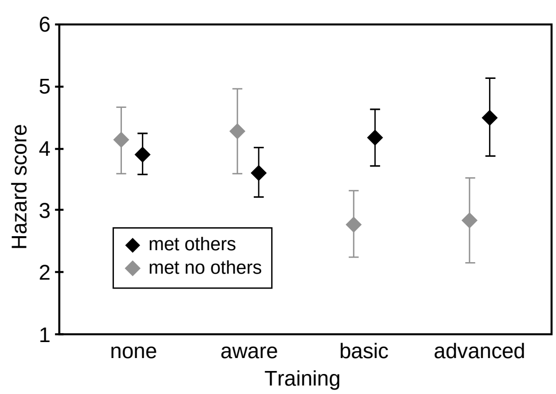

Figure 4. Comparison of hazard scores by training when victims met or did not meet other people prior to the accident, showing the 95% confidence interval about each mean.

If the social proof heuristic did in fact influence the victims' behavior in these accidents, its effect appears to be quite pronounced, particularly in victims with avalanche training. But is the heuristic reliable enough in avalanche terrain to justify such a high level of influence? One possible answer comes from examining one of the assumptions that underlies the social proof heuristic: the belief that a slope which has been skied/boarded/high marked is less likely to avalanche.

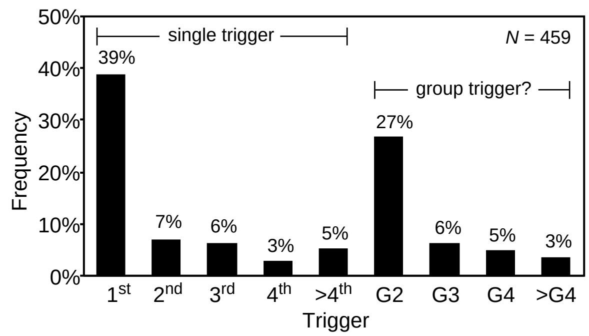

Figure 5. Triggers in recreational avalanche accidents. Most avalanches were triggered by a single individual (59%); the remainder were triggered with two or more people on the slab (41%).

To explore how social proof cues relate to the stability of avalanche slopes, I examined how each avalanche was triggered (Figure 5). In the majority of cases, a single individual clearly triggered the slab but in 21% of the cases that person was not the first one on the slope. In the remainder of the cases there was more than one person on the slab when it fractured, so the exact trigger was unclear. In some cases, most notably those involving snowmobiles engaged in high marking, the slope had been heavily tracked prior to avalanching. One surprising result was that in 204 cases, the slope that avalanched either had tracks on it or there were tracks nearby. Only 94 cases were reported where there were no tracks on the slope or nearby. All of this suggests that the social proof heuristic may have some marginal value in reducing risk, but in view of the large number of accidents that occur when social proof cues are present it cannot be considered in any way reliable.

3.4 The commitment heuristic

The commitment heuristic is the tendency to believe that a behavior is correct to the extent that it is consistent with a prior commitment we have made. This heuristic is deeply rooted in our desire to be and appear consistent with our words, beliefs, attitudes and deeds (Aronson, 1999). Public image aside, the heuristic works because it provides us a shortcut through complexity. Rather than sift through all the relevant information with each new development, we merely make a decision that is consistent with an earlier one. Given the ubiquity (many say the necessity) of the commitment heuristic in modern life, it's no surprise that our unconscious reliance on it frequently makes us unwitting shills in countless retail, charity and political campaigns (Cialdini, 2001).

To evaluate the possible influence of the commitment heuristic in avalanche accidents, I assigned each accident to one of three categories of commitment. Groups assigned to the high commitment category had a stated goal they were actively pursuing or a goal they were motivated to achieve because of approaching darkness, timing or other constraints. Victims I assigned to the low commitment category did not appear motivated to achieve a specific goal, while victims I assigned to the no commitment category had unintentionally exposed themselves to avalanche hazard while engaged in non-goal oriented activity (wandering onto a cornice while the rest of the party was eating lunch, for example). This last group was not included in the analysis due to its small sample size ($N = 13$).

As shown in Table 3, the presence of commitment cues (high commitment) was significant over all groups. The effect was not significant within any group size category. Due to limited data for cases where training levels were known but commitment cues were absent (low commitment), a piecewise t-test was not conclusive. Instead, a two-factor ANOVA across all levels of training showed that commitment cues were a significant factor in the hazard scores of these groups (Figure 6). To achieve the sample symmetry needed for this test some of the data points were randomly discarded.

Category	N_p	N_a	test	p
all accidents:	216	110	*t*	**0.022**
group size:				
1	30	11	*t*	0.83
2	63	37	*t*	0.98
3	44	29	*t*	0.13
4	31	12	*t*	0.64
>4	insufficient data		-	-
training:				
all levels	100	100	*ANOVA*	**0.043**

Table 3. Comparison between accidents where commitment cues were present (p) and absent (a). Significant differences exist between training levels.

While highly committed groups appeared more willing to expose themselves to greater avalanche hazard, the commitment heuristic itself appears to offer no additional margin of safety. The frequency of accidents involving highly committed groups was independent of the posted avalanche hazard ($p_{KW} = 0.65$).

3.5 The scarcity heuristic

Most skiers are familiar with the “powder fever” that seizes the public after a long-awaited snowstorm. Intent on getting first tracks down a favorite run, hordes of skiers flock to the lifts and the backcountry, often throwing caution to the wind as they compete with each other to consume the powder that is untracked for a limited time only. While this phenomenon is largely fueled by people’s enjoyment of powder skiing, it probably has deeper roots in our attitudes about personal freedom.

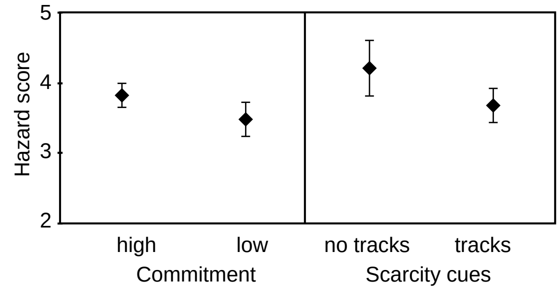

Figure 6. Comparison of hazard scores for commitment and scarcity cues, showing the 95% confidence interval about each mean. Both scarcity categories had other parties nearby.

A substantial body of research suggests that people react strongly, at times even aggressively, to any perceived restrictions to prerogatives they feel they are entitled to, regardless of whether or not they intend to exercise those prerogatives (see Pratkanis and Aronson, 2000, or Cialdini, 2001 for reviews). This principle, called psychological reactance, emerges at about the age of two and pervades the fabric of our social environment. In our everyday decision making, psychological reactance manifests itself as the scarcity heuristic: we tend to distort the value of opportunities we perceive as limited and to compete with others to obtain them.

To evaluate the possible influence of the scarcity heuristic in avalanche accidents, I compared the hazard scores of accidents where either of two conditions were met: 1) other groups were present and there were no tracks on the slope that eventually avalanched, or 2) other groups were present and there were tracks on the slope. In an earlier section I explored the significance of the presence of other people on hazard scores. Here, I wanted to test the significance of a limited opportunity – an untracked slope – on hazard exposure in avalanche accidents. Having test criteria for scarcity where people were present in both cases ensured that I was not merely measuring the effects of social proof.

Due to the fairly restrictive criteria I used, sample sizes ended up being fairly small (Table 4). Neverthe-

Category	N_p	N_a	test	p
all accidents:	29	120	*t*	**0.027**
group size:				
1	insufficient data		-	-
2–4	17	65	*t*	0.079
>4	insufficient data		-	-
training:				
none	9	33	*KW*	0.52
awareness	insufficient data		-	-
basic	10	17	*KW*	0.86
advanced	insufficient data		-	-

Table 4. Comparison between accidents where scarcity cues were present (p) and absent (a). Differences in hazard scores are significant overall, but there was not enough data available to gain insights into group size or training effects.

less, I was able to draw some general conclusions about the possible influence of the scarcity heuristic.

As shown in Figure 6, the presence of scarcity cues corresponded to a significant increase in hazard scores across all accidents that met the scarcity criteria (N = 149). While sample sizes were not sufficient to resolve exact differences between subgroups, groups of two to four showed a sensitivity to scarcity cues at the 94% confidence level. In short, the presence of scarcity cues corresponds to an overall increase in avalanche hazard exposure among all groups. Further investigation will be needed to asses the exact influence of scarcity cues on groups of varying sizes and training levels.

How good is the scarcity heuristic? If we compare the avalanche hazard between accidents we find that when scarcity cues were present, there was a 94% chance that hazard scores were *higher* ($p_{KW} = 0.073$). Consistent with what we would expect, the scarcity heuristic appears to work exactly contrary to personal safety; it is most influential when the avalanche danger is high.

4. Discussion: Evidence of heuristic traps

In any retrospective study such as this, it is far easier to demonstrate correlation than causation. We can never be absolutely certain of what decisions led up to each accident, nor can we really know how those decisions were made (even first-hand accounts are subject to a number of well-known biases). So, in lieu of controlled experiments on human behavior in avalanche terrain, we must instead rely on objective evidence that implies that certain decision processes took place prior to the accident. Did heuristic traps contribute to the accidents in this study? To answer this question there are three sources of evidence that we need to consider.

First, we have seen that certain avalanche victims exposed themselves to more hazard indicators when specific heuristic cues were present. If we accept the premise that the number of hazard indicators approximates the overall risk exposure of the victims (averaged over a large number of accidents), then it seems reasonable to assume that these heuristic cues correlate with greater risk exposure. While it is certainly possible that risk exposure and heuristic cues are correlated through some other set of spurious unknown factors, it seems unlikely given the independence of (and, in the case of scarcity cues, the inverse dependence on) the posted avalanche hazard. Thus, while the correlations themselves are by no means definitive, they are likely indicators of the influence of heuristic traps.

Second, there is a large body of empirical evidence that supports the idea that people habitually use unconscious heuristics in their decision making. Even if this theory was not well accepted in the social and behavioral sciences, the sheer size of an advertising industry ($165 B in the U.S. alone) that depends on unconscious heuristics for its success is a compelling testament to their prevalence. Given the evidence that people use such heuristics on a constant basis in their everyday lives, it seems highly unlikely that we would unknowingly suspend heuristic thinking when in avalanche terrain.

Finally, avalanche investigators have long recognized that heuristic traps play a prominent role in avalanche accidents, although the terminology differs. Fredston and Fesler (1994) discuss the "sheep syndrome" (social proof heuristic), the "cow syndrome" (commitment) and the "lion syndrome" (scarcity). Tremper (2001) discusses habituation (familiarity), the herding instinct (social proof), and summit fever (commitment). In these and other treatments, seasoned avalanche investigators frequently remark that even trained victims commonly ignore obvious clues and fail to take simple precautions. Such errors are classic characteristics of heuristic, single-piece-of-evidence-type decision making.

Do heuristic traps contribute to avalanche accidents? Given that a large body of evidence indicates heuristic reasoning pervades human thinking, that avalanche investigators believe heuristic traps play a role in accidents, and that the correlations described in this study support the role of heuristic traps, it seems highly likely that heuristic traps not only contribute to avalanche accidents, but that learning about them is crucial in preventing future accidents.

5. Implications for avalanche education

If heuristic traps lie at the heart of many avalanche accidents, there are some important implications for avalanche education.

Traditional avalanche education places a heavy emphasis on terrain, snowpack and weather factors. While there's no doubt that this knowledge can lead to better decisions, it is disturbing that the victims in this study that were most influenced by heuristic traps were those with the most avalanche training. The current and growing emphasis on human factors in avalanche education seems wholly appropriate, but will it be effective? Numerous studies suggest that merely learning a taxonomy of persuasion tricks does not make people any less susceptible to them (Pratkanis and Aronson, 2000). Thus it seems likely that effective human factors education must do more than provide a laundry list of heuristic traps: It must give people simple, viable tools for recognizing and mitigating heuristic traps and other decision errors in avalanche terrain.

6. Summary and conclusions

Numerous studies in social psychology, behavioral science and advertising provide ample evidence that people tend to use mental shortcuts, or heuristics, in their everyday decisions. Most of the time heuristics work well but in avalanche terrain, they can lead to potentially fatal errors in decision making.

In this paper, I examined evidence that four heuristic traps played key roles in recreational avalanche accidents in the United States. Table 5 summarizes the findings. The familiarity trap appeared to be triggered by previous experience with the avalanche slope, and was most likely to affect victims with significant avalanche training. The social proof trap was triggered by the presence of other people. Its influence was strongest in groups of three to four and in victims with formal avalanche training. The commitment trap was triggered by commitment to a specific goal, and was evident in all groups where there was sufficient data for

	Familiarity	Social proof	Commitment	Scarcity
All accidents:	○	●	●	●
Group size:				
1	○	○	—	—
2	○	○	◒	◒
3	○	◒	◒	◒
4	○	●	◒	◒
>4	—	○	—	—
Training:				
none	○	○	—	○
awareness	○	◒	—	—
basic	○	●	◒	○
advanced	●	●	—	—

Table 5. Preliminary evidence for heuristic traps in avalanche accidents. (●) 95% significance, (◒) 90% significance,(○) not significant, (—) unclear.

comparison. Finally, the scarcity trap was triggered by a combination of other people nearby and an untracked slope, and was most likely to influence groups of two through four people. Based on an analysis of avalanche hazard bulletins and triggering statistics, none of the heuristics underlying these traps appeared to be especially reliable in avalanche terrain.

Avalanche victims fall prey to heuristic traps because heuristics are simple to use and they have proven themselves in other areas of daily life. The challenge for avalanche educators continues to be developing and effectively teaching simple, effective tools that are viable alternatives to the heuristics traps described here.

7. Acknowledgments

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9. Appendix

Parameter	*Definition*
High forecast	High or extreme avalanche forecast posted for the region,
Recent avalanches	In the immediate area, within the past 48 hours,
Instability signs	Collapsing, cracking, hollow sounds or low stability test scores noted by the victims or the rescue party,
Recent loading	Loading by snowfall > 15 cm or wind in the last 48 hours,
Thaw instability	Above-freezing air temperatures or rain at the time of the incident,
Obvious path	A distinct start zone, track or runout zone, or a known avalanche path.
Terrain trap	Terrain features that increase the severity of the slide's effects

Table A1. Definitions of the hazard indicators used in this study.

Parameter	*Definition*
Training factors:	
None	No training; no awareness of avalanche hazard,
Aware	General awareness of avalanche hazard; took no precautions prior to the accident,
Basic	Formal avalanche training; took group management precautions (spacing, islands of safety, plan, etc.) prior to the accident,
Advanced	Extensive formal training; ongoing awareness and risk management, terrain awareness, performed snow stability tests.
Group factors:	
Group size	The size of the single cohesive group present at the time of the accident. If more than one group was involved, group size reflected only the largest cohesive group.

Table A2. Definitions of the training and group size factors used in this study.