

THESIS

Learning from avalanche accidents

How does avalanche accident change the way people evaluate risk and make decisions in backcountry skiing?

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Bachelor's Degree in Adventure and Outdoor Education
(210 ECTS)

5/2021)

ABSTRACT

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Bachelor's Degree in Adventure and Outdoor Education, 210 ECTS

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Title of thesis: Learning from avalanche accidents: How does avalanche accident change the way people evaluate risk and make decisions in backcountry skiings?

Number of pages: 47

Supervisor of the thesis: Kai Lehtonen

Commissioned by: CARE – Center for Avalanche Research and Education

This study aims to answer two questions: 1. How does a serious avalanche accident change the way people evaluate risk and make decisions in backcountry skiing trips? 2. What can we learn from people who have experienced the negative consequence of an avalanche accident? Qualitative interviews were conducted to seven people with an experience of a serious avalanche accident. Results include descriptions of eight different accidents including how did the accident affect victims and their peers. Discussion of the results concentrated on what can we learn from the accidents, reflecting on literature of avalanche safety, learning and decision making psychology. There is a need to emphasize the importance of systematic decision making in order to make reliable choices in avalanche terrain.

Keywords: avalanche accidents, systematic decision making, risk-assesment, backcountry skiing, qualitative interviews, accident prevention, learning from accidents

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1 INTRODUCTION

Avalanche terrain consists of a “wicked learning environment”, where feedback of ones decisions can often be irregular and distorted (Soyer & Hogarth, 2020, p. 17-20). Therefore it can be difficult to determine, whether we have made correct assessments, or simply succeeded because of luck. By thinking that we made the correct assessment, because we didn’t experience the negative consequence of an avalanche accident, can lead to positive reinforcement of risky behaviour. Learning through mistakes has been considered to be the most effective way to learn (Ellis, Carrette, Anseel & Lievens, 2014), however in avalanche terrain mistakes can have fatal consequences. Therefore it is beneficial to study those, who has experienced the negative consequence of an avalanche accident.

The study consists of a review of seven interviews of people that have experienced a serious avalanche accident. The severity of the accidents were determined by, if the victim, or someone in the party of the victim was injured, killed or suffered significant mental trauma as a result of the accident. For this study i had two study study questions.

In the results section, i will answer the first question: 1.How does avalanche accident change the way people evaluate risk and make decisions in back country skiing?

In the discussion part, i will answer the second study question: 2.What can we learn from people who have experienced the negative consequence of an avalanche accident? In this section i will reflect the results of the interviews in relation to relevant literature of avalanche safety literature, learning and decision making psychology.

2 KNOWLEDGE BASE

2.1 Avalanche accidents and education

Backcountry recreation in steep terrain is seeing an increase of popularity in Norway (Brattlien, 2017 p. 8), exposing increasing amount of people to a snow avalanche hazard. During the last 10 years (2010-2020) in Norway 69 people has lost their lives in avalanche accidents (NGI). Fatalities caused by avalanches worldwide count estimated to 250 people annually (Schweizer et al. 2015 as cited in Statham et al. 2018). Majority of the avalanche accidents are triggered either by the victim or someone in the company of the victim (Brattlien, 2017 p. 15., Mccammon, 2000).

Avalanche educators have long recognized the importance of education and decision making in order to prevent avalanche accidents (Mccammon, 2000, p. 4). Increasing the knowledge about avalanches and following the procedures recommended by avalanche professionals will decrease the likelihood of a fatal avalanche accident (Tremper, 2008 p. 23.)

2.2 What causes the accidents?

Today there is certainly many resources from which people can educate themselves about the technicalities of avalanche safety. But if one cannot use the knowledge to avoid getting caught, what is the use of it?

While some of the accidents are caused by simple ignorance, inability to identify the hazard, most accidents are caused by victims underestimating the hazard or overestimating their ability deal with it. Victims tend to make decisions based on desires and assumptions instead of integrating key pieces of physical data (Fredston, Fesler, Tremper, 1994).

As pointed out by Kjetil brattlien (lille snoskredboka) Fredstone and Fesler (1994) categorized avalanche accidents into two types: accidents involving people who didn't know that they were in danger, and accidents where people who actually knows better, exposed themselves to a danger anyway. The first type of accidents can be prevented by teaching the general avalanche knowledge ex. Evaluation of terrain, weather and snowpack. The second type which affects the people who know better, is explained by human decision making errors.

Mccammon applied the concepts of human decision making errors into analysing 622 recreational accidents. He named these decision making errors “heuristic traps”. Mccammon suggested four factors that might have influenced the accidents: familiarity, social proof, commitment and scarcity (Mccammon, 2002). He later added two more (expert halo and acceptance) and developed an acronym FACETS (Mccammon, 2004). Mccammon described, what he called “heuristic traps” as follows:

Familiarity: When exposed to a familiar setting, our past actions guide our behaviour. Even if the hazard level has changed, we still behave like we have been on that setting before. For example we might ski a steep slope in dangerous conditions because we have skied it before and it has never slid. In Mccammons study, this effect was most pronounced with the groups of highest levels of training, who exposed themselves to significantly more hazard in familiar terrain (Mccammon 2004, p.3).

Acceptance: Tendency to engage in activities that we think will get us noticed or accepted by people we like or respect. Hopes to impress others causes us to overlook warning signs.

Consistency: Subsequent decisions are easier if we maintain consistency with initial decision. Our desire to be consistent can overrule new information about the hazard. As we decided to ski that slope, we will do it regardless. In Mccammons study, this effect was marginally significant for parties of three people and significant for parties greater than four people (Mccammon 2004, p.4).

Expert halo: Informal leader makes critical decisions for the party. Leadership might be based on expertise or simply being older, better skier or more assertive than others. Positive impression of the leader leads participants to perceive a person to be expert in avalanche safety.

First tracks: Scarcity of resources. Tendency to value resources or opportunities in proportion to the chance that you may lose them. Individuals take risks to be the first to access untracked snow.

Social facilitation: Presence of other people enhances risk taking when subject or subjects are confident in their skills. People or parties who are confident in their skills, tend to take more risks in the presence of other people or parties.

A review of fatal avalanche accidents in United states in 1990 shows that human factors act as the primary factor in avalanche accidents. Review showed that 73 percent of the victims had at

least some level of avalanche training and many victims considerable amount of avalanche training. (Atkins, 2000 p. 1, 48).

2.3 Healthy decision making in avalanche terrain

Psychologists have identified two ways that humans make decisions. Fast thinking “System 1” is automatic, intuitive and mostly involuntary and slow thinking “System 2” is based on deliberate effort to direct attention to mental activities that demand it. Fast thinking is useful in everyday situations, when it is invaluable to be able to make quick decisions without consuming mental capacity. However fast thinking system is prone to systematic errors in certain circumstances and errors are often difficult to prevent. Errors of fast thinking can only be prevented with enhanced monitoring and effortful activity of slow thinking system in addition to that the slow thinking system is provided with clues to the possible errors. (Kahneman, 2011).

In the high risk and high consequence environment such as avalanche environment, it becomes obvious that we should not rely on our intuition to make decisions about whether to ski a terrain or not. Therefore to reduce human decision making errors in avalanche terrain, we must challenge our fast thinking system that is based on assumptions and desires and get involved into slow thinking processes by implementing systems and rules into our decision making.

To reduce the negative consequences of human decision making errors, it helps to have a good communication in the group: talk about what do you think, what can happen, talk about risk acceptance, consequences of a possible accident and pose critical questions towards your own assessments. Especially when your assessments gives you the answer that you hoped to get. Best way to mitigate the influences of human decision making errors is to use the aid of rules and systems to make thoughtful choices (Brattlien, 2017, s 92-93).

Some of the examples of established systems can include for example: hazard evaluation worksheets, rule-based decision making cards, avalanche-bulletins and danger level scales, safe travel rituals and operational procedures, mitigation measures such as rescue equipment and getting regular, accurate feedback through effective communication for example using “wisdom of the crowds” (Tremper 2008, s. 284).

2.4 Avalanche terrain as a learning environment

Avalanche terrain consists of a “wicked learning environment”, where experience is subject to many filters and distortions. In “kind learning environments” accurate and abundant feedback allows the lessons learned from experience to be reliable, for example in a game of tennis. Lessons learned from “wicked learning environments”, however can be misleading and can often result to wrong conclusions (Soyer & Hogarth, 2020, p. 17-20). For example when person goes skiing, makes risky choices but nothing happened, he concludes that the decisions that were made were safe, and thus get positive reinforcement for the behavior.

Learning through mistakes has been considered to be the most effective way to learn (Ellis, Carrette, Anseel & Lievens, 2014), however in avalanche terrain mistakes can have fatal consequences. It can become costly for everyone to learn the lessons of wrong decisions by getting caught in an avalanche. However learning from others experiences can help us to build our own competences (Soyer & Hogarth, 2020, p. 16). That way we can learn without exposing ourselves to a risk of getting caught into an avalanche.

2.5 Learning from the accidents

University of Tromsø has established a Center for Avalanche Research and Education (CARE) i.a to understand human factors better and with a vision of zero avalanche fatalities. They have launched a series of studies to test the role of experience of accidents in decision making.

This study has been commissioned by CARE in order to deepen our understanding of what people take away from serious avalanche accidents.

In this study im trying to answer the question: How does serious avalanche accident affect the victim and their peers, what kind of learning they acquire and how does it change the way they make decisions and assess risk during their backcountry trips?

Im going to discuss the results of the interviews in relation to what we know about the common factors that can contribute to causing avalanche accidents, what we know about the psychology of human decision making mechanisms and what are the recommended ways to mitigate the common factors that are identified to cause avalanche accidents.

3 METHODS

3.1 Data gathering

Qualitative one-to-one interviews were conducted to seven Finnish backcountry skiers who had experienced a serious avalanche accident in the past. This kind of interviews can provide insight peoples attitudes, experiences and perspectives and therefore was the most appropriate data collection method for this kind of study (Frances & Coughlan & Cronin, 2009, p. 5). Seriousness of the accident was determined by, if the victim or someone in the company of the victim was injured, killed, or suffered significant mental trauma resulting from the accident. Two participants were contacted trough a survey study conducted by CARE, where people who had experienced a serious avalanche accident were asked their willingness to participate in qualitative interviews. Four participants were contacted through social network of Humak university of applied sciences. One participant was contacted trough social media, in regarding to a news article, were the accident had been introduced. Selected participants were invited to be interviewed remotely using online video-conferencing application Zoom. Key importance of video-conferencing is to overcome the barred of geography (Nehls, Smith, Schneider 2015, p. 9). This allowed me to interview Finnish people around different parts of the country.

Interviews were semi-structured interviews and were conducted following an interview guide compiled by the commissioner of the thesis. Interview guide had series of questions about the story of the accident, consequences and changes that people experienced after the accident. Questions were open ended questions, allowing the interviewees describe their experiences as well as possible. Specifying questions were added to provide more detail on specific topics.

Interviews were recorded within Zoom applications own record function and was saved on the computer as audio files.

3.2 Analysis

I transcribed the interviews by listening the recordings with VLC media player. I chose VLC media player for the playback software because it has a function to adjust the speed of the playback and therefore allows more continuous writing without too many pauses. I wrote a literal transcript of the interviews to a word document. I ended up with approximately 90 pages of transcript after writing all of the seven interviews.

I did thematic analysis to the results. Thematic analysis allows researcher to see and make sense of collective or shared meanings and experiences (Braun & Clarke, 2012, p.2) I started the analysis by colour-marking the transcripts with two different colours. For this I was using my apple computers preview software. Statements related to the general story of the accident were coloured with yellow marker and statements related to change or learning was coloured with a green marker. I copied and pasted all of the green sections of the interviews under a single word document categorizing them under a name of the interviewee. I read the materials and summarized the contents into codes next to the paragraph. After coding all of the interviews I compiled the codes to another word document, categorizing them in six different categories: Things that played part resulting into accident, suggested improvements, changes afterwards in actions, consequences afterwards, general advice and positive things about the situation. The codes were placed under each category, under interviewees name.

3.3 Presentation

I will present the cases starting from a short description of a story of the accident and then move on to present the consequences, changes and learning that people experienced after the accident. I selected and presented quotes that were most representative of the research findings as including large portions of interview in research paper can affect the readability (Anderson, 2010, p.3). Each case were given a title, that points to something characteristic about that specific case.

4 RESULTS

4.1 Accident in a “small Finnish slope”

One of the groups in which the interviewee described the avalanche safety skills to have been poor in time of the accident decided to go on to a trip spontaneously and to an unfamiliar place. One of the participants had four years of experience in backcountry skiing and was carrying avalanche rescue equipment. Another participant was a beginner, without avalanche rescue equipment. They ascended a slope once and skied down a successful run. They searched a map and found another slope, where they found softer snow. They planned to traverse a slope that they were planning to ski down to ascend to the top from other side on gentler terrain. While traversing the slope both participants were taken by avalanche and ended up partially buried. They were able to call out a rescue. Victims were stuck under the snow approximately 45 minutes, until one of the victims were able to dig himself out of the avalanche. He had started to dig out the other victim while rescuers had arrived. One of the participants ended up with a leg injury.

“We found there from southern side a slope with good amount of snoft snow, but we should have been recognized it being avalanche terrain. We were a little blided by the good conditions, it was so great snow to ski there.”

Consequences after the accident

In less than a month after the accident interviewee completed a three day avalanche course. After experiencing the accident and taking the the avalanche course afterwards his experience of safety had increased.

“I feel more safe there now that I know what can happen in avalanche and after taking the course i got quite good info package of how can those situations be avoided”

He described that the accident also enlightened his peers about the avalanche danger in Finland. Several of his friends had signed up to an avalanche course after the accident. He described that many had been downplaying the avalanche risk on “small slopes of Finland” and after the accident himself, and several other people have taken the avalanche danger more into consideration.

“Couple of other friends have signed on to courses too and have started to be more careful about where to ski in Finland too. It helped several of my friends to take it more into consideration”

Interviewee described that his partner that was involved in the accident has not been skiing in the backcountry after the accident.

Learning points from the accident

Interviewee described that the situation started to go wrong from the beginning as there was no planning done for the trip.

“There was no actual planning to be honest”

They found a slope with good amount of fresh snow, but they should have recognized that to be avalanche terrain. He mentioned that they were blinded by the good weather and that the snow conditions seemed nice. He said that they should have recognised the weak new snow transported with wind.

“Wind had been so that it had deposited new snow there, surely should have identified that”

He added that since it was unfamiliar area they should have gotten more familiar to it beforehand, as during the accident they ended up to be on the most avalanche prone slope of the area.

Interviewee concluded that it was a bad idea to ski that slope and that they should have gone around the steep section and ski on the gentle part instead. Also they should have had longer safety distances while crossing the steep slope. He identified that he has been downplaying the avalanche risk in Finland because of relatively small slopes, but concluded that smaller slopes can avalanche too.

“Maybe i have underestimated it a little that we have supposedly so small slopes, but surely the small slopes can avalanche too..”

He added that the trips should be planned, and from the accident area he could have gotten information from his friends that had skied there before. After the accident and after the avalanche course he had become more aware what can avalanche and what kind of slopes will likely avalanche.

Changes in actions in planning phase

Interviewee described that after the accident he had been taking weather and snow conditions more carefully into consideration when moving in avalanche terrain.

“Conditions need to be so that there would be approximately safe to travel”

He described that from now on he will get more familiar with the intended ski area before the trip, plan the route more carefully and inform a friend where he is planning to go and when.

Changes in actions during the trip

Interviewee had been more focused on reading terrain after the accident. He gained knowledge of how to read terrain from the avalanche course. He has also been more ready to make changes to plans if the originally intended location seems unstable. He added that he doesn't take unnecessary risks. After the accident interviewee has been more carefully choosing the ascend and descend routes, instead of simply choosing the shortest route.

“It changed quite a lot, i choose more carefully the ascend and descend routes. So far i have skied quite randomly, looking at the shortest route and trying to go there”

Some of the risk mitigation techniques and tools that the interviewee had started using after the accident includes: keeping safety distances, using phone applications to see the steepness maps of the area, local measurements of steepness with avalanche beacon and using a decision making card as an aid in decision making before and during the trips.

4.2 Accident in 90s

Interviewee joined into a group that was planning to go skiing to a location where they had been on a previous day. It was a common location for local skiers to visit outside of the ski-resort area and was accessible with a ski lift with some traversing from the top of the lift. They had not made specific plans for the trip. He described avalanche safety skills of the group to have been poor in time of the accident. He added that avalanche awareness in that time was not a popular topic and that avalanche forecasts were not easily accessible. As they were skiing down from the chosen location, one of the participants dropped down to a gorge and triggered an avalanche. Some of the skiers were sent to the ski resort to call a rescue operation, since during the time of the accident mobile phones were not common. Victim was taken by the avalanche over a cliff and was soon found to be dead 1000 meters below by the interviewee.

“Skier, who died in avalanche accident jumped from a drop of some size and triggered an avalanche straight from the landing”

Consequences after the accident

Interviewee described that the accident had several mental consequences and that it has been traumatic. It took him a long time to recover from the immediate shock. He could not describe the long term consequences of the experience. The accident had pronounced impact on the ski community locally as well as in victims home-country, where he was an important figure in the skiing community.

“From that accident, time has passed about 25 years, and still there is arranged annually a commemorative event.”

Changes in actions after the accident

Interviewee didn't describe the accident to have had pronounced effect on changing his behavior during backcountry trips or during the planning phase of the trips. He said that the accident has maybe acted as a motif on the background to become more knowledgeable about the avalanche subject in along with other accidents that had happened to his peers during the years. As a single event, he didn't recognize the accident to have been significantly changing his actions. He said that already before the accident they had been doing functioning according to their best knowledge, but the competence level was not very high.

“That was just the case where i happened to be present myself.”

Interviewee described to have been part of a skiing community during the time of the accident, where it was a common ideology that passing away on mountains is in a way a natural way to die.

Interviewee described that knowledge about trip planning aids, and established decision making systems, was hardly available to the public during the time of the accident. Trip planning during the of the accident time had been rather simple process and almost like based on anecdotes in comparison to what it is today. He said that systematic decision making to backcountry trip planning had become involved much later and was learned later from other context. The accident had not directly affected the way he planned backcountry trips.

“That learning has been acquired later in other ways.”

Skiing tactics, such as skiing one at a time and using safety-spots had been in use for the interviewee during the time of the accident. The accident probably didn't have any effect on them.

Changes in experience of feelings after the accident

Interviewee didn't describe the accident to have resulted to decreased self-confidence in backcountry trips. He said that this and other incidents have instead resulted to increase in confidence as he had learned more about the avalanche subject later.

“Especially If I think about it now, that's where we have started, in that sense it has rather removed uncertainties. Other accidents that I have had to encounter, have rather raised my confidence. Of course rather trough learning this thing a bit better. Or getting hold of it by studying”

Learning points from the accident

Interviewee described some of the reasons that affected the result of the accident to be lack of understanding and implementing statistical probabilities into decision making. He added that this kind of thinking had come along much later.

“We haven't understood very well what statistical probabilities mean and their meaning in regarding to practices. This way of thinking has become involved much later.”

He said that in some way they were certainly ignorant, as they knew about the risks, but were incapable of managing them. During the time of the accident avalanche forecasts and weather forecasts were challenging to get access to as accessing internet were very limited.

“Could have known more things, could have had more skills, could have had ability to think better. Getting educated and studying the subject and smart thinking, self-improvement should be the way to move forward. Especially nowadays, it is especially pretty easy when the knowledge is available so it is recommendable to get it. Then it was different.”

4.3 Accident down in the forest

The group that did not have avalanche professional in the group, described the snow-safety skills of the group to have been in a good level during the time of the accident. He specified that all of the participants had lots of skiing experience, also from challenging terrain. They have had similar way of making decisions and risk management and they all knew how to use the necessary equipment. They had been aware of the avalanche risk during the accident day and had taken that into consideration in the trip planning. They decided that they will not go to ski risky terrain, but chose to ski on lower elevation so that they could ski mostly below the tree line. As they were skiing down from the top, they started carefully while deploying skiing tactics such as keeping long safety distances. They kept skiing carefully below the tree line, mostly in a mellow terrain. As they were almost on the bottom of the valley where they were the run was supposed to end, they arrived to a place with a dense forest. As it was approximately 100 vertical meters left to the bottom, they concluded that it was a success and there is no danger anymore. One of the group members started to ski the last part down in a brisk manner. He soon triggered an avalanche and got taken by with it. Interviewee described to be surprised of the slide, because he thought it was not that steep there and because of the dense forest. Rest of the group had first difficulties to locate the victim, because of the dense forest, but were able to get in contact to him by using walkitalkies. Victim had slid with the avalanche trough a steep gorge for a long distance. Victim was not buried but ended up with injuries from colliding with obstacles throughout the slide.

“We were much more careful up there and sort of mid section of the mountain. We kind of waited the avalanche and tried to do everything that we could not to trigger one, and we tought many things on the way. But when we were there very low, there came that kind of, we felt like okay here is no any risk anymore, but there was.

The interviewee described that the accident affected the skiing of the group during the rest of the trip and also generally his skiing afterwards. He said that there was lots of learning and that they were thinking about it a lot afterwards.

“I think that all of the skiers in same way, propably everyone learned something from it.”

Changes in planning phase

He described some of the things that had changed in result of the accident to be more careful planning and preparations. He specified that there has been more talking about the hopes of the individuals in regarding to the trip. What kind of skiing are they going to do, what kind of risks there are and how to control those risks. He added that he would also not assume that below treeline there could not be avalanches.

“Harmonizing the goals, maybe it is so that we talk before what kind of skiing were going to do and what kind of risks there is and..”

He said that after the accident he reads maps more carefully, focusing on the steep places. He said that one of the effects might have been that he didn't necessarily need to ski the steepest slopes anymore.

“Probably i read maps eaven more carefully, looking at the steep places”

Accident didn't decrease his amount of skiing, but it had decreased the amount of exposure to most avalanche-prone places when there is avalanche danger in the area. Route selection and the related decision making had become more conservative.

Changes in behaviour during the trips

The interviewee described that some of the changes after the accident included being more observant of the snow quality under skis and being more attentive about possible hazards during uphill and trying to avoid them. However, he could not be sure if these changes were result of the accident or something else. He described that the accident has probably made him more observant of the surroundings generally. He described that he is more alert and careful after the accident.

“That has probably changed that I try to observe my surroundings more”

Learning points from the accident

The interviewee described some of the relevant learning points from the accident to be that when you see the avalanche coming, the avalanche airbag should be deployed right away, or otherwise it might be too late, like in this situation happened.

“Because of if you think about it too long, it might be too late, like in this case happened that it was not possible anymore”

Secondly he mentioned, that one should not trust too much to the safety that trees can give to the skier. And that apparently they should still be cautious even when skiing in places that are experienced as safe. He had triggered an avalanche before on a mountain without any trees, and it had been much more clear where the avalanche started and ended in comparison to this case with a dense forest.

“Apparently one cannot be too careful even in a place that is experienced as safe.”

The interviewee also emphasized the importance of clarity of communication during the problem situations. He said that walkie-talkies were significant aid in the accident scene, when proximity of trees resulted into decreased visibility.

“Using walkie-talkies or some other way to ensure effective communication in a problem situation”

Lastly he mentioned that it is good to talk about the day within the group after a skiing day, especially after accident like that and reflecting how did it go and how could it have gone better.

4.4 Accident in “familiar backyard slope”

One of the three groups that had an avalanche professional as a participant was going to have a two-three hour trip to a familiar location, where they had been skiing regularly. Interviewee

described the group to have been experienced and all of the participants had some level of formal education in avalanche safety. They knew that there had come plenty of new snow with strong wind and as the weather turned sunny, they decided to go on to a trip.

“Maybe there was kind of a burn that now we must get to ski something soft too. We got that sunnier day and went on for this slope”

On the way up they discussed topics of avalanche safety and decision making. They dug a snowpit, observed the snow and decided to hold on to the decision to ski down the slope that they had previously decided to ski.

As all of the skiers had descended the steepest section and were standing below, waiting for a dog to follow down the tracks of the last skier, the slope fractured. The dog and the interviewee was taken by the avalanche. After been fully buried, the interviewee was able to make an air hole and dig herself up with help of a friend. The interviewee survived with minor injuries. The dog that was with the group could not be found afterwards.

“I didn’t start to ski right away, but i looked where should I ski, and I got to ski few meters maybe until the avalanche took me with it.”

The interviewee described that they all had been aware that there is a possibility for triggering a small avalanche. They thought that if the avalanche would come close, they would be skillful enough to ski away from it and to a safe spot.

“To be honest all of us certainly thought that there is a possibility to trigger some small avalanche, and if that avalanche would come towards us or come close enough, we thought that we are good enough to ski, that we can ski away is something releases. So that we can ski fast enough to a safe spot.”

None of the participants in the group expected the avalanche to be as big as it turned out to be. Some locals had said that there have been big avalanches before and some have been warning about the place more than the others. The interviewee described that for her and the rest of the group the slope had been a “regular backyard slope”. She said that they thought that they know it well enough and all of the dangers that there can be.

“One of us has lived here 10 years, and has never seen avalanche that big there before. But on the other hand, some locals said that there has been big avalanches before.”

“For us it has been sort of “basic slope”. In a way we thought that we would know it well enough, all of the dangers that there can be.”

She added that they thought, that if they would not go there now, then someone else would go there soon. And that there was other people planning to go there that day, but they were going first.

“Also in a way, we thought that if we don’t go there now then someone will go there soon certainly. And there was couple of friends going there during the same day, but we were going first.”

Interviewee described that they thought that they could control the risks sufficiently, but they didn't expect that they could remote-trigger something so big.

Changes in experience of feelings after the accident

The interviewee described that the accident has been traumatic and that she has seen many nightmares of avalanches afterwards. She described some of the consequences to have been loss of confidence into her own decision making during downhill runs. Some of the doubts that has been present include whether she manages to stop to a safe spot and whether she manages to avoid skiing over terrain shapes (rollovers) that might have potential to avalanche.

“I have gotten more fear towards my own assessments during the downhills.”

She described that she has not been very confident after the accident, however it felt good and mostly normal to go to mountains again. Sometimes she experienced sudden feelings of uncertainty, but could not point out whether it was the result of the accident or something else. Going out with a dog has caused some nervousness. She explained that the dog cannot escape even small avalanches. Forementioned things has been causing sometimes lots of stress, when moving on mountains.

“I haven't been very confident after the accident, if im able to make right decisions. On the other hand, it feels good to go to mountains and it feels mostly normal, as before the accident.”

“It causes quite a lot of stress sometimes when going there on mountains.”

She said that the feelings towards mountain sports and backcountry skiing has been more serious for the whole winter, and even more so after the accident. She said that after the accident, skiing on less steep terrain for a while had made her to miss skiing in steeper terrain. After she had started to ski more steeper terrain again after about a months break, she described that she felt more like herself again.

“I haven't felt that much of myself while skiing mellow, as safe as possible, nonetheless fun lines. I have skied so safely that there has not been that much to get excited about.”

Acute changes in trip-planning

For approximately a month, interviewee wanted to plan the backcountry trips mainly away from avalanche terrain and to cross some smaller uncertain places only in as stable as possible conditions. She wanted to plan the days without need to stress about the avalanches and some situations choosing a safer route down if feelings of nervousness arised.

“If we have chosen to ski some line and then I started to get nervous, that maybe I don't want or maybe its not safe enough, then I skied safer route down, a different route.”

She said that after a month she felt that she wants to ski something steeper as well. She regained her confidence to ski the places in lower elevations where weak layer cannot cause big avalanches. She described it to feel good to ski steeper terrain lower in the forest as long as she takes windloading into consideration.

“I think that about a month i took it very carefully, but now I feel like I want to ski something steeper too.”

Changes in behaviour during the trips

The interviewee described to have been more focused during the trips in noticing dangerous terrain features, for example rollovers, where it is possible to trigger avalanches and terrain traps, where snow can be accumulated.

“Its relatively mellow and easy slope, but eaven there maybe i focus now more on the dangerous places.”

She added that it had reminded her of the basics about terrain shapes and that eaven “so called safe slope” is not safe anymore if you happen to be in runout zone of possible avalanche and therefore risk remote triggering an avalanche. She added that after the accident, she has been more focused on noticing safe-spots and planning the downhill skiing strategy during the uphill. She has become aware of the challenges of navigating to safe spots and acknowledged the need to practice that.

“I have felt like i just have to practise the navigation more and focus on it more.”

She said that during the trips she observes the snow quality under the skis more and tries to do quick assessments of snow on the way up.

She described that the accident had affected most choosing the downhill skiing routes. After the accident she has been taking the unstable snow conditions more into consideration when choosing the route down, sometimes choosing a less steep and safe route instead of fun looking route.

“Eaven that I would like to ski some line that looks fun, I might end up not skiing it and ski more mellow and safer line.”

“Now especially the conditions are so, that its not necessarily recommended to ski where it looks most fun, but have to really stay in the safe areas.”

Changes to trip planning and preparations

We asked if the accident has been changing the way interviewee plans her trips to avalanche terrain. She described that she has been reading the avalanche forecast more carefully. Instead of relying mainly on her own and trip-companys assesments, she has implemented other peoples assesments found in varsom regobs application more widely in trip planning.

“That its not only my own assessments and trip-companys assesments but. I try to use others assessments also in my trip planning. And reading what they have found when they have dug snowpits and assessed the snow.”

She said that some of the things that had chaged was that she has been more strict of bringing the dogs to backcountry trips. If there would be possibilities for eaven small avalanches, she didn't want to bring the dog along.

She added that after the accident they have been more openly discussing the hopes of the participants and focusing on making the plan together. She added that after the accident the communication within the group had improved and that has made the trip planning easier.

“After the accident, we discuss more openly what each of us want to ski, and we make the plan together.”

“I feel like I can say honestly if something doesn’t feel good and I would rather ski the other way.”

Learning points from the accident

Interviewee described some of the learning points to be to think from various perspectives what is safe and what is not and that on that given day their assumed to be safe local slope was not safe.

“This kind of our basic safe-assumed slope, well was certainly not safe on that specific day.”

There was others going to the same location and could have ended up in accident following the interviewees and her groups tracks.

“Others thought too that it would have been safe enough that day.”

She said that they could have avoided the accident by choosing another, less steep route down and skiing down following the uphill tracks.

“Probably smartest would have been that we would not have skied that slope, but skied the same route that we ascended. That would have probably been safe.”

They all knew that strong wind had blown from such a direction that it had collected lots of fresh snow onto the steeper accident slope and she said that they should have taken that much more into consideration.

“We should have taken that much more into consideration.”

They thought that because of wind loading, there could be some small avalanches, but they didn’t take into consideration of how widespread the weak layer was, how low in elevation it was and that it could lead to remote triggering big avalanches. They also didn’t take into consideration how far could avalanche be remote triggered and how big avalanche can be remote triggered.

“We all knew it, that something small can release because of this, but we didn’t consider how widespread the weak layer was, and that it was so low in elevation that time too.”

4.5 Two accidents with communication issues

One of the interviewees who had avalanche professional in the group had experienced two accidents that shared some similarities in a way that they both involved a failure of communication that led into problems with group management.

4.5.1 Leader behind the group

During the first accident the group was touring in clearly avalanche prone conditions. Strong wind was blowing new snow from the north and therefore they chose to go skiing on a gentle and safe wind-facing slope where the snow would not accumulate. However he did not remember that the route goes through a depression that has a leeward facing slope. At the beginning of the trip, they crossed the slope without problems, but on the way back wind had accumulated snow on that slope.

“On the way there we didn’t have problems, but when we came back wind had deposited snow there.”

The most experienced person was leading the group and opening track. He started to have problems with the ski-bindings and so the other participants took over and started to walk in the front. Less experienced participants who were now opening the track started to hear sounds of snowpack collapsing and tried to communicate that to the more experienced person who was behind the group. But strong wind resulted into them not hearing each other. Group kept walking forward and soon the person on the front got taken by avalanche. He described that in this case as well as the second accident, the failure of communication resulted into decision making error and that led to the accident.

“Same as in the other case, when its strong wind and snow, and in this case safety distances, the message didn’t come to me who was in main responsibility and that resulted to failure of decision making.”

How the accident affected others

In the first accident, the person who got buried was a beginner and resulting from the accident had a strong mental reaction. After the accident the person who got buried had become very conservative towards moving in avalanche terrain. She has been avoiding avalanche terrain as much as possible, however they had not completely stopped moving in avalanche terrain.

“Psychic damage was quite significant.”

“We keep safety margins quite big, and mostly have skied in the forest. In a terrain where there is no avalanche danger.”

Changes in experience of feelings after the accident

Interviewee described that after the accident he has experienced more fear and worry towards others as well as increased sense of responsibility.

“Worry and neuroticism has increased in it.”

Interviewee didn't experience any trauma after the first accident, but described that it has affected his decision making and actions.

Changes in planning phase

After the accident the interviewee had become more conservative in selecting the trip location and route selection while taking the conditions and the group into consideration.

“It has affected what slopes to ski in what conditions and the route selection. Also to what kind of group to go where to ski.”

The interviewee described that if the group had participants who were inexperienced and in lacking capabilities to assess risks and individual decision making or willingness to accept risk, the decision making and route selection has in those cases become very conservative, choosing routes that are certainly safe.

“In these kind of situations I will choose more clearly routes that are certainly safe.”

When there was several women in the group, the route selection was more conservative than with a male-only group. He could not be sure if it is because those women he has travelled with had been less experienced than men who he has been travelling with or because women generally wants to take less risk.

“In the male group there is clearly more willingness to take risks.”

He had been skiing less in most avalanche prone terrain after the accident diminishing his exposure to avalanche risk, however he added that aging had been probably affected that as well. He has been more conservative in decision making generally, but could not be sure how much aging has affected in comparison to the accident.

“I am more conservative, but I have been thinking whether it is because of the accident or it had become with age. Im not sure how much each has affected.”

Changes in behaviour during the trips

Interviewee said that the accident has not diminished the amount of travelling in avalanche terrain other than in the previously mentioned circumstances, however he added that in the situations where risk-level has risen for example in result of a sudden change in weather, it has led to more conservative decisions. He described that after the accident he has more commonly chosen alternative routes during the trips when clues pointing towards heightened avalanche risk had occurred.

“If the risk level has been clearly rising, it has lead to more conservative decisions.”

“Maybe I have more easier chosen alternative routes, when there is evidence of heightened avalanche risk.”

After the accident he has skied more often in the forest, since he had experienced it to be safer.

Interviewee described that a clear change resulting from the accident was that he has been focusing more to group management, common procedures withing the group and and ensuring good communication and collaborative decision making.

“Actually to the common decision of the group of where to go, and that we listen to the all of the participants.”

“These kind of rules of moving with the group. If there is this kind of uncertain place, we don’t let anyone to go there.”

Learning points from the accident

Some of the learning points from the accident included importance of communication. He described that failure of communication resulted into the accident. Cold and loud wind resulted into not hearing others and need to move quickly. He said that the both accidents had the same problem. He concluded that the communication and that it reaches everyone needs to work better.

4.5.2 Peek around the ridge

During the second accident interviewee was with another group. During the time of the accident avalanche risk was rated at 3: considerable. They chose a familiar location, gentle terrain with a ridge that they knew to be safe. They ascended along the ridge and decided to ski down from tree line. One of the group members was ready to ski down before the others and decided to take a look to other side of the ridge while waiting for the others. He went approximately one meter around the ridge and then got taken by avalanche. The rest of the group was in a safe spot and got hit by the avalanche but were not taken. The person, who was taken went 110 meters down with the avalanche. As a result, he suffered a knee injury. The interviewee described the accident to have been resulting from a problem with communication and lack of common procedures of how to move and function together.

“We had this kind of communicational problem and organization problem in how to move and function as a group.”

Changes in result of the accident

After the accident the interviewee organized everyone that had been involved in the accidents to take avalanche course together. He wanted to distribute the responsibility of safety more with other group participants and persuaded the others to take an avalanche course.

“I said that I want to lessen the responsibility that I have in this travelling. I want that others have knowledge and skills to be able to take responsibility and know where they are going. So you should take this avalanche course.”

Some of the participants took a beginner course quickly and then advanced course afterwards. All of the participants eventually took advanced avalanche course.

Changes in planning after the second accident

Interviewee described that after the second accident he has been more strict about skiing in avalanche dangerous areas and have requested more rational reasoning to ski in places that can be avalanche prone.

“Decision making has to be based on facts and procedures better than before.”

He added that he has been considering to hire a guide for the next trip to increase the safety of the group, and feeling of safety as well as decreasing his need to take responsibility in the group.

“Because it affects the safety of the group, and feeling of safety so it is possible to enjoy more. Also it would help me to be less responsible in the safety of the group.”

Comparison to the first accident

After the second accident, interviewee didn't experience major changes in feelings. He acknowledged that similar kind of mistakes repeated in the second accident and it resulted into some self-criticism. The interviewee described the first accident to have had bigger impact on him in many ways and that the second accident acted as a reminder that there is still need for operational improvements.

“First accident had bigger impact in many ways. This was more like a reminder that there is still improvements needed in the practices.”

The interviewee described that in the second accident there occurred a similar situation as in the first accident, as it was cold wind and snowing. The conditions resulted into not discussing about the route selection together and while one person started to lead, the others followed, being uncertain about the route.

“Conditions resulted into not discussing properly enough where to go. It happened that one started to go own route and other followed with uncertainty.”

Later they realized that they had chosen a wrong route and that could have resulted to an accident. He concluded that reinforcing the communication and creating common procedures failed in the both cases of accidents.

“Reinforcing the communication and having common rules how to function as group failed in both cases.”

4.6 Accident with students

One of the accidents that had avalanche professional in the group happened during a school trip with students. Group consisted of a teacher and two students. They had a trip plan, including a detailed route plan and ATEs-rating previously made for the trip. Goal of the trip was to go to see how is the snow situation in that time of a year in that area.

“We didn’t set any particular skiing goals.”

They did a risk assessment and read avalanche forecast before leaving to the trip. The teacher had also done avalanche forecast in the same aspect previous day. They followed a protocol that they have with the school groups, including buddy check of the avalanche beacons. On the way to the accident slope they made continuous observations of snow quality. They walked on top of the accident slope and observed that there was no cornices in the area and dug a snowpit. Snowpit showed stable conditions and no weak layer.

Avalanche forecast was rated 3:considerable during the time of the accident. Local forecasters had given a number 2, including himself. Avalanche problem was persistent weak layer and the weak layer had been deep in the snowpack. The weak layer could not be seen in the snowpit that was dug by the group above the accident slope.

“Up there when I dug the snowpit, there was no weak layer.”

They decided to ski the slope according to their previously defined protocol. Teacher skied first and was going to give a sign to ski for the others after he would be down. As he skied down, on the point where the slope turned more gentle and snow quality changed softer, he got taken by a big avalanche. He tried to engage the avalanche airbag, but was unable to do so. He travelled approximately 400m with the avalanche and stopped, ending up fully buried. He was able to make an air hole with his hand. The students descended down and were able to dig out the victim without need for additional help. The victim ended up with a knee injury.

“It had released 100-200 meter above me. Over a meter deep.”

Changes after the accident

The interviewee described that some of the things that had changed in result of the accident was increased openness in the school organization about their operations and basis of their decision making. They had updated their trip plans and risk assessments to cover the locations with more simple terrain types in addition to the previously made plans for more complex terrain types. Trip plans had become open for the parents to observe. They had started to do the risk assessments in collaboration with the students, compared to previously only made by teachers. All of the students had started to fill up risk assessment to each trip including looking at the avalanche and weather forecast and self-assessment. The interviewee summarized that what the accident had most effect on was that the operations of the school organization

had become more open and collaborative. Resulting from the accident, the parents had been more interested about the school organisations operations and that had increased the openness and collaboration.

“We have gotten the organization much more open and there is more conversation. It has made the operations more open and communal.”

The interviewee wanted to increase the openness about the snow-safety theme in the school organization, for example by posting videos about avalanche safety in social media. He wanted to educate people about the realities of avalanche risk in Finland.

“Avalanche risk is real also in Finland, like this year has shown.”

Changes in behavior after the accident

Interviewee described some of the changes in his behavior in result of the accident been for example focusing more carefully in decision making and risk-assesment. He said that after the accident he has been more careful and more skeptic.

“More thinking about decision making and risk-assesments.”

Changes in behavior during the trips

Some of the changes in result of the accident during the trip was that the interviewee had increased the amount of reflecting of his own snow-observations and forecasts to the other local avalanche forecasts.

“I reflect my own and regional avalanche forecasts to the snowpack of the area and terrain. I have allways done it but maybe eaven more after that.”

He added that he has been more focusing on observing his surroundings after the accident for example snow and weather. He has additionally been more alert after the accident.

Changes in the planning phase

He said that after the accident he had become more open and collaborative about trip planning and decision making, often engaging the students to participate.

“I want to emphasize making decisions together reflecting on avalanche and weather forecasts.”

Learning points from the accident

Interviewee described some of the learning points from the accident to be that because the location where the accident happened is very avalanche prone, it should not be skied until later in the spring as the slope is very prone to collect wind drifted snow. He added that people should realize that big avalanches can happen in Finland too.

“I don’t understand where does the idea come from that in Finland there could not be avalanches, while they regularly happen.”

4.7 Accident in Tamokdalen

In this case the interviewee was most experienced in the group of eight people in total with approximately 15 years of back country skiing experience. Other participants had varying amounts of experience ranging from 10 years of back country skiing to five and three years. Six of the participants were beginners with relatively little back country experience. All of the participants knew how to use avalanche rescue equipment and had done at least some practice with them.

Interviewee originally had a plan to ascend a certain slope by a known, regular route. Because of a sudden failure of their vehicle, they had difficulties to access the normal starting point of the route. As a result, they decided to approach the slope directly from their accommodation with relatively big group of people and eventually ended up following a wrong route. Weather was challenging with some snowfall. The interviewee was opening track and noticed that the snow on the slope that they were ascending was unstable. However, they decided together to keep ascending the route, but not to ski it down and rather choose a different, less steep route. As they reached the top, snowfall was intensifying and resulted into reduced visibility. They did not want to descend the different route with reduced visibility, since they had not ascended it and there was dangerous rocks and cliffs in the area. So they decided to follow the same route down, even tho they knew that there was potentially dangerous slope with unstable snow. They skied the uncertain slope carefully one by one and everything seemed to be fine. As sixth skier was descending the slope, he triggered an avalanche.

“We have to go this same route down where we came from. It is familiar and we know it. There is that one slope, that is dangerous but lets go carefully.”

The person who triggered the avalanche and two other skiers, including the interviewee was taken by the avalanche. Snowboarder who triggered the avalanche was partially buried and was able to dig himself free. The interviewee was fully buried, but was able to make an air-hole, and eventually dig himself free. Third skier who was taken, was buried upside down with a leg above the surface, on of the skiers who was not taken by avalanche was able to dig her free. The interviewee ended up with a leg injury resulting from collision with obstacles during the avalanche, the other people were not injured.

“I remember cursing that i had I have my beacon in the backpack so now I cannot let the backpack go anywhere.”

Consequences for other people from the accident

One of the skiers, who did not end up being taken by the avalanche was seeing nightmares about the event for some time after the accident. One of the persons who were buried upside down, had not been skiing in the mountains after the accident.

Changes in behavior during the trips

Interviewee described some of the things that had changed as a result from the accident. After the accident he dug more snowpits during the trips, when he was concerned. He has also skied in smaller groups after the accident, preferably in two to three or maximum of four people groups. He had been more aware of the small challenges adding up, and been more ready to abort the trip if the challenges multiply too much.

“At that point I have rather aborted the trip, when it seems like now its getting multiplied something littlebit too much.”

After the accident interviewee had focused more on assessing the snow quality during the trips, by skiing on the side of the track and stopping occasionally to study the snow if he observed changes in the snow quality.

“If I don’t understand why it changes, i start to observe it more, why it changes and what is underneath there now.”

He described that he has been more alert after the accident during the trips. He has also been more careful in selecting the group participants and location according to the participants. When there has been people in the group who he doesn’t know so well, or he doesn’t know their capabilities, he has been keeping higher safety margin in comparison to the cases where he is travelling with people whos decision making and skills he can trust. After the accident he likes to ski with more experienced, skilled people who has capability to assist with decision making, when needed.

“Then safety margins are considerably bigger in comparison to when im with people whos decisions I can trust and they are capable of helping me.”

Changes in planning phase

Some of the things that interviewee had changed after the accident in regarding planning was that he follows the weather forecast, avalanche forecast and other snow observations very closely, however he could not be sure if the it resulted from the accident. He added that something the accident has probably affected was the route planning. After the accident he had been keeping the route choises more open for changes, often preferring to have several alternative route options to choose from. He had been specifying the route choises during the trip, while taking the snow conditions into consideration. He has been trying to avoid situations similar to the accident, when he was very limited in his route options.

“I try to avoid situations where I don’t have options. I try to allways keep few options to choose from, what feels best in the moment.”

After the accident interviewee has been preferred to ski in familiar locations, especially when weather has been challenging.

“I like it because then i know where i can go and when.”

After the accident interviewee has been enjoying to maintain a bigger safety margin. He specified that he prefers, as a basis to ski in safer locations and better conditions rather than trying to find a safe way out from challenging places. However he added, that it might also be a result of aging.

“I find more pride in not having to find safe route down, but rather skiing in safer places and in better conditions.”

Learning points from the accident

Some of the learning points from the accident that the interviewee mentioned included that ability to choose between two choices is always better than not being able to choose. Being forced to follow a certain route is not a favourable situation. He added that when there the smaller challenges multiply too much it is better to abort the trip, rather than forcefully continue, since it can lead to problems escalating.

“Possibility to choose between two options is always better than no possibility to choose.”

“Should be able to abort the trip when it feels like im forcefully carrying on while everything seems to be against it.”

5 DISCUSSION

In the knowledge base section i reviewed the avalanche accident subject from different points of view, leaning on to prior research and literature of avalanche accident statistics as well as human psychology of decision making and two different types of learning environments. I introduced some of the factors that contribute to causing avalanche accidents as well as recommendations of how to mitigate the effects of those factors to be able to recreate safely in backcountry environment.

I pointed to the importance of education and decision making in prevention of avalanche accidents as well as the importance of using systems and rules to reduce the effect of human decision making errors that we are prone to.

I collaborated with CARE research center to do qualitative interviews of seven people, who had experienced a serious avalanche accident in order to deepen our understanding of what people take away from avalanche accidents and how does it change the way they make decisions and risk assessments during their backcountry skiing trips.

In this section im going to discuss the results of the interviews, trying to identify cues to what we know about the common contributory factors of avalanche accidents, human decision making mechanisms and the recommended ways to mitigate the effects of human decision making errors. Im going to discuss the cases one by one in same order that they were presented in the results section.

Accident in a “small finnish slope”

In this case, interviewee described the avalanche skills of the group to have been poor and victims were unable to identify the avalanche hazard. Interviewee said that he had been underestimating the avalanche hazard in Finland because of relatively small slopes that we have in comparison to other more mountainous countries. He described that before the accident his route selection had been rather intuitive process and mainly based on impressions like “that seems like the shortest way, so lets go that way”. After the accident he completed an avalanche course and as a result, gained knowledge of systems and decision making tools that he started to implement to his decision making during his backcountry trips.

To be able to prevent accidents like this, group must have the knowledge and skills to make decisions based on the evaluation of terrain, weather, snowpack and participants. Avalanche victims tend to make decisions based on desires and assumptions instead of integrating key pieces of physical data (Fredston, Fesler, Tremper, 1994). In avalanche terrain, instead of relying on our intuitive, fast thinking thought processes, route choices should be made using what Kahnemann (2011) called the slow thinking system.

If the slow thinking system is not provided with cues for possible errors, it is unable to prevent the errors of fast thinking system. In other words, if person doesn't have the knowledge to identify possibly dangerous conditions of terrain, snowpack, weather and people, they are left to make the decisions based on impressions, intuitions and feelings of fast thinking system which in combination with irregular and misleading feedback that avalanche environment is know for, can lead to developing erroneous beliefs and dangerous habits. Like in this case a belief that avalanches cannot basically happen in Finland because the victims or their friends had not encountered one had lead to rather casual and intuitive decision making in route choices, that in turn resulted in dangerous accident.

This accident illustrates what a transition from intuitive, fast thinking decision making process to potentially slow-thinking, effortful thought process can look like. Moving from making route decisions based on intuition and beliefs into using tried and tested systems with clues to possible hazards to be able to make more reliable choices in high-risk environments. It is worthy to mention that while avalanche course can provide us the knowledge and tools to be able to identify clues to possible hazards, it cannot force us to actively challenge ourselves to make informed choices with enhanced monitoring and effortful thinking. This we must do ourselves. It is a precondition to be able to overcome the decision making errors that we are prone to, and there is many tricks that our minds can play to inhibit our chances of accessing those clues.

Accident in 90s

Another accident where interviewee described the avalanche safety skills of the group to have been poor in time of the accident happened approximately 25 years ago. Interviewee described some of the challenges during the time of the accident to have been difficulties to access avalanche and weather forecasts and lack of established decision making systems. He said that decision making in the planning of the trips had been rather simple process and almost like

based on anecdotes in comparison to what it is today and that systematic decision making had become involved into backcountry skiing much later. Some risk mitigation measures that the interviewee had already been implementing was: skiing tactics, such as skiing one at a time and skiing from a safety spot to another as well as using avalanche rescue equipment. He described that the accident had maybe acted as a motif to learn more about the avalanche subject and that generally studying, smart thinking and self-improvement should be the way to move forward with the issue, especially in the modern days when the information is available.

Like in the former case that i discussed, in this case the group participants were in lack of essential knowledge and systems to make informed and safe terrain choises. Absence and accessibility issues of systems and procedures to mitigate the risks that the group was exposing themselves to, had resulted them to retreat into making critical decisions with dangerous consequences based on intuition and belief. However, the group was not completely absent of risk mitigation measures, as they had been implementing skiing tactics and at least the interviewee was carrying some kind of avalanche rescue equipment (beacon). As information, modern procedures and risk management methods that people commonly learn from avalanche courses were significantly more limited and hardly accessible during the time of the accident, those who wanted to go skiing in avalanche terrain regardless had to compensate the relatively lower safety levels with higher risk-tolerance and probably some amount of ignorance.

Accident down in the forest

In this case interviewee described the avalanche safety skills of the group to have been in a good level. All of the participants had lots of skiing experience, also from challenging terrain. He said that all of the group members knew how to use the necessary equipment and that they had fairly similar, smart way of planning the trips and managing the risks. Other than that, he did not mention if participants had experience of formal or informal training specifically in avalanche safety skills. The group was aware of the avalanche risk during the accident day, and exercised precautions on a terrain that they considered to be risky. Interviewee mentioned that during the planning phase, they managed the avalanche danger by choosing to go skiing on terrain that is mostly below the treeline.

As they arrived to the location above the accident slope, they experienced that there is no risk involved anymore. Interviewee described to have been surprised of the avalanche happening in a terrain with dense forest that he didn't think to be so steep.

Some of the learning points from the accident that interviewee described, included that he should not trust that below the treeline avalanches would not happen so easily.

Like in the previously discussed cases, it seems like this case has similar kind of background when we look at it from human decision making perspective. What becomes clear from the accident report is that the group members were unable to recognize the hazard, as they were surprised that avalanche would release in a terrain with a seemingly dense forest.

Conclusion, that the terrain was safe and decision to ski it was therefore made according to a belief, that avalanches rarely happen in the forest. This is essentially an illustration of a decision making based on fast thinking system of our minds. As we have discussed before, avalanche environment consists of a so called “wicked learning environment”, where the feedback from our actions can be irregular and misleading and consequences for possible errors can be fatal. Therefore, we should not make critical decisions about terrain choices based on belief. Because of that kind of decision making requires a consistent and reliable feedback from the environment to function without errors. To make reliable choices in such an environment, we must employ tried and tested systems, recommended by avalanche safety professionals to help us making informed choices based on physical data. To be able to prevent the errors of our intuitive thinking mind, we must be met with two conditions: clues to the possible errors and enhanced monitoring of slow thinking system. In this case, the monitoring was deployed at the beginning of the ski run and was eventually dis-employed just before the accident happened. If the monitoring would have continued throughout the trip, this could have not prevented the error either. The reason is that the other precondition of being provided clues to the error, which in this case would have been the ability to recognize the hazard, would have not been met.

Whether the group had knowledge to recognize the key characteristics of avalanche terrain or not, did not become clear from the interview. Therefore it is difficult to judge whether in this case the accident resulted from participants being absent of the clues to the possible error in the first place (ability to recognize avalanche terrain) or simply because of the disemployed monitoring of the slow thinking system.

Accident in a “familiar backyard slope”

Something clearly different in this case compared to the previous discussed ones was that all of the group members had some level of formal avalanche education and one of the group participants was an avalanche safety professional. It has been recognized that education plays a key role in the prevention of avalanche accidents. But what about cases like this when participants are already educated, but they still end up in an accident?

As it is mentioned before, while some of the accidents are caused by participants inability to identify the hazard, most accidents are caused by victims underestimating the hazard or overestimating their ability deal with it. In this case interviewee described that all of them were aware of a possibility to trigger a small avalanche and in that matter they were relying on their skills to be able to escape it by skiing away if such thing would happen. One of the group members had been living in the area for 10 years, and had never seen there before an avalanche of that size. For the group members the location that they were skiing on was very familiar and they thought that they knew all of the dangers that there can be. But this assumption turned out to be wrong, as they did not expect the avalanche to be as big as it turned out to be and that they ended up triggering it remotely.

We discussed before the avalanche environment being a “wicked learning environment” where inconsistent and misleading feedback from our actions can lead us to develop erroneous beliefs that can in turn result into dangerous behaviour. Like in this case beliefs that only small avalanches could happen, that they would know all of the dangers that there can be, and that they would be able to ski away from a possibly triggering avalanche. We should not ground our decisions in a high risk environment such as avalanche terrain, in intuitive, fast thinking thought processes based on assumptions and beliefs as they are prone to errors, particularly in a “wicked learning environment”. Instead we should implement tried and tested systems to challenge our decisions, to be able to provide clues to the errors that we are prone to and actively monitor ourselves to be able to make reliable choices.

It has been suggested that prevention of accidents where victims are unable to identify the hazard, are generally solved by educating people about for example terrain, weather and snowpack assessment. And in cases like this, where participants already should have the basic avalanche safety knowledge, the prevention of the accidents is centered around identifying and mitigating the effects of human decision making errors. Reason for this is that in particular types of circumstances, people tend to expose themselves to a heightened amount of risk, regardless of the level of their avalanche education. To be provided with clues to be able to recognize those

circumstances and most importantly actively monitor ourselves in a systematic fashion using our slow thinking system becomes the key for avoiding these kind of accidents.

Some of the decision making errors that have been identified to have been present in avalanche accidents includes “**Familiarity**”, where we let our past actions in familiar terrain guide our behaviour. For example we might ski a steep slope in dangerous conditions because we have skied it before and it has never slid. This effect has been found to be most pronounced in experienced groups, who exposed themselves to significantly higher risk levels in familiar terrain.

In this case we have already mentioned that the terrain where the accident happened was very familiar to the group as they had visited it often and interviewee described it as “familiar backyard slope”. They thought that they would know the slope well enough and all of the dangers that there can be, but turned out that they didn't. All in combination with the description that one of the group members had been living in the area for 10 years, raises a strong suspicion that this particular heuristic trap called “**Familiarity**” could have been affecting the group and resulting into them exposing themselves to heightened amount of risk.

It could be possible to identify cues to other common heuristic traps from this accident, however perhaps not as clearly as in the case of “Familiarity”. Interviewee described that in the planning process they thought that if they don't go to ski that slope, someone else will go there soon. This could be an indication of a heuristic trap called “**First tracks**”, where individuals take risks to be the first to access untracked snow.

As I mentioned before, best way to mitigate the influences of human decision making errors is to use the aid of rules and systems to make thoughtful choices. Some of the mentioned examples of established systems can include for example: hazard evaluation worksheets, rule-based decision making cards, avalanche-bulletins and danger level scales, safe travel rituals and operational procedures, mitigation measures such as rescue equipment and getting regular, accurate feedback through effective communication.

In this case the group was implementing safe travel rituals and were carrying avalanche safety gear. They also exercised good communication and were making decisions together. Interviewee mentioned that something that she had changed after the accident was to start implementing the local avalanche-bulletin to the trip planning, instead of trusting into her own and friends snowpack assessments only. Whether the group was using some decision making aids that cover the effects of human decision making errors didn't become clear from the interviews.

Two accidents with communication issues

LEADER BEHIND THE GROUP

In this case the group had avalanche professional as a participant. One of the other participants had moderate knowledge of avalanche safety and third participant had least knowledge of them. Interviewee described that they knew about the avalanche danger and according to this they chose to ski a slope that they assessed to be safe on those given conditions, implementing their knowledge of avalanche safety. However in the planning phase they overlooked the fact that the approach route involved crossing a slope that was avalanche prone, or more specifically, could become avalanche prone during those particular conditions. On the beginning the trip they proceeded crossing the slope without problems as snow had not been yet accumulated on to that slope.

To be able to prevent these kind of accidents, where group already had avalanche knowledge, we often look towards human decision making errors. One of the common “heuristic traps” that has been identified to have been affecting groups that ended into avalanche accidents is called “**Consistency**”. It is explained by our desire to maintain consistency with the initial decision and as a result overrule new information about the hazard. Like in this case, initial decision to ski the slope that was assessed to be safe, but overruling the new information that on the way there was another slope that they needed to cross and that which could become dangerous in those conditions. In this case it resulted them to be exposed to heightened amount of risk.

On the way back they noticed that snow had been deposited on to that slope and noted the heightened risk level. At this point they reacted and adjusted their return route, making a plan to go around and avoid most avalanche prone slopes. However, resulting from a sudden failure of equipment, the most experienced person, leader of the group fell behind the others and as a result the least experienced person of the group ended up to the front and with a responsibility of navigation. Person on the front observed sounds of sudden snow pack collapsing, and tried to communicate it to the most experienced person in the group. But strong wind and long safety distances resulted the message not reaching the leader. The person on the front made a decision to keep going forward, and soon triggered an avalanche and was taken by with it.

We have previously mentioned that to be able to make reliable decisions in avalanche terrain, we must use systems and procedures recommended by avalanche professionals to avoid a retreat into making decisions based on intuition and assumptions. But if the systems and procedures are not available, that is what we tend to do. And in this case the person who ended up to be on the front without assistance of essential avalanche safety knowledge, resorted into making critical decisions based on intuition and assumptions.

As we have mentioned before, best way to mitigate the influences of human decision making errors is to use the aid of rules and systems to make thoughtful choices. For this particular case I would like to point out firstly that to be able to avoid common human decision making errors, we must challenge our intuitive decision making systems with clues to possible errors and actively monitor ourselves using our slow thinking decision making system. More specifically, using established system of assessing the presence of some of the common conditions for “heuristic traps”, and therefore be on the lookout for those errors. Another system that I would like to point to, would be implementation of operational procedures and ensuring effective communication to be able to access the essential safety knowledge and procedures during the critical moments of the trip.

PEEK AROUND THE RIDGE

As many of the discussed accidents, these two accidents shared a common theme. A person failed to implement systematic decision making procedures and as a result ended up making critical decision based on assumption and desire. Something that was also similar to the other case, was that there was an avalanche professional as a participant in the group. Other group members had varying amounts of practical experience and one of the participants had done a basic avalanche course.

As we have mentioned before, best way to mitigate the influences of human decision making errors is to use the aid of rules and systems to make thoughtful choices. When the avalanche safety knowledge is unevenly distributed in the group, by implementing operational procedures and ensuring effective communication can help to distribute the essential knowledge more evenly and thus assist the decision making of those, who might not be educated enough to make informed choices independently. This of course has its challenges, for example when group size is big, and when there is some additional disturbances like strong wind, it becomes more challenging to implement operational procedures and ensure effective communication. This kind of

situation requires effective leadership and can put a lot of responsibility and challenge for the leader of the group when other participants are unable to make individual decisions. In this kind of case, thorough risk assessment including participant assessment can be a useful tool to be able to identify the additional challenges that group management and communication can pose.

Accident with students

To be able to prevent these kind of accidents, where group already had significant amount of avalanche safety knowledge, (in this case formal education of avalanche forecaster), we often look at human decision making errors. However, from this interview i could not identify clues to human decision making errors: commonly known as “heuristic traps”, that have identified to have been present in many avalanche accidents.

As we have mentioned before, avalanche terrain consists of a “wicked learning environment”, where irregular and misleading feedback from our actions can lead us to develop erroneous beliefs and wrong conclusions. To tackle this problem we should use tried and tested systems and procedures recommended by avalanche professionals to be able to make informed choises and therefore mitigate the decision making errors that we are prone to make.

Some of the systems and procedures that the group was implementing during the accident day included: previously made location specific trip plan with ascend and descend routes including ATEs-rating, risk assessment before leaving to the trip including a review of avalanche bulletin, participants carrying avalanche rescue equipment, testing of avalanche rescue equipment and implementation of skiing tactics. All of these systems and procedures help to mitigate the effect of human decision making errors and consequences of those errors. They enable the participants to make thoughtful choises in a high consequence environment.

When we discussed the accident that happened approximately 25 years ago, i concluded that during the time of the accident systems and procedures that we commonly implement today into our decision making were not as developed and accessible as they are today. That being said, people who wanted to ski in avalanche environment needed to have higher risk-tolerance, in comparison to people that decide to ski in avalanche terrain today. Modern risk-management systems and procedures enable us to ski more safely in avalanche terrain. However, we still haven't reached a point where the systems developed by avalanche professionals could reliably

prevent any avalanche accidents to happen. This is why we must not stop to do research and develop new, better and more accurate systems to prevent people ending up to be victims of avalanche accidents.

Accident in Tamokdalen

When we focus on prevention of accidents where people know that they are in danger, but exposes themselves to it anyway, we commonly look at how to identify and mitigate the effects of human decision making errors.

Some of the known “heuristic traps” that have been identified to affect people who ended up in avalanche accidents includes: “**Consistency**”. It is explained with our desire to be consistent with our initial decision and as a result overrule new information about the hazard. Like in this case, holding on to the initial decision to keep ascending a slope regardless of new information about the stability issues of the snowpack. Overruling new information about the hazard resulted into the group exposing themselves to heightened amount of risk. In this case relatively large group size could have made the group more prone to this, as it is found that this effect is more significant for groups larger than four people in comparison to smaller groups.

As we discussed before, to be able to avoid decision making errors that we are prone to, particularly in “wicked learning environments” such as avalanche terrain, we must use systems and rules to guide our behavior. Implementing systematic decision making with enhanced monitoring of our slow thinking decision making system is the best way we can mitigate the effects of human decision making errors.

As mentioned before, some of the examples of established systems that can be a great help for ensuring more reliable decision making in high consequence environment such as avalanche terrain includes for example: hazard evaluation worksheets, rule-based decision making cards, avalanche-bulletins and danger level scales, safe travel rituals and operational procedures, mitigation measures such as rescue equipment and getting regular, accurate feedback through effective communication ex. using “wisdom of the crowds” (Tremper 2008, s. 284).

6 CONCLUSIONS

In this study I examined two study questions:

- 1: How does avalanche accident change the way people evaluate risk and make decisions in back country skiing?
- 2: What can we learn from people who have experienced the negative consequence of an avalanche accident?

Study question number one was answered by providing the results of the interviews in the results section of this study. Question number two was answered in the discussion section of this study, by discussing the results of the interviews in relation to what we know about avalanche safety, learning and decision making psychology.

Limitations

Time was a limiting factor in this study. Data gathering and processing took a major portion of the time that was available for making this study. Therefore it became a limiting factor for the knowledge base and discussion, which i would have liked to expand to cover the changes that interviewees made in their risk evaluation and decision making in addition to discussing about the accident reports and risk prevention.

In this study the results are gathered from a very specific group of people, who have experienced a serious avalanche accident. Eaven when preliminary studies support the findings, without controlled experiments of people in avalanche terrain we cannot reliably conclude causation of accidents to human factors or lack of education, since there might be other causes present that doesn't become clear from the interviews. Therefore the discussion section has its limitations and the conclusions should be seen as illustratory and supportive to the findings from preliminary studies, rather than causal statements.

Recommendations

In the discussion section of this study, i pointed to the problems that lack of systematic decision making in avalanche terrain can lead to, illustrating the points with the results of the interviews. Many of the interviewees had implemented some kind of risk-mitigation systems during the time of the accidents. However, in many cases we could find cues for critical decisions made

according to intuitive thought process based on assumptions and desires. As we could see from the results, risk-prevention in avalanche terrain can be a complicated affair. We must be able to recognize the key aspects of risk-prevention, understand their relationships to each other and implement systems and procedures that will assist us in all of the decisions that are critical to make the trip safe. The systems that we choose to use, must cover all of the critical aspects of the safety and decision making including the possible human decision making errors. In addition to mentioned, our procedures and systems need to be simple enough and accessible to wide variety of people, so that they will find their place in back country travellers repertoires.

Further work

As I mentioned before, i would have wanted to expand the knowledge base and discussion to cover the changes that interviewees had made as a result of the avalanche accident that they experienced. This could provide more in depth understanding about how avalanche accident changes the way people evaluate risk and make decision in back country skiing.

In regarding the recommendations section, studying what kind of decision making procedures and systems back country skiers that have not experienced an avalanche accident use could provide useful information about the development needs of avalanche safety awareness and education. Studying the decision making processes of back country skiers could provide information whether the risk-mitigation systems and procedures that we have available are accessible and simple enough, so that we can find evidence of them in back country skiers decision making repertoires.

7 ACKNOWLEDGEMENTS

I would like to thank my commissioner CARE and Audun Hetland for good collaboration and for giving me the possibility to work with very interesting and motivating subject. I would also like to thank my supervisor Kai Lehtonen for guiding the thesis process and Anita Saaranen-Kauppinen for providing invaluable advice and support on the background. Lastly i would like to thank all of the interviewees who shared their unique stories and learning moments for to use in this study.

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