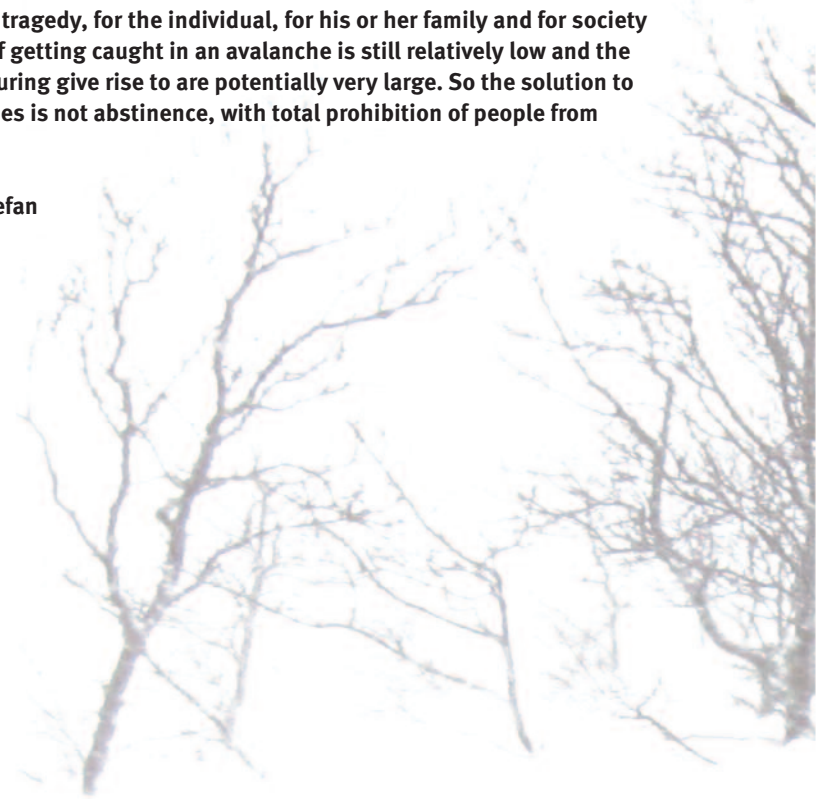


Who's at risk in the backcountry?

Whenever someone gets injured or killed in an avalanche, it is a tragedy, for the individual, for his or her family and for society as a whole. But let us be honest, for most of us the probability of getting caught in an avalanche is still relatively low and the health benefits and economic contributions that backcountry touring give rise to are potentially very large. So the solution to the problem of people triggering and getting caught in avalanches is not abstinence, with total prohibition of people from venturing into avalanche terrain.

by Andrea Mannberg, Jordy Hendrikx, Markus Landrø, Martin Stefan



S

So what then is the solution?

Today, a range of groups and organizations offer avalanche-training opportunities that target sequential levels of experience and industry needs. The structure of these courses (especially recreational avalanche courses) vary, but they are rarely tailored to fit different needs of different groups. In addition, most of the material taught is based on the assumption that side- and backcountry skiers make rational decisions. In other words, it is assumed that we gather all available information, and that we weigh the benefits of skiing a run to the costs in a way that is optimal for us.

don't know if these characteristics are associated with higher cumulative risk exposure because we do not know if we see these effects just because e.g. men ski backcountry more than women and therefore are more likely to turn up as victims or if men actually do take greater risks. If the assumption of rationality isn't valid, then a restructuring of avalanche education courses is needed, but to know how to do this (and to know if such restructuring is needed at all) we need to test if some groups expose themselves to more risk than others and (perhaps even more important) why.

b

But do we?

The problem is that the answer to that question still is: We don't know. There are some indications that we make irrational decisions in the heat of the moment and that some groups expose themselves to more risk than others (see e.g., McCammon, 2004; Furman et al., 2010; Haegeli et al., 2010; Marengo et al., 2017). Although these studies have provided very important information about individual (e.g., gender), group (e.g., size and gender composition) and situation (e.g., familiar vs unfamiliar terrain) characteristics that are associated with a higher accident frequency (McCammon, 2004), we

t

The White Heat project

The White Heat project is a cross-disciplinary research project which is collaboration between researchers at the School of Business and Economics (HHT) and the Center for Avalanche Research and Education (CARE) at UiT – the Arctic University of Norway, the Snow and Avalanche Lab at Montana State University, USA and the School of Business and Economics at Umeå University in Sweden. On our team we have researchers in economics, psychology and snow science. We also collaborate with mountain guides and avalanche forecasters.

The main aim of the White Heat project is to analyze motivating factors behind risk-taking behavior in avalanche terrain. We are especially interested in if and how group dynamics and bounded rationality affect decision-making in a high-risk environment. The goal of

The photo was taken on February 16th, 2014, in Kittelfjäll, Sweden.

I, my partner Martin and our friend Maria were out ski touring. When we reached alpine terrain, we decided to back down from our plan A because we deemed it too risky. Our approach had been along a very low inclination ridge formation. Skiing down that would mean that we would have to keep our skins on. We could not resist climbing a few meters up the mountain just to get a few turns in. We stepped out on a snow field, it collapsed and the fracture spread up the mountain. The avalanche released approximately 50 vertical meters above us. It was about 300-500 meters wide and it went down almost 500 meters. We were tossed into the trees. Fortunate for us, we were still just above the ridge, so we stopped just 50-75 m further down. I was buried up to my chest, as was Martin. Maria was completely buried but so close to the surface that she could free her head. I broke my left fibula and my right tibia. Maria broke her femure. We were extremely lucky to survive. I have written about the incident (and all – or at least the ones I noticed – the mistakes that led up to it) here:

<https://hungryhen.wordpress.com/2014/02/22/not-so-much-kicking-but-alive-the-kittelfjall-avalanche-2014/>, and here <https://whiteheatsite.wordpress.com/2017/03/15/a-close-encounter-with-human-factors/>.

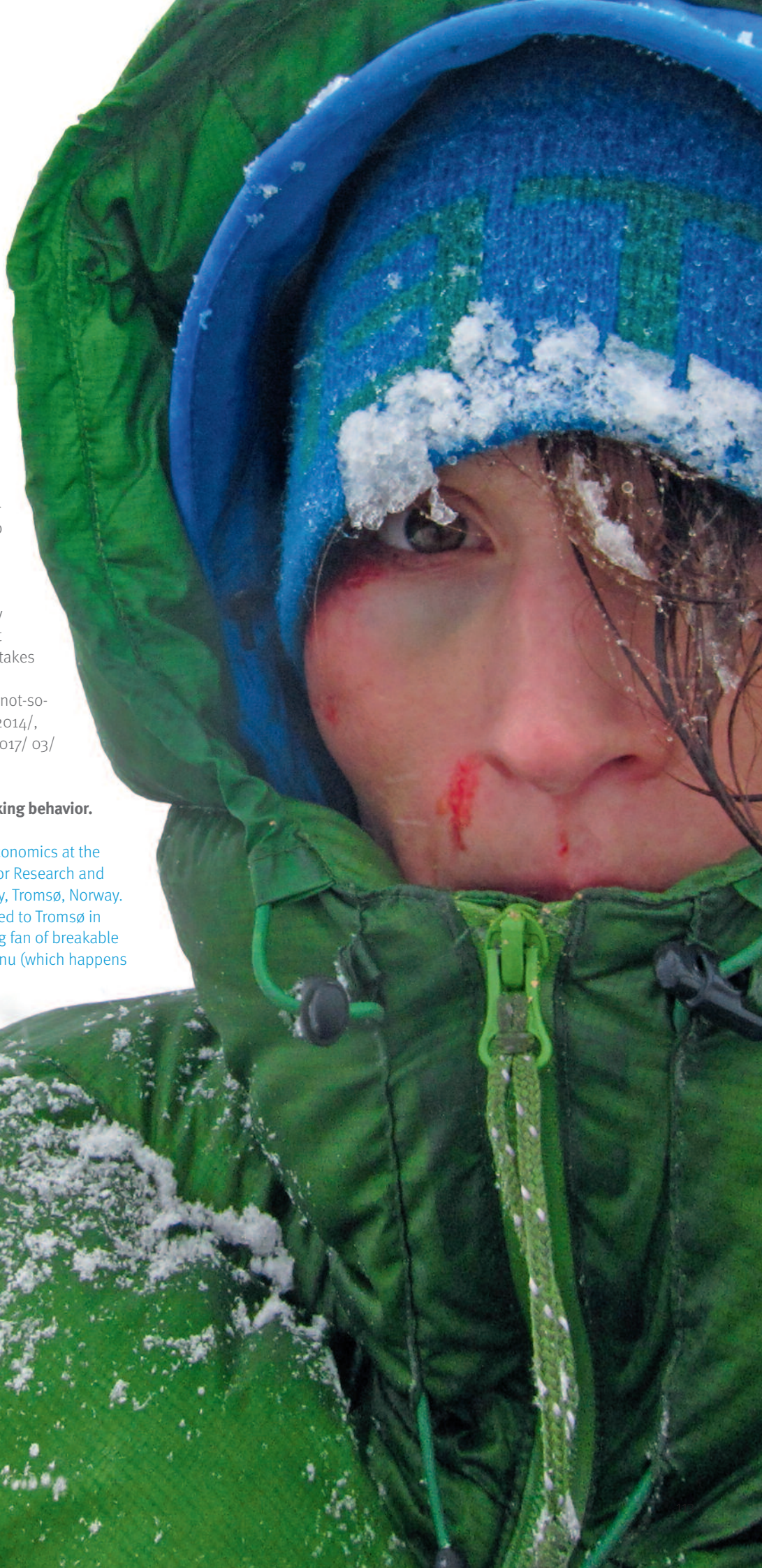
I have good incentives to do research on risk taking behavior.

Andrea Mannberg is an Associate Professor in economics at the School of Business and Economics, and Centre for Research and Education at UiT – the Arctic University of Norway, Tromsø, Norway. Originally from the flatlands in Sweden, she moved to Tromsø in North Norway for her love of mountains. Not a big fan of breakable crust but will accept it if that is what is on the menu (which happens often in the Arctic).

Photo: Lebnes (mountain), Kittelfjäll (village), Västerbotten (county), Sweden.

Photographer: Martin Stefan

Subject: Andrea Mannberg



Stormheimsfjellet, Breivikeidet, Tromsø, N-Norway.
Photo: Andrea Mannberg

Figure 1 Self-assessed backcountry travel skills.

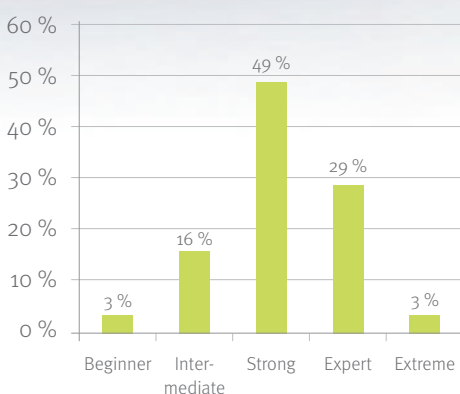


Figure 2 Number of years with at least 10 days of skiing the backcountry.

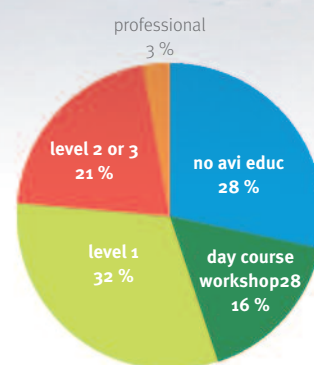
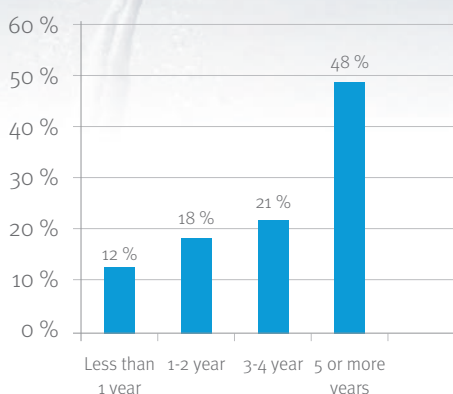


Figure 3 Avalanche training.

the project is to generate knowledge that will help improve avalanche training and policy related to recreational activities in high-risk environments and to reduce the number of avalanche accidents. During spring 2017 we launched the first pilot study within the White Heat project. The pilot was a web-based survey which we distributed via Centre for Avalanche Education and Research (CARE), national and regional outdoor organizations and various backcountry oriented webpages and magazines. One aim of the survey was to find information that would help us understand if some groups of people are more likely to expose themselves to higher avalanche risk.

0

Online survey

A total of 457 people participated in the survey. Of these, 70 percent were men and 30 percent were women. Most participants were between 23 and 37 years old (the youngest participant was 18 years old and the oldest was 68 years old. Median age was 32). Slightly more than 50 percent had some type of formal avalanche training (had at least one 2-3 day avalanche course with certified instructors) and 28 percent had no avalanche training by certified instructors at the time of the survey but many had a relatively high level of skiing and backcountry experience: 43 percent had more than 20 days skiing on average over the past 5 years and over 80 percent consider themselves to be skilled or very skilled backcountry travellers. These results are summarized in figures 1, 2 and 3.



Figure 4 Hypothetical terrain choices in our online survey.

Photo: Jordy Hendrikx

Photo: Antti Pohjola

<h2>The Ridge</h2> <p>„A friendly giant. Mellow and safe skiing.“</p> <p>Slope Max: 23° / mean: 20° Aspect: NW Vertical drop: 1000 meter</p> <p>Dangers: No dangers Exposure: Very low</p>	<h2>The Field</h2> <p>„A nice and fun run. Easy going skiing from top to bottom.“</p> <p>Slope Max: 35° / mean: 25° Aspect: NW Vertical drop: 1000 meter</p> <p>Dangers: 20 m > 30° Exposure: Low</p>	<h2>The Bowl</h2> <p>„A scenic run with consistently steep skiing.“</p> <p>Slope Max: 40° / mean: 30° Aspect: NW Vertical drop: 1000 meter</p> <p>Dangers: 400 m > 30° Exposure: High Terrain trap</p>	<h2>The Chute</h2> <p>„An adrenaline rush. No fall zone from top to bottom.“</p> <p>Slope Max: 45° / mean: 37° Aspect: NW Vertical drop: 1000 meter</p> <p>Dangers: 1000 m > 30° Exposure: High Terrain trap</p>
<div> <p>Avalanche hazard: Moderate (level 2). Wind slabs constitute the main avalanche problem. A poor bonding between the old and new snow, and a persistent weak layer further down in the snow pack. Human triggered avalanches are possible at a large additional load, especially on steep slopes. Snow: Mostly loose powder, but at places, the wind has created soft wind slabs.</p> </div>			

We measured risk-taking behavior in avalanche terrain in two ways: first we asked participants about their experience of avalanche accidents and near-miss incidents. These experiences provide us with information on situations in which risky decisions were made. However, avalanche terrain is a so-called “wicked learning environment” – i.e. we often make risky or bad decisions without getting any feedback on those decisions. This means that past experience of avalanche incidents only give us a part of the puzzle, as many individuals may take a lot of risk and may have simply been lucky enough to not have an avalanche incident. We therefore also asked our participants to make hypothetical terrain choices under a specific scenario.



Four scenarios

To create a somewhat realistic setting for the hypothetical choices, we asked the participants to imagine that they were out on a back-country ski tour with their ski partners in late March, that they had just reached the summit and were about to make a choice concerning which way they would ski down.

The participants were told that the mountain offered four alternative ways down. Two of these runs were described as relatively safe (no, or short sections with slope > 30°, no exposure from above or below) and two as relatively risky (long sections with slope > 30°, terrain trap features). We asked the participants which run they would like

most to ski down, given the snow and avalanche conditions, and which runs they would accept to ski given that someone else wanted to ski it. The run choices are shown in figure 4.

To help with the decision we provided information on both historic and current weather (historic: a big snow fall two days earlier, current: cold, sunny and bit windy), the avalanche hazard (level 2 – a poor bonding between the new and pre-storm snow and a deeper persistent weak layer) and snow conditions (untracked snow consisting of mostly loose powder and, in some places, soft wind slabs). These characteristics were the same for all runs. We chose to use a moderate avalanche hazard to make the choice to ski the Bowl and the Chute risky, but not completely crazy.

There are of course several problems associated with using hypothetical choices as an indicator of real life behavior: different people may interpret the described situation in different ways, important information needed to make the decision may be missing and some participants may answer in a way they think that the researchers want instead of stating their true opinion. Finally, what people think that they would do in any given situation, and what they actually do when the situation occurs, may be two completely different things.

To avoid some of these problems we asked the participants how risky they perceived that it would be for them to ski down each of the runs on a scale between 1 (no risk) and 6 (very high risk). We only used answers from individuals who ranked the Bowl and the Chute as strictly more risky than the Field, and the Field as more risky than the Ridge (i.e. we only used the participants with risk

Jordy Hendrikx (PhD) is the Director of the Snow & Avalanche Laboratory and an Associate Professor in the Department of Earth Sciences at Montana State University in Bozeman, Montana, USA.

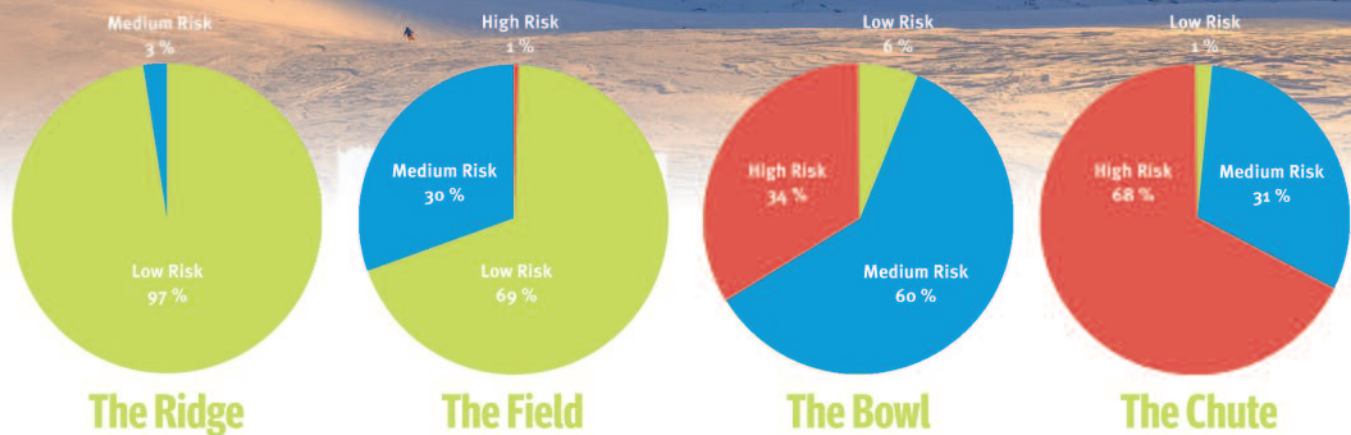


Figure 5 Perceived risk of the hypothetical runs.

assessments consistent with our intent). As can be seen in the graph (figure 5) the participating individuals perceived the Bowl and the Chute to be relatively risky, and the Field and the Ridge to be relatively non-risky.



To what extent are people involved in avalanche incidents and how risky terrain do they want to ski?

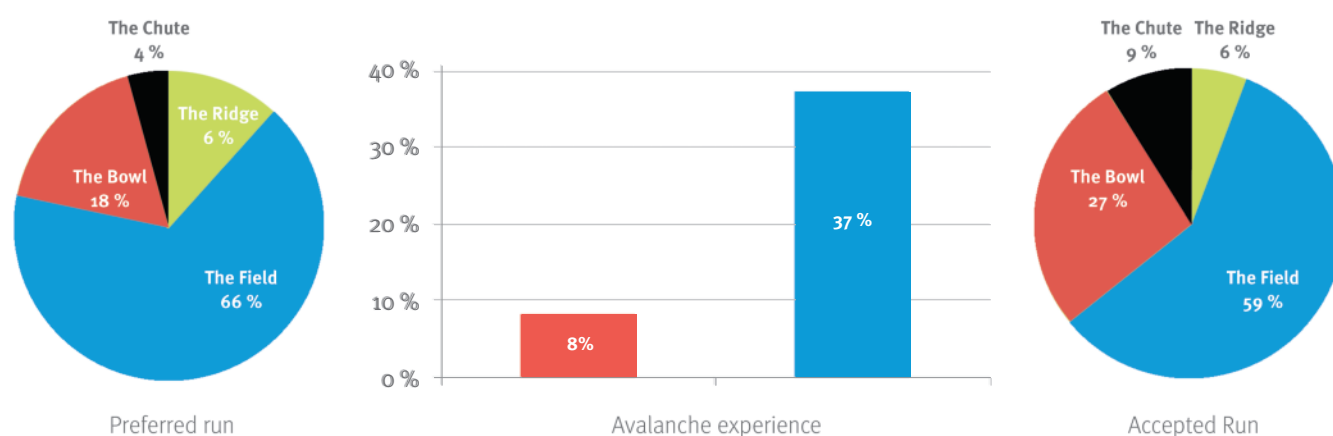
Among our sample participants the great majority (88 percent) states that they prefer to ski relatively safe terrain. However, 37 percent have been involved in at least one near-miss accident during the past 5 years and 8 percent has had an avalanche accident in which someone was injured or killed. These two descriptive results seem incompatible but perhaps at least a part of the missing link can be found if we look at the difference between the type of terrain our participants prefer to ski, and the type of terrain that they accept to ski? We find that our participants are significantly more likely to accept to ski the Bowl and/or the Chute if others in their hypothetical group were to pick this terrain and no one objected, than they are to prefer it. In other words, they accept more risk than they state that they prefer (figure 6).



But what lies behind the choice to ski a relatively risky run and what personality characteristics are correlated with having been in an avalanche incident?



Figure 6 Preferred and accepted run choices, and direct avalanche accident experience.



We ran a set of analyses on the choice to ski the relatively steep runs (the Bowl or the Chute) and on past experience of avalanche incidents (both full and near-miss accidents).

We find that similar but not identical individual characteristics predicts hypothetical terrain choices (summarized in figure 8) and avalanche experience (summarized in figure 10): individuals who perceive the risk to be low or who have a positive attitude towards risk are more likely to say that they prefer and would accept to ski the relatively steep runs. We similarly find that individuals with positive risk attitudes and relatively much experience of backcountry skiing have been involved avalanche incidents to a greater extent than those with more negative attitudes towards risk and less time in avalanche terrain. Finally, we find that participants who state that they admire other skiers who ski steep or exposed terrain are relatively more willing to ski the relatively steep runs. These results probably do not come as a surprise to many.

However, we also find results that are perhaps a bit more surprising. For example, we find that the individuals in our study are willing to accept to ski significantly more risky slopes than they state that they prefer. More specifically, while only 21 percent prefer to ski the Bowl or the Chute, 36 percent would accept to ski these runs if someone in their group wanted to do so.

Avalanche training (level 1 courses or higher) does not appear to have an effect on the type of slope that our participants prefer most, but we find that individuals with formal avalanche training are signi-

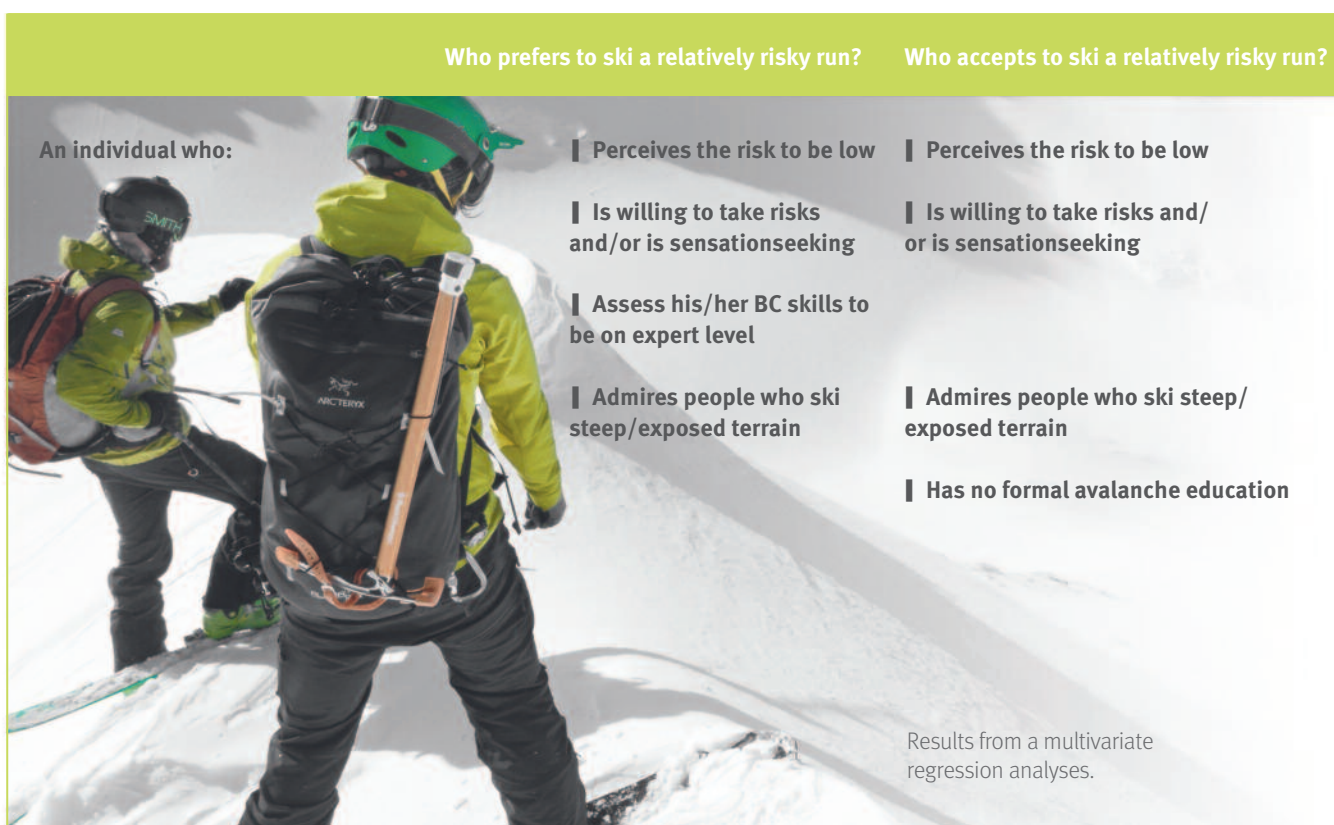
ficantly less likely to accept to ski down the relatively risky runs. We intentionally provided the participants with information on avalanche danger and terrain features that increased the probability and consequence of an avalanche, so that avalanche knowledge would not affect the decisions. At least in our sample then, it appears as if avalanche training does not alter preferences; those who like steep runs do so with or without avalanche training. Instead, our results suggest that avalanche training may increase the ability to withstand group pressure. However, to know for sure what is causing this effect, we need to study more.

The two steeper runs were described as demanding in terms of ski skills. It is therefore not surprising that we find that mostly expert backcountry travellers state that they prefer to ski these runs. However, when we ask which runs the participants would accept to ski, we find that individuals at all levels of backcountry travel skills are willing to ski down both the Bowl and the Chute.

Backcountry travel skills and perceived risk are subjective evaluations and it may therefore be interesting to take a closer look at these measures.

As depicted in figure 9, our analysis shows that perceived risk and self-assessed skills depend on factors that should intuitively reduce risk and increase backcountry skills. For example, we find that individuals who have been active backcountry skiers for many years and who assess their skills to be high also perceive their personal risk of skiing down the steeper runs as lower than do individuals with less

Figure 7 Explanatory factors correlated with preference for skiing the Bowl or the Chute, and acceptance to ski these runs.



Picture taken on Store Russetinden, Nordkjosbotn, Tromsø, North Norway. Photo: Andrea Mannberg (skiers: Stian Warløs Grahn (left) and Martin Stefan (right)).

experience and skill. This appears as an adequate evaluation of risk. A person who has been skiing a lot has less chance of falling, is likely lighter on the snow and possibly has a greater chance of skiing out of an avalanche (although it should be noted that a slide doesn't care if a victim is king – or queen – on skis or not). We also find that self-assessed skills to a great extent depend on backcountry experience and avalanche education, two factors that should increase an individual's ability to travel safely in avalanche terrain.

In part, however, the perceived riskiness of the risky runs also depends on things shouldn't affect objective risk, and some individuals seem to overestimate their skills in handling steep terrain.

For example, we find that participants who imagined that they were out touring with someone more skilled in backcountry skiing than themselves perceived the risk of the steep runs as less risky than participants who imagined that they were touring with individuals of less or equal skill as themselves. This effect does not depend on the participants' own self-assessed skill or backcountry experience. We find the effect for all levels of ski experience. Keep in mind that the participants were told that no other information than the one provided by us was available. The only way a skilled touring partner can reduce the objective risk of a run then is if that person is skilled in terms of rescue or if she or he skis in a way that minimizes the risk of triggering an avalanche. Remember also that we asked the participants how risky they thought that it would be for them, personally, to ski down the slope in terms of falling or triggering an avalanche. Having a more skilled ski partner should not affect that risk.

Avalanche training is positively correlated with self-assessed backcountry skills but when we analyze the effect more closely, we find that individuals who have only taken a daylong avalanche course or participated in a workshop perceive their skills to be surprisingly high: individuals with just a day course rate their skills almost on par with individuals with level 2 courses or higher (which typically require multiple days to complete). We find no effect of having taken a level 1 course.

Finally, we find that men assess their skills as significantly higher than women do. Men in our sample have more experience of backcountry travel than women, but we find that if we hold the number of days and years skiing the backcountry constant, men still perceive their skills as higher than women do. We also find that men in our sample on average say that they are willing to take risks to a higher degree than women in the sample do, and that they have more sensation-seeking preferences. Could this finding explain the fact that we find that men are substantially overrepresented among those with experiences of avalanche incidents?

Figure 9 summarizes our findings on avalanche incidents. When we analyze experience of avalanches we find that the most important explanation is time in the backcountry that is cumulative risk. But men have 27 percentage points higher probability than women of having been involved in an accident given cumulative risk. In other words, we find this effect even if the number of ski days and years of skiing the backcountry is the same.



Figure 8 Explanatory factors correlated with perceived risk of the risky runs and self-assessed skills.

Who perceives the risk to be relatively low?	Who assess their BC travels skills as high?
<p>An individual who:</p> <ul style="list-style-type: none"> Has been touring the backcountry for many days and years Assesses his or her backcountry travel skills as high Presumed that he or she was touring with more skilled people 	<ul style="list-style-type: none"> Has been touring the backcountry for many days and years Says he or she is willing to take risk Has avalanche training on level 2 or higher or only has a avalanche day course or workshop is male <p>Results from a multivariate regression analyses.</p>

Figure 8 Explanatory factors correlated with past direct experience of avalanche incidents.

Who has had an aval.-incident?
<p>An individual who:</p> <ul style="list-style-type: none"> Has many days and years of skiing the backcountry Is a sensation-seeker Has formal avalanche education Compares the type of terrain they ski with the type of terrain that others ski <p>Results from a multivariate regression analyses.</p>

Martin Stefan. Phd in Physics, passionate splitboarder. Favorite snow – 30-40 cm of settled, progressive powder. But really anything, as long as it does not slide.

We also find a link between sensation-seeking preferences and avalanche experience, but we find no effect of willingness to take risk. The latter means that individuals who state that they are very unwilling to take risks are equally likely to have been involved in an incident as are individuals who state that they are very willing to take risk. This is puzzling and calls for further research.

Finally, we find that individuals with formal avalanche training are more likely to have been involved in avalanches than are individuals without this training, and that avalanche victims compare the type of terrain that they ski with the type of terrain that other skiers ride down. The effect of avalanche training is not compatible with the negative effect of avalanche training on willingness to ski the relatively risky runs. However, we cannot conclude that avalanche training increases risk-taking because it may well be the case that the avalanche experience gave the individual incentives to seek out avalanche training and that it is this effect that we see. The tendency to compare terrain may indicate that individuals who are preoccupied with skiing “steep enough” terrain exposed themselves to more risk. However, it may also be the case that the avalanche experience made them more aware of their short-comings and that they therefore have started to compare their terrain choices.

Our work so far has created almost more questions than answers. It is important to remember that our sample is small and that all effects are correlations. This means that even if we control for backcountry experience, knowledge and so on, we are unable to prove what is cause and what is effect. Hypothetical choices and avalan-

che experience can only tell us so much about decision-making in avalanche terrain. To fully understand real life risk-taking choices we need to study real-life behavior over time. Prof Jordy Hendriks and Prof Jerry D. Johnson at the Snow and Avalanche Lab, Montana State University, have over the past few years collected GPS tracks and personal data from backcountry riders in many parts of the world.

In the next phase of the White Heat project we will connect our survey to these GPS-tracks to get a more nuanced picture of skiers' behavior in avalanche terrain. We encourage you to participate in this next phase and send us your GPS tracks and complete our surveys. More details about this next phase can be found here: <http://www.montana.edu/snowscience/tracks.html>

