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ORIGINAL ARTICLE

Trend effects on perceived avalanche hazard

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Abstract

Hazard-level forecasts constitute an important risk mitigation tool to reduce loss of economic values and human life. Avalanche forecasts represent an example of this. As for many other domains, avalanche risk is communicated using a color-coded, categorical risk scale aimed at informing the public about past, current, and future risk. We report the results from three experiments in which we tested if an irrelevant past trend in forecasted avalanche danger affects perceptions of current and future avalanche risk. Our sample consisted of individuals from three different populations targeted by national avalanche warning services. All three experiments showed that the perception of avalanche risk is influenced by the trend, but that the effect is opposite for perceptions of current and expectations of future avalanche risk. While future avalanche risk is extrapolated in the same direction as the change from the previous day, we found that perceived current risk appears to be based on an average of past and current risk. These effects diminish when we provide participants with a scale indicating the exact level of avalanche danger. For most of our measurement instruments, however, the effects remain significant. These results imply that targeted populations may consider historic information more than was intended by the sender. As such, our results have implications for both avalanche warning services and risk communication in general.

KEYWORDS
risk communication, risk perception, trend effects

1 | INTRODUCTION

Ninety percent of all fatal avalanche accidents in Europe and North America are caused by the victims or someone in the victims' group (e.g., Tschirky et al., 2000). While some of these accidents can be attributed to lack of avalanche knowledge (Adams, 2004), many victims were knowledgeable about the avalanche danger and had appropriate training (McCammon, 2000). Studies have indicated that human factors such as cognitive, social, and emotional biases are important in decisions leading up to accidents (e.g., Atkins, 2000; Furman et al., 2010; McCammon, 2002, 2009). Consequently, avalanche research has shifted from primarily focusing on physical causes, to also including a focus on human decision processes (e.g., Furman et al., 2010; Haegli et al., 2010; Johnson et al., 2016; Mannberg et al., 2020; Mannberg et al., 2018; Marengo et al., 2017; Zweifel & Haegeli, 2014). Of particular interest in the present study is how people interpret avalanche warnings.

In this article, we report the results from three experiments in which we tested if the perceived current and future risk of avalanches was dependent on a nonrelevant trend in avalanche danger. The forecasted avalanche danger is an important factor for decisions in avalanche terrain (Furman et al., 2010; Haegeli et al., 2010; Marengo et al., 2017; Procter et al., 2014; Winkler & Techel, 2014), and may be an important tool in reducing avalanche accidents; however, research suggests that perceived risk may be affected by irrelevant trend factors (Hohle & Teigen, 2015, 2019; Løhre, 2018; Maglio & Polman, 2016).

1.1 | Communicating risk

Effective risk communication is integral to the preparedness authorities mandate to manage societal risk (see, e.g., the risk management guidelines in ISO Standard No. 45001: 2018). However, research demonstrates that communicating risk is challenging (e.g., Gigerenzer & Edwards, 2003; Slovic, 1987; Slovic et al., 1978; Slovic et al., 1981; Visschers et al., 2009). One important reason is that perceived risk is more influenced by psychological factors, such as perceived control and catastrophic potential, than by the technical risk indicators used by experts (Slovic, 1987; Slovic et al., 1981). In addition, many people have difficulty interpreting and understanding risk estimates (Visschers et al., 2009), regardless of whether the risk is presented as a single-event probability (Gigerenzer & Edwards, 2003), cumulative risk (Slovic et al., 1978), relative risk (Nyström et al., 1996), or in absolute numbers (Lipkus et al., 2001).

Presenting risk using frequencies (Cosmides & Tooby, 1996; Gigerenzer & Hoffrage, 1995), graphically (Ancker et al., 2006; Lipkus & Hollands, 1999), or as qualitative risk indexes (MacKenzie, 2014) seems to help, but communicating risk to the public remains a challenge (Balog-Way et al., 2020; Visschers et al., 2009). For instance, avalanche danger is communicated on a five-level ordinal scale (low, moderate, considerable, high, and extreme). These types of scales are widely used to communicate risk, because they transform complex risk information into a format that is easy to understand and implement (Cox, 2008; Hubbard, 2020; MacKenzie, 2014). However, because such scales do not comprehensively account for the uncertainty inherent in rare and severe events, and thus, represent a simplified account of a given risk, receivers may interpret them differently from what the sender intended.

1.2 | Trend effects in perceived risk

Many risks are dynamic, and risk communicators therefore need to continuously update the information presented to the public. Research suggests that people are sensitive to such changes (e.g., Erlandsson et al., 2018; Hohle & Teigen, 2015, 2019; Hsee & Zhang, 2010). Revised estimates provide a comparison standard that increase the evaluability of a given risk (Hsee & Zhang, 2010), but may also create a sense of an upward or downward development (Erlandsson et al., 2018; Hohle & Teigen, 2015, 2019; Løhre, 2018; Maglio & Polman, 2016).

Hohle and Teigen (2015) refer to the tendency to extrapolate current and future risk based on observed changes as the *trend effect*. They first identified the trend effect in an experiment on perceived risk of climate change, which showed that forecasts that had been adjusted downward were expected to be even lower in the future, whereas estimates that were adjusted upward were expected to continue to rise. In a different experiment in the same article, they found a similar effect on the perceived danger of landslides. More specifically, they found that danger level 2 (on an ordinal scale from 1 to 5) was perceived as more dangerous when the current forecast was upgraded from level 1 than when it was downgraded from level 3. Participants also expected the trend to continue and be further updated in the same direction.

The trend effect has been demonstrated for numerous measures of risk forecasts, such as percentages, quantities, and categorical risk scales (Hohle & Teigen, 2015); the width of prediction intervals (Løhre, 2018); probabilities (Maglio & Polman, 2016); single-bound probability estimates (Hole & Teigen, 2019); and even social status or rank (Pettit et al., 2013). It has been found in forecasts produced by computers, single-human forecasters (Hohle & Teigen, 2015), and in forecasts provided by separate experts (Hohle & Teigen, 2019). The trend effect persists when participants are asked to provide possible reasons for the revised forecast, which indicates that the effect is robust to more thorough, analytical processing (Teigen & Hohle, 2019).

Perceived trends might also affect how people think, feel, and behave regarding current risk (Erlandsson et al., 2018; Maglio & Polman, 2016). Erlandsson et al. (2018) manipulated estimated death risk for various types of cancers either upward or downward and found that an upward trajectory not only led participants to expect future mortality rates to be higher but also affected perceived severity and willingness to donate money to cancer research. Similarly, Maglio and Polman (2016) found that event probabilities that are adjusted upward (as opposed to downward) are felt to be more likely to happen and consequently affect behavioral intentions.

1.3 | Communicating avalanche risk

The main purpose of avalanche warning services (AWS) is to inform preparedness authorities and travelers in avalanche terrain about current and forecasted avalanche danger to promote safe behavior and mitigate avalanche risk. AWS are provided throughout the world. The Norwegian Avalanche Warning Service (NAWS) was established in 2013 in response to an increased interest in backcountry skiing and recreation and an associated increase in avalanche fatalities (Engeset et al., 2018).

Avalanche forecasts from NAWS, like many other AWS, are presented online using an inverted pyramid approach (Burkeljca, 2013; Engeset et al., 2018). The upper part of the webpage shows the avalanche danger (on a scale from 1 to 5) during the past 10 days, the current avalanche danger, and the forecasted danger for the next day.[1] The current avalanche danger is highlighted and presented together with a short summary of the forecaster's evaluation of current conditions and travel advice. This information is followed by detailed information about current avalanche problems, snowpack, and weather history. The warnings are designed to reach a diverse user audience, with the most prominent

[1] For an example, see https://www.varsom.no/en/avalanche-bulletins/forecast/Troms%c3%b8/

information aimed at beginners with limited knowledge and the more detailed description aimed at professional users and experts (Engeset et al., 2018).

Research suggests that nonexperts find the avalanche danger rating most useful, whereas experts focus on information about the type of avalanche (Hallandvik et al., 2017; St. Clair et al., 2021), indicating that avalanche bulletins are read as intended. However, research on how efficiently avalanche warnings are communicated and understood are still scant (Engeset et al., 2018), and there is currently no global standard for the structure and content of avalanche bulletins. For example, while AWS in Switzerland (https://www.slf.ch) and Canada (https://www.avalanche.ca) do not include historic information about the avalanche danger scale, AWS in Norway (http://www.varsom.no) and France (meteofrance.com) do.

1.4 | The present research

In this article, we use experimental survey data to analyze trend effects on perceived avalanche risk. More specifically, we test if the direction of change in avalanche danger from the previous day affects perceived *current* and expected *future* avalanche risk. Our hypotheses were that: (a) An upward change in the forecasted avalanche danger from the previous day would be associated with a higher perceived current and expected future risk than a downward change in the forecasted danger (a positive trend effect), and (b) that information and avalanche knowledge would attenuate the trend effect.

We tested these hypotheses in three studies. Study 1 tested for trend effects on perceived risk with and without additional information about the distribution and type of avalanche problems, whereas Study 2 tested if visualizing the exact avalanche danger level (i.e., the seriousness of avalanche danger 3) on a scale removes the trend effects. We tested for trend effects with and without information and with and without a scale in Study 3. Finally, we pooled the data from our three studies and used panel data regression analysis to evaluate the potential interaction effects of our different information treatments and controlled for background variables.

Our study contributes to the literature in several ways. First, in contrast to previous research on the trend effect (Erlandsson et al., 2018; Løhre, 2018; Hohle & Teigen, 2015, 2019), our samples represent target populations for the specific risk message under study: workers in avalanche terrain, students living in an avalanche prone area, and backcountry skiers. Second, our study includes an experimental manipulation that allows us to test if the trend effect is robust to increased information. Hohle and Teigen (2019) have shown that the trend effect persists even when participants provide possible reasons for the revised forecast. In our study, participants in the high-info conditions were provided with the expert's justification for the forecasted danger level, which could be expected to reduce the trend effect by drawing attention toward the most current forecast.

Finally, our study is practically relevant, as a steadily increasing number of backcountry recreationalists relies on AWS as their primary source of risk information (Furman et al., 2010), and there is currently no established best practice on how and where the avalanche danger scale should be presented (Fisher et al., 2021). Consequently, knowledge on how relevant target audiences interpret avalanche warnings has the potential to substantially affect accident rates.

2 | STUDY 1: WORKERS IN AVALANCHE TERRAIN

2.1 | Materials and methods

2.1.1 | Participants

As the majority of individuals involved in avalanche incidents have avalanche knowledge and expose themselves to avalanche hazard voluntarily (McCammon, 2002, 2004), we targeted individuals who make decisions in or about avalanche terrain. An online survey was sent out to all employees and associates of the Norwegian Public Roads Administration (Statens Vegvesen, SVV) who work in fields related to avalanches and have some degree of standardized training required by their workplace. In total, 351 individuals received the survey link. Eighty-seven (25%) agreed to participate, and 58 (17%) completed all relevant sections.

Eighty-five percent of participants were male. Thirteen percent were 34 years or younger at the time of the survey, 46% were between 35 and 49 years old, and 41% were 50 years or older. Eleven subjects (20%) had no formal avalanche training, eight subjects (15%) had attended an avalanche seminar or a 1-day course, and 64% had participated in a 2- or 3-day course with field practice, or more. On average, subjects in our sample spent 10 days in avalanche terrain each season (SD = 10.75, Min = 1, Max = 41) and had 6 years' experience of working or recreating in avalanche terrain (SD = 5.93, Min = 1, Max = 11).

2.1.2 | Experiment design

Our main interest was to evaluate the trend effects on perceived risk of avalanches, where trend was defined as an extrapolation of perceived avalanche danger based on a change in the forecasted regional avalanche danger from the previous day. Participants were randomly assigned to one of four conditions, each containing two scenarios describing a group of backcountry skiers moving through potential avalanche terrain. Each scenario described relevant weather conditions and the complexity and slope angle of the terrain. All participants read identical scenarios, and the two scenarios presented in each condition were

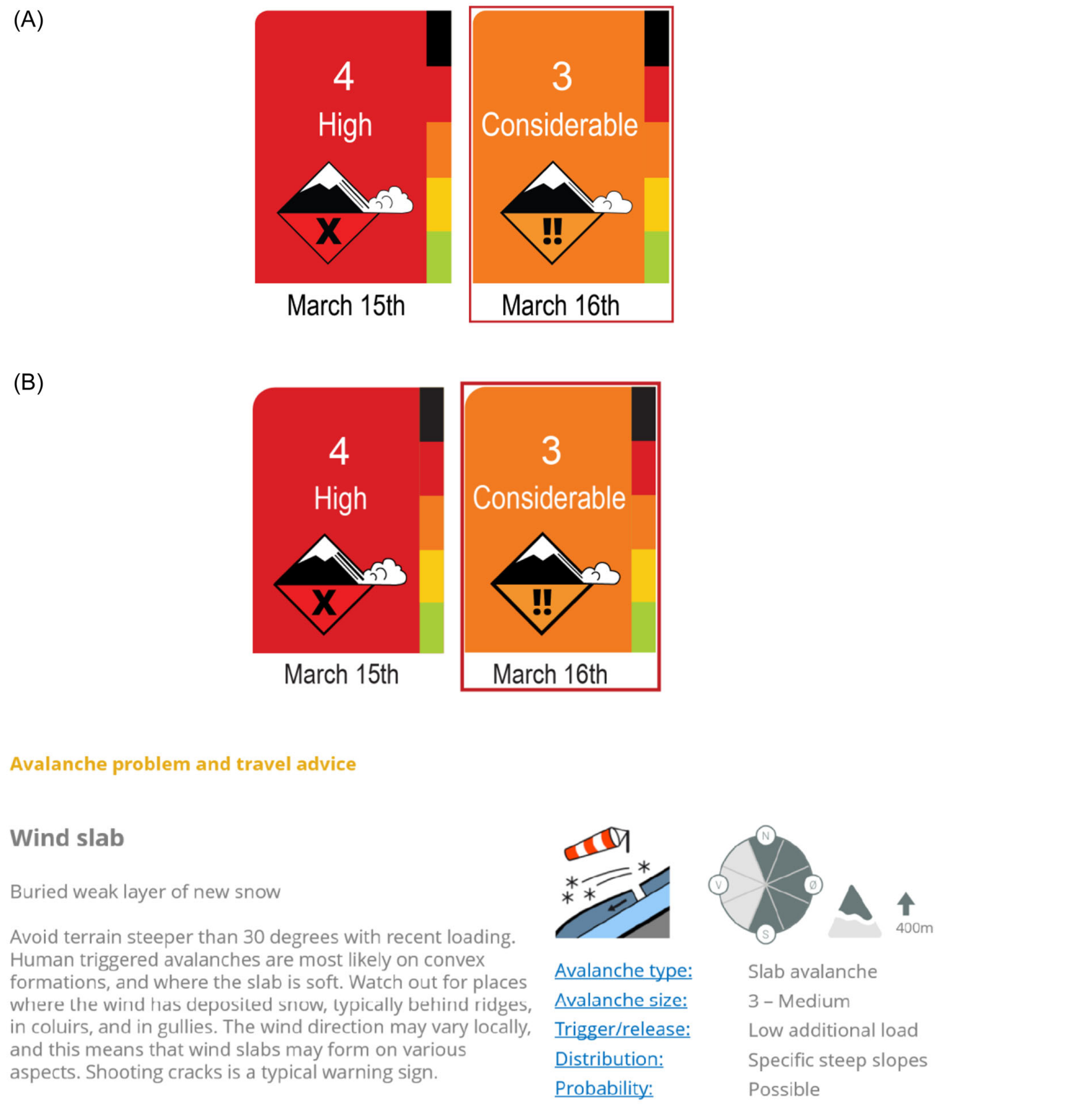


FIGURE 1 (A) Downward change in avalanche danger: Low information, Studies 1–3. (B) Downward change in avalanche danger: High information, Studies 1–3

identical except for the date (Scenario 1: March 16; Scenario 2: March 22). Translations of the scenario are given in Appendix A.

Each scenario was further presented with an avalanche bulletin, designed based on the bulletins used by the NAWS, indicating that the current regional forecasted avalanche danger was level 3 (considerable). To evaluate if information has a moderating or mediating effect on potential trend effects, half of the respondents (randomly selected) only saw information about the avalanche danger level (Figure 1A), whereas the other half had access to relatively detailed information about the avalanche problem (Figure 1B).

All respondents evaluated both an increase (level 2 to level 3) and decrease (level 4 to level 3) in forecasted avalanche danger. The order of presentation was randomized—that is, half of the respondents evaluated an upward change in Scenario 1 (March 16) and a downward change in Scenario 2 (March 22), whereas the other half saw a reversed order.

Figure 2 illustrates the survey flow used to identify the effects of the direction of change and information, and Table 1 shows the distribution of respondents across treatments. This design allowed us to test for the effect of upward versus downward perceived trends both within and between subjects, as well as the effect of information between subjects.

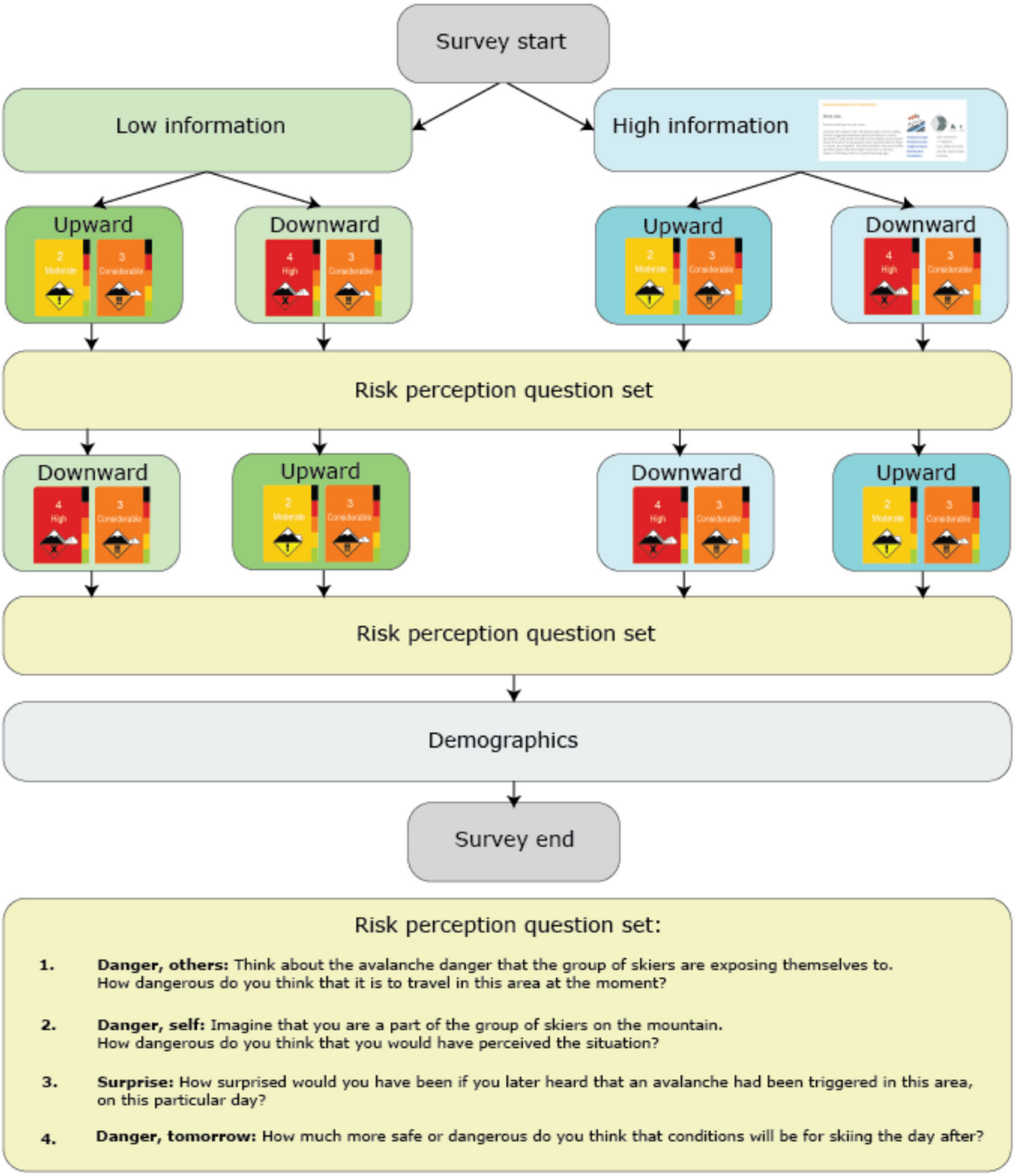


FIGURE 2 Flowchart of the survey structure and randomization. Studies 1–3

2.1.3 | Measurement instruments

For each scenario, the respondents answered three questions aimed to measure perceived current avalanche risk and one question about the expected avalanche danger the following day. More specifically, we asked the participants the following questions:

1. **Danger, others**: "Think about the avalanche danger that the group of skiers are exposing themselves to. How dangerous do you think it is to travel in this area at the moment?" Scale: 1 (not dangerous at all) to 7 (very dangerous)
2. **Danger, self**: "Imagine that you are a part of the group of skiers on the mountain. How dangerous do you think that you would have perceived the situation to be?" Scale: 1 (not dangerous at all) to 7 (very dangerous).
3. **Surprise**: "How surprised would you have been if you later heard that an avalanche had been triggered in this area, on this particular day?" Scale: 1(not at all surprised) to 7 (very surprised)

TABLE 1 Perceived avalanche risk, Study 1. Between- (Mann–Whitney U tests) and within-subject (Wilcoxon signed-rank tests) comparisons

	Trend			Between-subject (Mann–Whitney U test)		Within-subject (Wilcoxon signed-rank test)	
	UP	DOWN	Diff.	|z|	Pr > |z|	|z|	Pr > |z|
All							
Danger, others	5.50	5.91	−0.41	1.80	0.073	3.14	0.002
Danger, self	5.21	5.52	−0.31	1.46	0.143	2.83	0.005
Surprise	2.22	1.84	0.38	1.48	0.139	1.42	0.155
Current danger, average score	5.49	5.86	−0.37	1.98	0.048	3.06	0.002
Danger, tomorrow	4.62	4.28	0.34	1.59	0.112	2.11	0.035
No. of observations	58	58					
No information							
Danger, others	5.44	5.88	−0.44	1.22	0.224	1.99	0.047
Danger, self	5.03	5.41	−0.38	1.17	0.244	2.31	0.021
Surprise	2.34	1.91	0.44	1.22	0.222	0.96	0.338
Current danger, average score	5.38	5.79	−0.42	1.37	0.170	2.03	0.043
Danger, tomorrow	4.78	4.63	0.16	0.68	0.499	1.10	0.272
No. of observations	32	32					
Information							
Danger, others	5.58	5.96	−0.38	1.36	0.174	2.65	0.008
Danger, self	5.42	5.65	−0.23	0.89	0.375	1.66	0.097
Surprise	2.08	1.77	0.31	0.78	0.436	1.13	0.258
Current danger, average score	5.64	5.95	−0.31	1.33	0.184	2.39	0.017
Danger, tomorrow	4.42	3.85	0.58	1.47	0.142	1.93	0.054
No. of observations	26	26					

4. **Danger, tomorrow**: "How much safer or more dangerous do you think conditions will be for skiing the day after?" Scale: 1 (Much safer) to 7 (Much more dangerous).

Cronbach's α for the three questions measuring perceived current risk (1−3) was $\alpha = 0.64$ for scenario 1, $\alpha = 0.81$ for scenario 2, and $\alpha = 0.73$ combined.

2.2 | Results

The main results are illustrated in Figure 3 and Table 1, which both display responses to scenarios with a downward and upward change, respectively. Note that we have pooled the results from scenarios 1 and 2 for ease of presentation. We present the items related to perceived current avalanche danger both individually and combined (average score). In the combined score, we have reversed the responses for surprise so that higher values indicate a higher perceived risk

The distribution of answers in these two figures appears to confirm the findings of Hohle and Teigen (2015)—that is, participants expect that the current trend in avalanche danger will continue the following day. However, contrary to the trend effect previously reported, the participants in Study 1 perceived the current avalanche risk to be *higher* when the change was downward (from 4 to 3) than when the change was upward (from 2 to 3). Similar to Hohle and Teigen (2015), these effects are rarely significant at the 5% level when we analyze direct differences between subjects (see column 6 in Table 1).

However, because avalanche danger is measured on an ordinal scale, one individual's perception of a point 5 (on a scale from 1 to 7) may differ from another individual's perception of the same number. Furthermore, when faced with a new danger scenario, the first scenario may function as a point of reference for the evaluation. We therefore also evaluate within-subject differences. If no trend effect is present, these differences should, on average, be zero.

Figure 4 shows the mean differences between the second and first scenario for the combined score of perceived current danger and expected future avalanche danger. A positive difference indicates that participants rated the danger in the second scenario as higher than the first, and vice versa. As can be seen in the graph, participants who saw an upward change in the first scenario, and a downward change in the second, on average, increased their rating of the *current* danger. By contrast, participants who saw an upward change in the second scenario, on average,

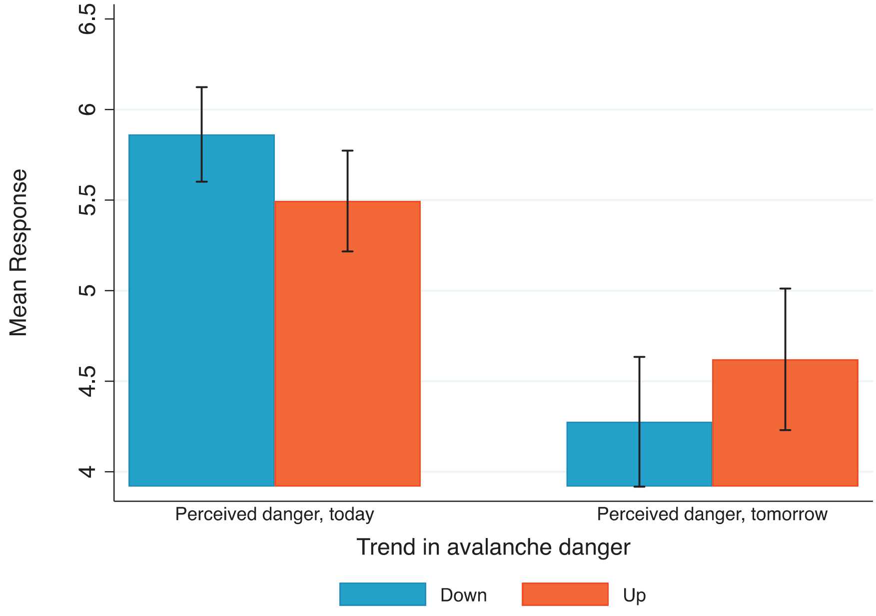


FIGURE 3 Study 1: Perceived avalanche risk and expected trend in avalanche danger, pooled sample ($N = 116$). Means and 95% confidence intervals

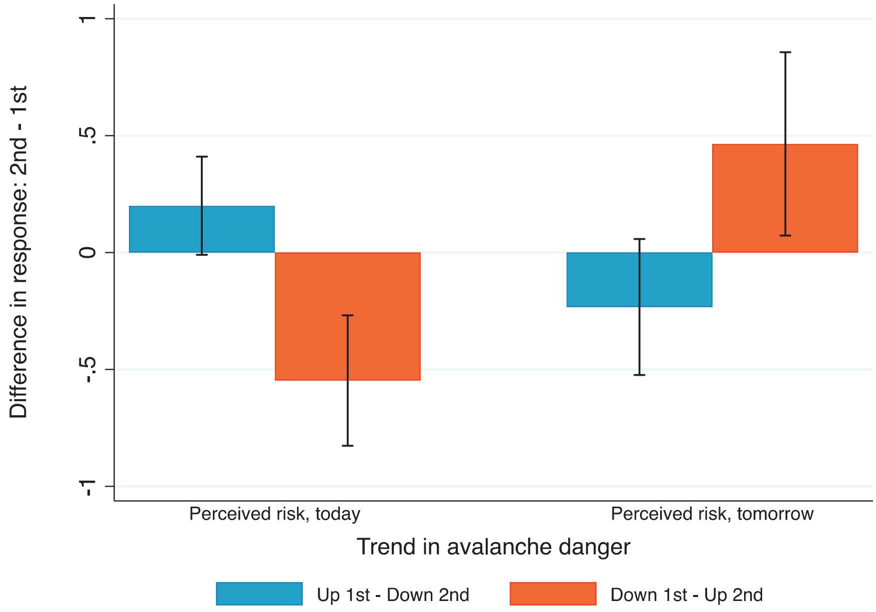


FIGURE 4 Study 1: Mean differences in response: 2nd Scenario – 1st Scenario. Bars represent 95% confidence intervals

downgraded the current danger. However, expected future danger followed a reversed pattern. Participants, who saw an upward change in the second scenario, on average upgrade the danger tomorrow, whereas participants who saw a downward change expected that the avalanche danger would continue to decrease.

With the exception of surprise ($z = 1.422$, $\Pr > |z| = 0.155$), all effects are significant when we compared within-subject responses across information treatments (Wilcoxon signed rank test, see columns 7 and 8 in Table 1). When we analyzed the information treatments separately, many effects become insignificant at the 5% level. However, the difference in the combined score of perceived current avalanche danger remains significant in both information treatment groups (no information: $z = 2.03$, $\Pr > |z| = 0.043$, Information: $z = 2.39$, $\Pr > |z| = 0.017$).

2.3 | Discussion

Our within-subject analysis lends some support to the hypothesis that perceived trends in the avalanche danger level influence perceived current and expected future avalanche risk. In accordance with Hohle and Teigen (2015), we found that subjects expected the current trend in avalanche danger to continue in the future. However, in contrast to their findings, our analysis suggests that perceived current avalanche risk is lower when the avalanche danger has increased and higher when the avalanche danger has fallen. Past avalanche hazard is not completely irrelevant for current avalanche hazard. Some avalanche problems, such as wind slabs, stabilize over time. In the absence of new snow or wind, it is therefore rational to expect that conditions will improve as time passes. However, the forecasted current danger level incorporates this dynamic. An extrapolation of past avalanche danger onto current avalanche danger therefore implies a form of double counting, unless users have private information on local conditions that are unavailable to the forecaster.

Our results for the different information treatments are inconclusive. Although the sign of the effect is the same across treatments, many of the effects are insignificant. A potential reason for the lack of significance is the small sample size used in the analysis, which creates low statistical power.

3 | STUDY 2: REPLICATION IN A STUDENT SAMPLE

The purpose of Study 2 was twofold. First, we wanted to test if the observed effects would also be present among participants with limited knowledge about avalanche danger, controlling for the possibility that experts and lay people view avalanche risk differently. Second, one possible explanation for the observed effect is that subjects think that danger level 3 is on a higher level when conditions were recently very unstable (level 4) than when conditions were previously relatively stable (level 2). This interpretation would be in line with “the golden rule” of forecasting (Armstrong et al., 2015). Although all subjects in Study 1 read the exact same information, the presumption of differences in avalanche danger is not necessarily wrong. The avalanche forecast does not provide complete information, and the actual danger level does vary within a given forecasted level. Furthermore, changes in the snowpack often tend to be gradual and vary by location, and as the sample in Study 1 consisted largely of participants with avalanche knowledge, they may have accounted for this by using a pooled average of past and current risk. It may therefore be reasonable to be conservative when updating risk estimates. Indeed, Armstrong et al. (2015) state that conservative estimates are particularly advisable in physical and biological systems, as they are typically characterized by uncertainty and high complexity.

In Study 2, we therefore wanted to test if the observed effects disappeared when we included a scale indicating the exact level of danger within a given danger level. This should highlight that the AWS forecasted avalanche danger is the same in all conditions, regardless of the forecast for the previous day, and should require no further adjustment from participants. This should eliminate the effect observed on perceived current avalanche risk, but not influence perceived future risk.

3.1 | Materials and methods

3.1.1 | Participants

We recruited participants among students at UiT (the Arctic University of Norway) in three rounds. In the first round, data were collected in the intermission of on-campus bachelor’s level lectures in research ethics ($N = 46$) and mathematics ($N = 48$) on two occasions during the fall of 2019. In the second round, we recruited students from two courses in research ethics ($N = 29$) and societal security ($N = 16$) to participate in an online survey during autumn 2020 and early spring 2021. The online survey approach was used due to the COVID-19 pandemic. In total, 133 students provided complete answers to all questions on perceived avalanche risk.

Fifty-eight percent of the samples were male. To avoid identification of participants, we did not collect information about age. On average, participants spent 9 days in avalanche terrain each year (SD = 18.85, Min = 0, Max = 100) and had 3 years’ experience of traveling in the backcountry (SD = 5.66, Min = 0, Max = 41). Sixty-six percent of the sample had no avalanche training, and 23% had only attended an avalanche seminar or a 1-day course. Ten percent had basic formal avalanche training, and 1% had advanced avalanche training.

3.1.2 | Experiment design and measurement instruments

Study 2 used the same materials as Study 1, with two important exceptions: (a) All subjects received the high information treatment (see Figure 5A), and (b) half of the subjects saw a scale indicating the exact danger level (see Figure 5B). The survey structure was identical to the structure used in Study 1, and the same questions were used to measure current and projected perceived avalanche danger.

3.2 | Results

The results of Study 2 largely replicate the findings in Study 1, with a few notable exceptions. As in Study 1, our data revealed that perceived current risk appears to be based on an average of the current and past danger level, whereas future risk appears to be extrapolated in the same direction as the change for the previous day (see Figure 6). However, in contrast to Study 1, most effects on perceived current risk were significant at the 5% level when we compared between subjects. All effects were strongly significant in the within-subject analysis (see Table 2). As in Study 1, the sign of the effects remained intact when we analyzed the different information treatments. In Study 2, all participants saw detailed information about the avalanche problem, and half of the participants saw a scale indicating the exact level of avalanche danger. The scale treatment reduces all effect sizes and makes

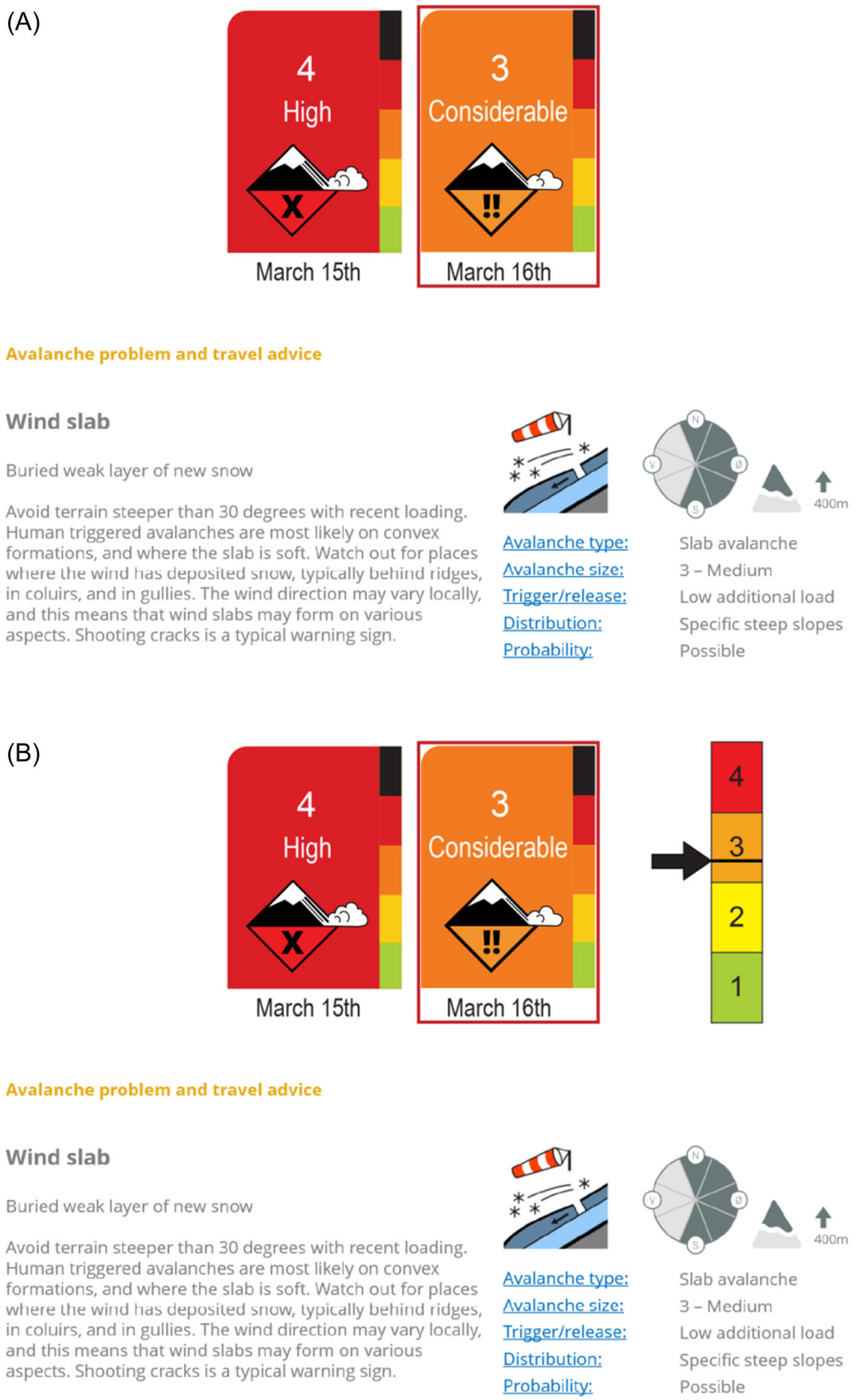


FIGURE 5 (A) Treatment 1: High information: No scale, Study 2 and Study 3. (B) Treatment 2: High information: Scale, Study 2 and Study 3

the trend effect on expected future avalanche danger insignificant. The effect on perceived current avalanche danger remained strongly significant in our within-subject analysis and weakly significant in our between-subject analysis ($p = 0.051$).

3.3 | Discussion

The results of experiment 2 largely confirm the findings from experiment 1. Perception of immediate or current avalanche risk appears to be a result of averaging current and past

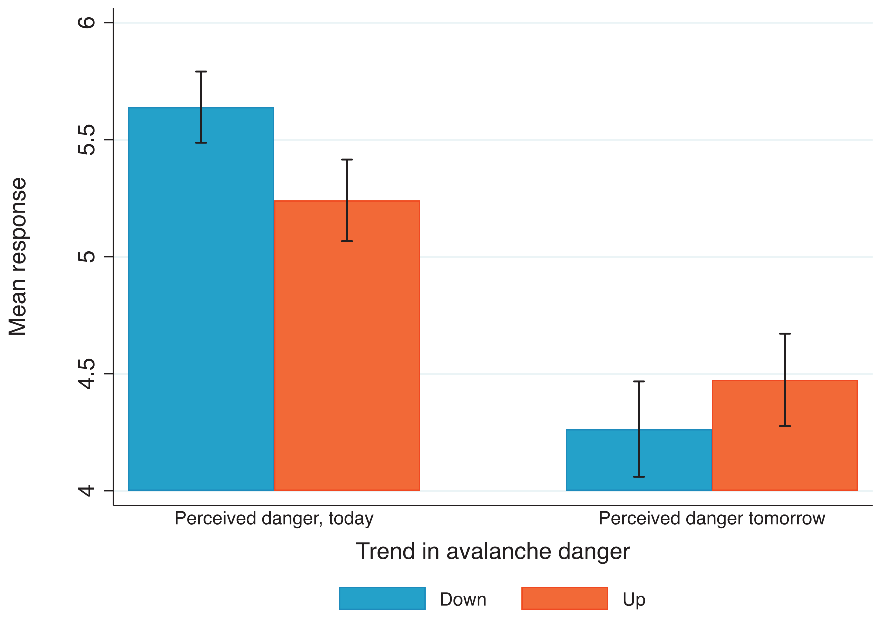


FIGURE 6 Study 2: Perceived avalanche danger today (average score) and expected avalanche danger tomorrow pooled sample ($N = 278$). Means and 95% confidence intervals

danger, whereas the projected future avalanche danger is extrapolated in the same direction as the change from the previous day. The presence of a scale indicating a more specific avalanche danger level reduced all effects. However, the trend effect for expected avalanche danger tomorrow was still weakly significant and the effect observed for current avalanche danger remained very significant. Importantly, as the data were collected in a sample without professional avalanche training, knowledge of snow cover processes does not account for the observed effects.

4 | STUDY 3: BACKCOUNTRY TRAVELERS

The purpose of Study 3 was to test if the observed trend effects on perceived avalanche risk were present among the largest target group of avalanche forecasts—that is, people who venture into avalanche terrain on a regular basis.

4.1 | Materials and methods

4.1.1 | Participants

We recruited participants via the Center for Avalanche Research and Education (CARE)[2] Facebook page from late November 2020 to early January 2021. The CARE Facebook page has 2900 followers and reaches over 17,000 people. Most people who follow the Facebook page work directly or indirectly with avalanches or recreate in avalanche terrain. We also posted links to the online survey on several Facebook groups dedicated to backcountry touring. All participants provided written consent to participate.

A total of 680 people opened the survey, and of these, 427 (63%) provided complete answers to all questions about perceived danger and were over 18 years of age. Four-hundred and five provided complete answers to all sociodemographic questions, and of these, 70% were male and 30% were female. The average age in the sample was 35 years (SD: 11.13, Min: 18, Max: 74). On average, subjects skied 19 days per season (SD = 23.89, Min = 0, Max = 300) and had toured in the backcountry for 8 years (SD = 7.98, Mini = 1, Max = 51). Twenty percent of the sample had no avalanche training, 36% had attended an avalanche seminar or a 1-day course, and 33% of the sample had basic formal training, whereas 12% had advanced or professional avalanche training.

4.1.2 | Experiment design and measurement instruments

The survey structure in Study 3 was similar to Study 1 and Study 2. All participants read two hypothetical scenarios, one with an upward change in avalanche danger (2 to 3) and one with a downward change (4 to 3). The order of presentation was randomized. To evaluate the effect of both information and a scale, we randomized four information treatments across participants: (a) Low info: Only avalanche danger; (b) High info: avalanche danger and avalanche problem; (c) Scale: avalanche danger and a scale; and (d) High info + Scale: avalanche danger, avalanche problem, and a scale. Each participant was exposed to a single treatment group.

[2] CARE is a cross-disciplinary research group at UiT (the Arctic University of Norway). The research conducted within CARE focuses on decision-making under risk and uncertainty in general, and on decision-making in avalanche terrain in particular. The social media accounts of CARE are used by affiliated researchers to disseminate research and recruit participants to research studies.

TABLE 2 Perceived avalanche risk, Study 2. Between- (Mann–Whitney U tests) and within-subject (Wilcoxon signed-rank tests) comparisons

	Trend			Between-subject (Mann–Whitney U test)		Within-subject (Wilcoxon signed-rank test)	
	UP	DOWN	Diff.	|z|	p	|z|	p
All							
Danger, others	5.36	5.83	−0.47	3.86	<0.001	4.53	<0.001
Danger, self	4.99	5.46	−0.47	2.83	0.005	4.29	<0.001
Surprise	2.63	2.37	0.26	1.81	0.070	2.20	0.028
Current danger, average score	5.24	5.64	−0.40	3.17	0.002	4.08	<0.001
Danger, tomorrow	4.47	4.26	0.21	1.86	0.063	2.87	0.004
No. of observations	133	133					
No Scale							
Danger, others	5.34	5.84	−0.49	2.94	0.003	3.28	0.001
Danger, self	4.86	5.34	−0.48	1.92	0.055	2.93	0.003
Surprise	2.78	2.37	0.41	1.74	0.082	1.93	0.053
Current danger, average score	5.14	5.60	−0.46	2.48	0.013	3.06	0.002
Danger, tomorrow	4.58	4.37	0.21	1.43	0.152	2.25	0.024
No. of observations	73	73					
Scale							
Danger, others	5.38	5.82	−0.43	2.49	0.013	3.07	0.002
Danger, self	5.15	5.60	−0.45	2.11	0.035	3.15	0.002
Surprise	2.45	2.37	0.08	0.75	0.456	1.08	0.278
Current danger, average score	5.36	5.68	−0.32	1.95	0.051	2.65	0.008
Danger, tomorrow	4.35	4.13	0.22	1.20	0.229	1.70	0.089
No. of observations	60	60					

4.2 | Results

The results of Study 3 replicate the effects observed in Study 1 and Study 2. Participants perceived the risk of avalanches at danger level 3 as higher when this was preceded by danger level 4 than when it was preceded by danger level 2. Study 3 also replicates the trend effect on projected avalanche danger. Subjects who saw an upward change expected that the avalanche danger on the next day would be higher than subjects who saw a downward change in avalanche danger (see Figure 7). Both between- and within-subject effects are significant below 1% level (first panel in Table 3). As can be seen in Panel 2 in the table and in Figure 8(A), the effects for perceived current avalanche danger are robust to introducing information. The effect on expected future avalanche danger dropped below significance in the between-subject analysis but significant at 5% level in the within-subject analysis (Figure 8B).

The inclusion of either a scale in isolation or a scale in combination with information rendered most between-subject effects on current and expected future avalanche danger insignificant. However, most within-subject effects on perceived current avalanche danger remained strongly significant. Surprisingly, although we did not find a trend effect on expected future avalanche danger among students who saw the avalanche danger and a scale, we found a significant trend effect among subjects who saw both a scale and read information about the avalanche problem.

4.3 | Discussion

The sample in Study 3 consisted of more active backcountry travelers (average 19 days per season) than the participants in Study 1 (average 10 days per season) and Study 2 (average 9 days per season). The share of participants with formal avalanche training (33%) was larger than in Study 2 (8%), but smaller than in Study 1 (64%). Despite these differences, Study 3 at large replicates the findings in Study 1 and Study 2 that an increase in avalanche danger is associated with a lower risk estimate of current avalanche risk, and an increase in the estimate of future avalanche risk, compared to when the forecasted danger has fallen. The effect is especially strong for perceived current risk, and weakest for surprise at avalanche activity. One important difference between Study 3 and the other two studies is the substantially larger sample size. However, due to the number of treatments, the statistical power remains relatively weak and does not allow us to evaluate if the different information treatments affected the trend effects to a significant extent.

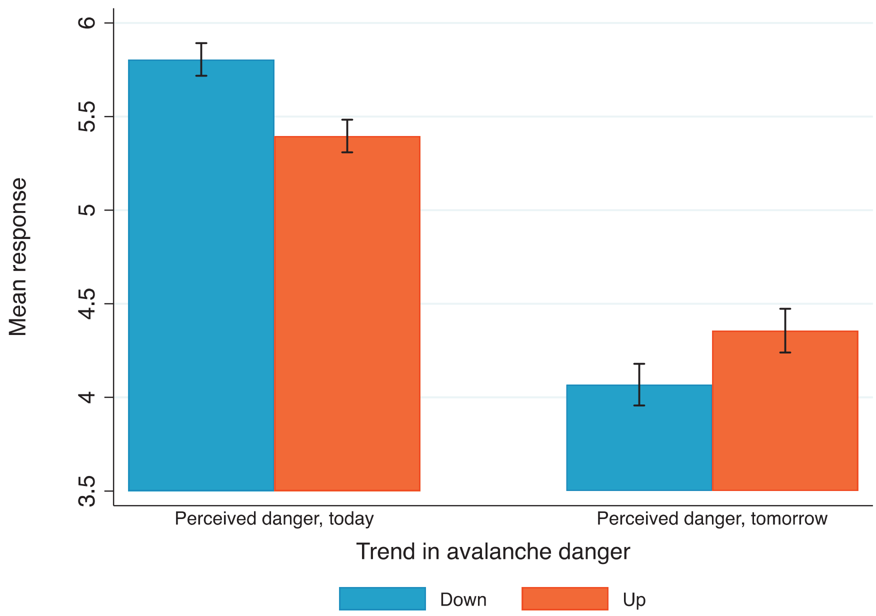


FIGURE 7 Study 3: Perceived avalanche danger today (average score) and expected avalanche danger tomorrow, pooled sample (N = 878). Means and 95% confidence intervals

5 | MULTIVARIATE REGRESSION ANALYSIS OF THE POOLED SAMPLE FROM STUDIES 1– 3

The small sample sizes of Study 1 and Study 2 do not allow us to conduct multivariate statistical analysis. To test for potential interaction effects of our different treatments, and to evaluate if avalanche knowledge and experience affect the trend effect, we merged the samples from Study 1, Study 2, and Study 3.

5.1 | Materials and methods

5.1.1 | Participants

The sample used for analysis in this section consisted of a merged sample of the participants in Study 1, Study 2, and Study 3.

5.1.2 | Statistical analysis

We ran a set of ordered probit regressions to test if the change in avalanche danger drove changes in perceived avalanche risk. More specifically, we tested whether seeing an upward change (from level 2 to level 3) in scenario 2 (downward change in scenario 1) made participants more likely to revise their risk estimates downward than seeing a downward change in scenario 2(upward change in scenario 1). The outcome variables in these regressions therefore take the value 1 if the subject perceived a *lower* avalanche risk in scenario 2 compared to scenario 1 (a downward adjustment), 2 if the subject perceived the *same* avalanche risk in the two scenarios, and 3 if the subject perceived a *higher* avalanche risk in the second scenario (an upward adjustment).

We included controls for an upward change in the second scenario (i.e., a downward change in the first scenario), treatment groups, and interactions between the treatments and seeing an upward change. To test for effects of avalanche knowledge, we controlled for avalanche training and backcountry experience (average days in avalanche terrain per season during the past five seasons). Finally, we controlled for interaction effects between treatments and avalanche training. To test for sample-specific effects, we included controls for data collection round.

To test if the changes in forecasted avalanche danger affected the *level* of perceived risk, we ran a random effects panel regression using the same control variables as in the ordered probit model.

5.2 | Results

The results of our ordered probit are presented in Table 4. The dependent variable in these regressions measures changes in perceived current (column 1) and expected future (column 2) avalanche risk between scenario 1 and 2. The table shows the estimated coefficients. We provide the regression results for all individual items and conditional marginal effects in Table B1 and Table B2, respectively, in Appendix B.

As can be seen in Table 4, our results suggest that seeing an increase in avalanche danger in the second scenario significantly increases the probability that participants, with the same level of backcountry experience and avalanche knowledge, adjust *current* risk estimates downward and *future* risk estimates upward. We find very few significant interaction effects between the information treatments and the direction of change in the second scenario. The only treatment group that appears to significantly reduce the trend effect is the combination of detailed information and a scale indicating

TABLE 3 Perceived avalanche risk, Study 3. Between- (Mann–Whitney U tests) and within-subject (Wilcoxon signed-rank tests) comparisons

	Trend			Between-subject (Mann–Whitney U test)		Within-subject (Wilcoxon signed−rank test)	
	UP	**DOWN**	**Diff.**	**|z|**	***p***	**|z|**	***p***
1. All							
Danger, others	5.34	5.80	−0.46	6.83	<0.001	8.30	<0.001
Danger, self	5.09	5.57	−0.48	6.14	<0.001	8.45	<0.001
Surprise	2.30	1.98	0.32	4.65	<0.001	6.74	<0.001
Current danger, average score	5.38	5.80	−0.42	6.71	<0.001	9.35	<0.001
Danger, tomorrow	4.41	4.12	0.29	3.59	<0.001	4.80	<0.001
No. of observations	439	439					
2. Avalanche danger							
Danger, others	5.26	5.81	−0.55	4.22	<0.001	4.90	<0.001
Danger, self	5.01	5.58	−0.58	3.87	<0.001	5.07	<0.001
Surprise	2.52	1.98	0.54	3.73	<0.001	4.79	<0.001
Current danger, average score	5.25	5.80	−0.55	4.54	<0.001	5.64	<0.001
Danger, tomorrow	4.69	4.34	0.35	2.54	0.011	3.23	<0.001
No. of observations	113	113					
3. Information							
Danger, others	5.38	5.99	−0.62	4.53	<0.001	5.20	<0.001
Danger, self	5.13	5.72	−0.59	3.99	<0.001	5.16	<0.001
Surprise	2.28	1.87	0.41	3.05	0.002	4.49	<0.001
Current danger, average score	5.41	5.95	−0.54	4.60	<0.001	6.34	<0.001
Danger, tomorrow	4.40	4.06	0.35	1.61	0.106	2.26	0.024
No. of observations	104	104					
4. Scale							
Danger, others	5.33	5.65	−0.32	2.64	0.008	3.53	<0.001
Danger, self	5.06	5.50	−0.44	2.59	0.010	3.79	<0.001
Surprise	2.27	2.03	0.24	3.73	<0.001	3.27	<0.001
Current danger, average score	5.37	5.70	−0.33	2.67	0.008	4.01	<0.001
Danger, tomorrow	4.46	4.22	0.23	1.37	0.172	1.85	0.065
No. of observations	125	125					
5. Information + Scale							
Danger, others	5,42	5,79	−0,37	2,33	0.020	2,76	0.006
Danger, self	5,18	5,49	−0,32	1,87	0.062	2,74	0.006
Surprise	2,11	2,04	0,07	0,44	0.658	0,80	0.425
Current danger, average score	5,49	5,75	−0,25	1,72	0.086	2,43	0.015
Danger, tomorrow	4,05	3,81	0,24	1,69	0.091	2,20	0.028
No. of observations	97	97					

the precise level of avalanche danger. This reduction is only significant for perceived current danger.

Concerning our background variables, we found that participants with avalanche training, on average, revise their risk estimate of current danger upward between scenario 1 and scenario 2, regardless of the direction of change in avalanche danger. In addition, we found a negative and significant interaction effect between formal avalanche training and seeing an upward change. In other words, formal avalanche training appears to *reinforce* the effect on perceived current danger.

Let us now turn to the effect of the change in avalanche danger on the *level* of perceived risk. We present the coefficients from our panel regression analysis of perceived current and expected future avalanche risk in Table 5 and Figures 9(A) and 9(B), below. We present the full set of results and estimated marginal effects in Appendix B

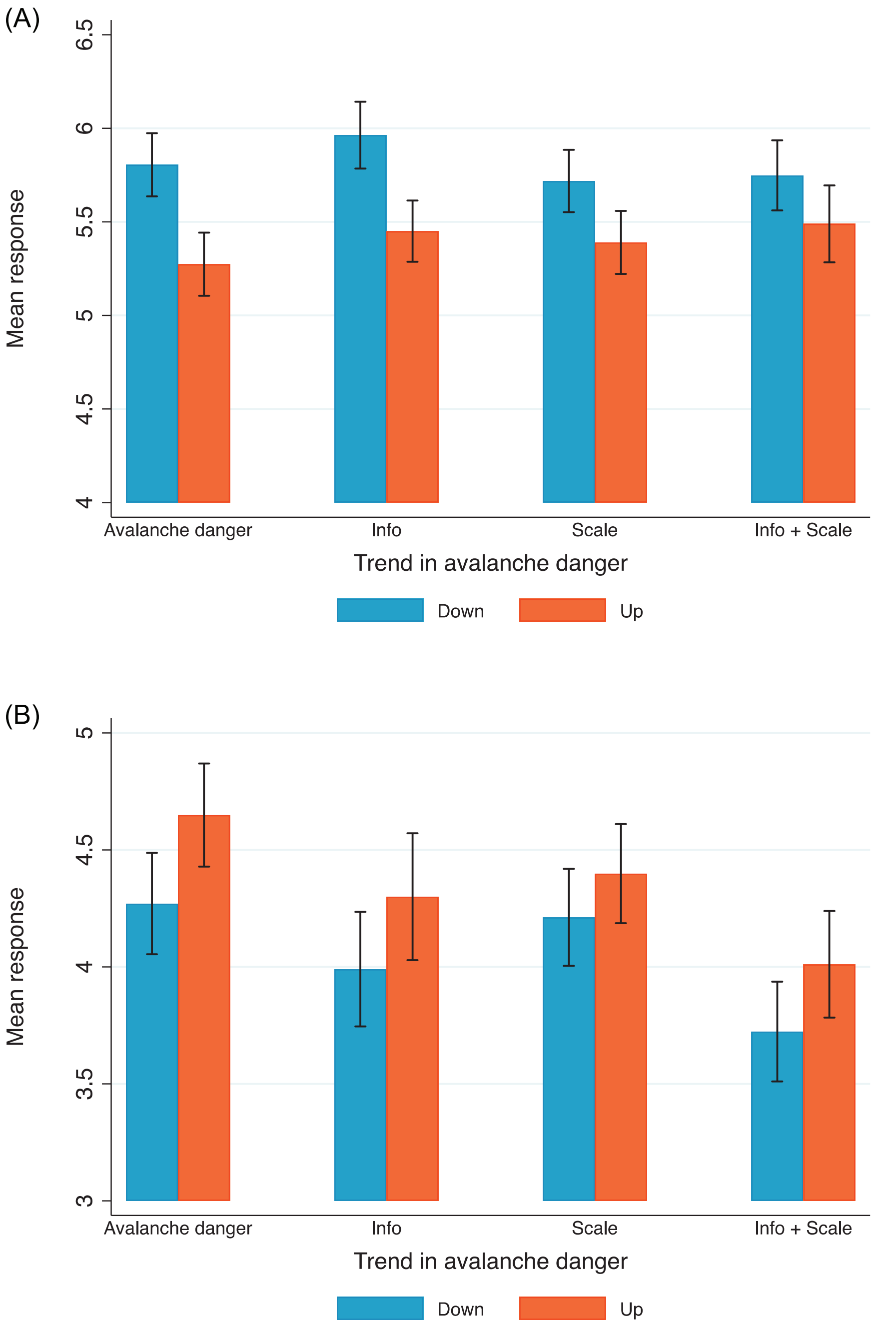


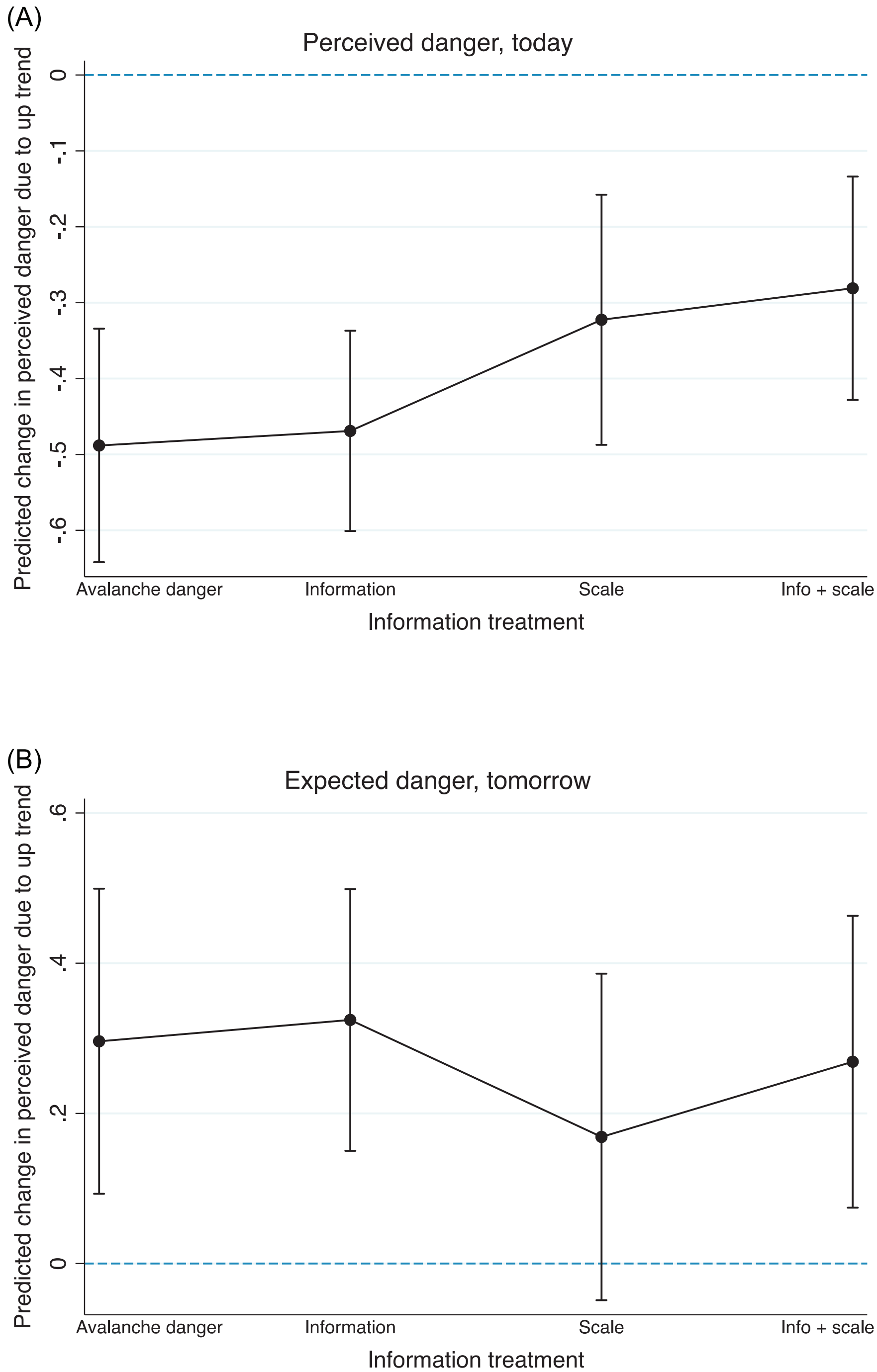
FIGURE 8 Study 3: Mean responses and 95% confidence intervals divided by information treatment (only avalanche danger: $N = 226$, Information: $N = 208$, Scale: $N = 250$, Information and Scale: $N = 194$). (A) Perceived avalanche danger, today (average score) and (B) expected avalanche danger, tomorrow

(Table B3 and Table B4, respectively).[3] The coefficient on the variable upward change shows the effect of seeing an increase in avalanche danger from level 2 to level 3 for individuals without avalanche training who only received information about the avalanche danger (no extra information). The interactions between the information treatment groups and the upward change variable tested whether participants who received information about the avalanche problem, a scale, or a combination of information and a scale, reacted differently to an increase in avalanche danger from 2 to 3 than participants who only saw the avalanche danger. Similarly, the interaction variable between avalanche training and upward change tested if individuals with avalanche training reacted differently to an increase in avalanche danger compared to untrained individuals.

Figures 9(A) and 9(B) display the conditional marginal effects of seeing an upward change in avalanche danger on perceived current and expected future avalanche risk. The blue lines in the figures represent the null hypothesis of no trend effect. The black dots represent the predicted effects of seeing an upward change in avalanche danger in each information treatment, conditional on all background variables.

[3] We have also estimated pooled ordinary least squares regressions, with standard errors clustered at the individual level. The results are robust to this alternative specification. The results are available from the authors upon request.

FIGURE 9 Merged sample: Studies 1–3. Conditional marginal effects of upward change in avalanche danger on perceived avalanche risk. Bars represent 95% confidence intervals. Estimation method: Random effects panel regression. (A) Perceived avalanche danger, today (average score) and (B) expected avalanche danger tomorrow



The black vertical lines show 95% confidence intervals. Predicted effects below the blue line imply that seeing an upward change reduced the rated danger. Correspondingly, effects above the blue line represent an increase in perceived danger due to an upward change (for effects on individual variables, see Figures B1–B3 in Appendix B).

The results in Table 5 (first column) Figures 9(A) reiterate that subjects perceived current avalanche risk to be significantly lower when the avalanche danger increased from level 2 to level 3 than when it fell from level 4 to level 3. The presence of a scale, or a scale in combination with detailed information reduced the size of the effect, but the reduction is only significant for the combined scale and information treatment, and the trend effect remains significant. Figure 9(B) similarly replicates our finding that our participants expected that future risk of avalanches would be higher when the avalanche danger is increasing than when it is falling. The presence of a scale makes the trend effect insignificant. However, as in the ordered probit, we found that the trend effect remains significant among participants who saw both a scale and read information about the avalanche problem.

Interestingly, we found no evidence that avalanche education reduces the trend effect. Indeed, individuals with avalanche training seemed to respond more to information

TABLE 4 Change in perceived risk between scenario 1 and 2. Marginal effects from ordered probit Regressions, estimated at means. Merged sample, Study 1, Study 2, and Study 3

	Danger, today (avg score)	Danger, tomorrow
Upward change	−0.784**	0.677**
	(0.227)	(0.216)
Information treatment (*ref is only avalanche danger level*)		
Information	−0.130	0.142
	(0.202)	(0.191)
Scale	−0.159	0.219
	(0.221)	(0.208)
Scale and information	−0.351+	0.160
	(0.209)	(0.198)
Up#Information	0.099	−0.127
	(0.276)	(0.258)
Up#Scale	0.270	−0.441
	(0.301)	(0.285)
Up#Info + Scale	0.637*	−0.204
	(0.288)	(0.271)
Sample (*Ref is Study 1*)		
Students (Study 2)	0.961**	−0.374+
	(0.226)	(0.212)
BC riders (Study 3)	0.085	−0.229
	(0.185)	(0.177)
Formal avalanche training	0.399**	0.126
	(0.149)	(0.138)
Up#Formal avalanche training	−0.627**	0.064
	(0.206)	(0.193)
Avg days in avalanche terrain	−0.004	−0.002
	(0.002)	(0.002)
Male	−0.056	−0.080
	(0.110)	(0.103)
N	588	588
Chi-square	129.981	43.570

**$p < 0.01$.
*$p < 0.05$.
+$p < 0.10$.

TABLE 5 Level of perceived current and expected future avalanche risk. Coefficients from panel regression with individual random effects. Merged sample, Study 1, Study 2, and Study 3

	Danger, today (avg score)	Danger, tomorrow
Upward change	−0.411**	0.241*
	(0.086)	(0.114)
Information treatment (*ref is only avalanche danger level*)		
Information	0.148	−0.362*
	(0.110)	(0.142)
Scale	−0.003	−0.102
	(0.120)	(0.155)
Scale and information	0.070	−0.605**
	(0.117)	(0.152)
Up#Information	0.019	0.028
	(0.104)	(0.137)
Up#Scale	0.166	−0.127
	(0.115)	(0.152)
Up#Info + Scale	0.207+	−0.027
	(0.109)	(0.144)
Sample (*Ref is Study 1*)		
Students (Study 2)	−0.318*	−0.022
	(0.149)	(0.191)
BC riders (Study 3)	−0.080	−0.283+
	(0.124)	(0.160)
Formal avalanche training	0.237**	−0.433**
	(0.083)	(0.108)
Up#Formal avalanche training	−0.196*	0.141
	(0.078)	(0.103)
Avg days in avalanche terrain	−0.003	−0.001
	(0.002)	(0.002)
Male	−0.316**	−0.003
	(0.074)	(0.094)
Second scenario	−0.052	−0.074
	(0.038)	(0.050)
Constant	6.026**	4.861**
	(0.144)	(0.185)
No. of observations	1176	1176
Chi-square	156.190	84.295

**$p < 0.01$.
*$p < 0.05$.
+$p < 0.10$.

about the danger level the previous day. Figures 10(A) and 10(B) show the predicted effect of an upward trend on perceived risk for individuals with and without formal training, respectively. Note that the differences between the two groups are not significant at the 5% level for expected future avalanche danger (also shown by the nonsignificant interaction effect in Table 5, column 2).

5.3 | Discussion

The results from our multivariate regression analysis confirm our bivariate tests. We consistently found that an increase in avalanche danger results in a downward adjustment in perceived current danger and an upward adjustment of expected future danger. Neither information about the seriousness of the avalanche problem, nor avalanche education eliminates the effect. The effects observed for the current avalanche danger are theoretically interesting, as the results differ from those reported in previous research (Hohle & Teigen, 2015). However, the effects are also of practical significance, as they

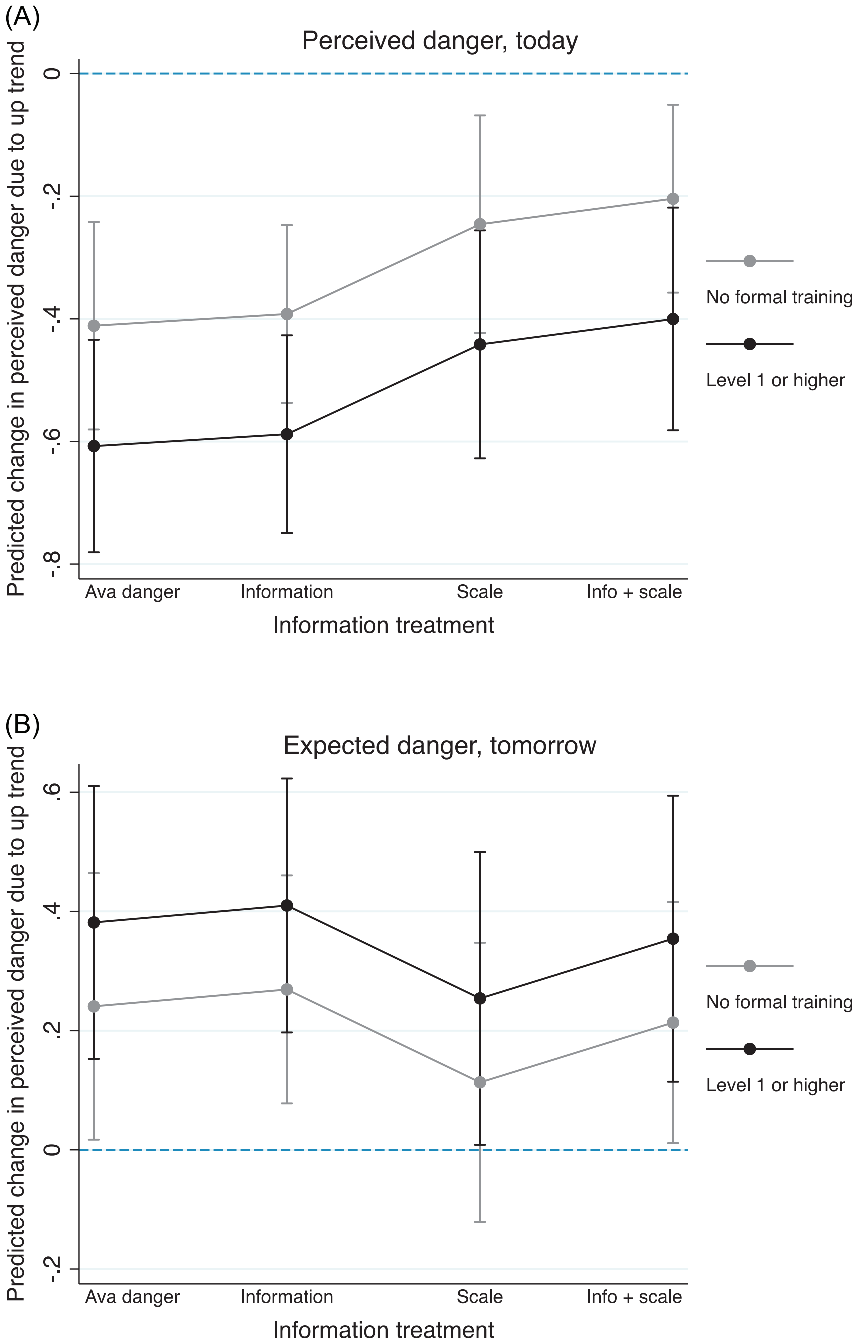


FIGURE 10 Merged sample: Studies 1–3. Conditional marginal effects of an upward change on perceived risk on individuals with and without formal avalanche education. Dots represent change in the level of perceived risk. Bars represent 95% confidence intervals. Estimation method: Random effects panel regression. (A) Perceived avalanche danger, today (average score) and (B) expected avalanche danger, tomorrow

address avalanche warnings used by preparedness authorities and indicate that recipients of the forecast may systematically interpret the forecast in a way not intended by the AWS.

6 | GENERAL DISCUSSION AND IMPLICATIONS FOR POLICY

Trend effects on perceived avalanche risk, which are not rooted in changes in actual avalanche danger, can have potentially catastrophic consequences. Our results suggest that both perceived current and expected future avalanche risk are affected by information about past avalanche hazard, regardless of backcountry experience and avalanche training. Indeed, individuals with avalanche training appeared to react more strongly to trends than people without avalanche education. In contrast to previous research (e.g., Erlandsson et al., 2018; Hohle & Teigen, 2015), we found that subjects perceived the current avalanche danger to be lower when the avalanche danger has increased than when it has fallen. Consistent with previous research on the trend effect (e.g., Erlandsson et al., 2018; Løhre, 2018; Hohle & Teigen, 2015, 2019) and on trend perception more generally (e.g., Ji et al., 2001; Lewandowsky, 2011; Maglio & Polman, 2016), participants' future risk estimates are projected in line with perceived trends in the past. Both findings imply that participants consider historic information when assessing current danger, rather than trusting that experts have already accounted for relevant background information in their most recent evaluation. The observed trend effect thus violates "the golden rule" of forecasting (Armstrong et al., 2015), which suggests that forecasting accuracy generally increases when forecasts are conservative and based on cumulative knowledge.

There are at least three potential reasons why we found a different result for perceived current risk than previous research on the trend effect (e.g., Erlandsson et al., 2018; Hohle & Teigen, 2015, 2019). First, our research involves a shorter time frame. Previous research has focused on how revised forecasts affect expectations about long-term forecasts (Erlandsson et al., 2018; Hohle & Teigen, 2015, 2019). For instance, Erlandsson et al. (2018) provided participants with mortality statistics from 2011 and 2013 and asked participants to estimate both severity of risk and expected mortality rates in 2015. The time frame between the two risk estimates in Hohle and Teigen's (2015) study focusing on landslides was 2 weeks. In our study, participants were provided with estimates that were revised from 1 day to the next, and participants may have anchored their estimate of current risk on the previous day's forecast because of the shorter time interval.

Second, historic information may also differentially affect risk perception depending on beliefs about the underlying mechanisms driving the risk. It is possible that the risk of rockslides, climate change (e.g., Hohle & Teigen, 2015 2019), or mortality rates (Erlandsson et al., 2018) are perceived as the result of relatively stable underlying processes that are consequently expected to develop in a specific direction. In comparison, avalanche risk can change rapidly. If our participants perceived avalanche risk as more volatile, making it more difficult to predict a direction of development, they may have anchored their current risk estimate on the past.

Finally, and perhaps most importantly, past avalanche danger is not completely irrelevant, because snow stabilizes over time. Although the avalanche forecast takes this development into account, the avalanche danger level (1 to 5) represents an interval. In the absence of information about the avalanche problem (likelihood of triggering, size of avalanche, distribution of weak layer), participants with experience of avalanche danger assessment may therefore rationally include this knowledge in their interpretation of the forecasted avalanche danger. However, detailed information about the avalanche problem should remove this effect. Our finding that the effect persists therefore suggests that experienced users are indeed forecasting the forecasters.

Our study design does not allow us to test whether subjects overestimate the current danger under a decreasing trend or underestimate it when the trend is increasing. However, if people reduce their danger estimates based on the irrelevant fact that conditions were relatively stable before, this could increase the risk of avalanche accidents. Our results indicate that historic information may divert recipients' attention toward the past, rather than focusing on the present avalanche danger and the specific avalanche problems addressed in the bulletin. AWS should therefore be cautious when displaying previous avalanche danger levels on today's forecast.

Future research should address whether the trend effect on perceived avalanche risk is robust to the level of avalanche danger—that is, if we observe a similar trend effect when the avalanche danger is on level 2 or on level 4. It is also important to investigate if the observed trend effects have behavioral implications. That is, if backcountry recreationalists and workers exposed to avalanche hazard behave differently depending on the trend in avalanche danger.

The results reported here may have implications for risk communication more generally. The simplified, categorical scheme used to communicate avalanche risk is also used for other hazards (Bostrom et al., 2008; see also the *Risk Management Guide* at the US Centers for Disease Control and Prevention). Reducing a complex assessment of risk into a single numerical or color category may be easy for the recipient to both understand and evaluate, but it does not provide the recipient with a full understanding of the assumptions underlying the risk assessment (Cox, 2008). Risk communicators should be aware that the public's perception of a given risk may depend not only on the current danger level but may also be evaluated in comparison to past forecasts.

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DECLARATION OF INTERESTS

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX A

Hypothetical scenario used in the survey experiment:

You are driving your car through mountainous terrain. The sky is overcast and the date is 16th (22nd) of March. You can see two parked cars on a trailhead next to the road, and ski tracks on the mountainside above. The tracks are on an eastern face of the mountain. You know that this mountain has several sections with a slope above 30°.

Based on the number of cars at the trailhead, you can presume that at there is at least one group of skiers on the mountain, but you have no information on their skill level or other characteristics.

You can see snow drifts from the west on the mountain. You have access to the following avalanche advisory on your mobile phone.

APPENDIX B

TABLE B1 Change in perceived danger between scenarios 1 and 2. Coefficients from ordered probit regressions. Standard errors in parentheses. Merged sample, Study 1, Study 2, and Study 3

	Danger, other	Danger, self	Surprise	Danger, today (avg score)	Danger, tomorrow
Upward change	−0.872**	−0.810**	0.867**	−0.784**	0.677**
	(0.219)	(0.219)	(0.218)	(0.227)	(0.216)
Information treatment (*ref is only avalanche danger level*)					
Information	0.036	−0.249	0.138	−0.130	0.142
	(0.191)	(0.194)	(0.190)	(0.202)	(0.191)
Scale	−0.110	−0.225	0.127	−0.159	0.219
	(0.209)	(0.213)	(0.209)	(0.221)	(0.208)
Scale and information	−0.012	−0.292	0.192	−0.351+	0.160
	(0.198)	(0.201)	(0.197)	(0.209)	(0.198)
Up#Information	−0.105	0.010	−0.221	0.099	−0.127
	(0.263)	(0.262)	(0.259)	(0.276)	(0.258)
Up#Scale	0.395	0.367	−0.192	0.270	−0.441
	(0.288)	(0.289)	(0.288)	(0.301)	(0.285)
Up#Info + Scale	0.221	0.253	−0.616*	0.637*	−0.204
	(0.275)	(0.275)	(0.273)	(0.288)	(0.271)
Sample (*Ref is Study 1*)					
Students (Study 2)	0.086	0.208	−0.190	0.961**	−0.374+
	(0.215)	(0.213)	(0.210)	(0.226)	(0.212)
BC riders (Study 3)	0.131	0.177	−0.128	0.085	−0.229
	(0.180)	(0.178)	(0.176)	(0.185)	(0.177)

(Continues)

TABLE B1 (Continued)

	Danger, other	Danger, self	Surprise	Danger, today (avg score)	Danger, tomorrow
Formal avalanche training	0.241+	0.292*	−0.059	0.399**	0.126
	(0.140)	(0.141)	(0.138)	(0.149)	(0.138)
Up#Formal avalanche training	−0.299	−0.548**	0.106	−0.627**	0.064
	(0.196)	(0.197)	(0.194)	(0.206)	(0.193)
Avg days in avalanche terrain	−0.001	−0.001	0.005*	−0.004	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Male	−0.146	−0.047	−0.057	−0.056	−0.080
	(0.104)	(0.104)	(0.104)	(0.110)	(0.103)
N	588	588	588	588	588
Chi-square	96.430	97.137	58.753	129.981	43.570

**$p < 0.01$.

TABLE B2 Change in perceived danger between scenarios 1 and 2. Conditional marginal effects from ordered probit analysis. Merged sample, Study 1, Study 2, and Study 3

	Perceived avalanche danger, *today* (avg score)			Expected avalanche danger, *tomorrow*		
	Perceived risk in scenario 2 compared to scenario 1					
	Lower	Same level	Higher	Lower	Same level	Higher
Upward change	0.281**	0.023*	−0.303**	−0.185**	0.021*	0.164**
	(0.034)	(0.009)	(0.036)	(0.031)	(0.010)	(0.028)
Information treatment						
Information	0.037	0.004	−0.040	−0.017	0.003	0.014
	(0.052)	(0.006)	(0.057)	(0.048)	(0.008)	(0.040)
Scale	0.003	0.000	−0.003	−0.015	0.002	0.013
	(0.054)	(0.008)	(0.062)	(0.052)	(0.008)	(0.044)
Scale and information	0.027	0.003	−0.030	−0.027	0.004	0.023
	(0.054)	(0.006)	(0.061)	(0.051)	(0.008)	(0.044)
Sample (Ref is Study 1)						
Students (Study 2)	−0.305**	−0.070**	0.375**	0.124+	−0.000	−0.124+
	(0.075)	(0.021)	(0.080)	(0.066)	(0.016)	(0.071)
BC riders (Study 3)	−0.048	0.003	0.046	0.100+	0.004	−0.104
	(0.074)	(0.006)	(0.068)	(0.052)	(0.013)	(0.064)
Formal avalanche training	−0.063	−0.007	0.071	−0.050	0.006	0.044
	(0.041)	(0.006)	(0.046)	(0.037)	(0.005)	(0.034)
log(BC experience)	0.021*	0.002+	−0.023*	−0.002	0.000	0.001
	(0.010)	(0.001)	(0.011)	(0.009)	(0.001)	(0.008)
Male	0.018	0.002	−0.020	0.034	−0.004	−0.030
	(0.039)	(0.005)	(0.044)	(0.035)	(0.004)	(0.032)
N	601			601		
Chi-square	142.894			46.074		

**$p < 0.01$.
*$p < 0.05$.
+$p < 0.10$.

TABLE B3 Level of perceived current and expected future avalanche risk. Coefficients from panel regression with individual random effects. Standard errors in parentheses. Merged sample, Study 1, Study 2, and Study 3

	Danger, other	Danger, self	Surprise	Danger, today (avg score)	Danger, tomorrow
Upward change	−0.427**	−0.340**	0.467**	−0.411**	0.241*
	(0.103)	(0.106)	(0.116)	(0.086)	(0.114)
Information treatment (*ref is only avalanche danger level*)					
Information	0.174	0.166	−0.104	0.148	−0.362*
	(0.119)	(0.151)	(0.144)	(0.110)	(0.142)
Scale	−0.095	0.069	−0.017	−0.003	−0.102
	(0.130)	(0.164)	(0.157)	(0.120)	(0.155)
Scale and information	0.062	0.148	0.000	0.070	−0.605**
	(0.127)	(0.161)	(0.154)	(0.117)	(0.152)
Up#Information	−0.024	−0.029	−0.111	0.019	0.028
	(0.123)	(0.127)	(0.140)	(0.104)	(0.137)
Up#Scale	0.201	0.053	−0.243	0.166	−0.127
	(0.136)	(0.141)	(0.155)	(0.115)	(0.152)
Up#Info + Scale	0.104	0.111	−0.406**	0.207+	−0.027
	(0.130)	(0.134)	(0.147)	(0.109)	(0.144)
Sample (*Ref is Study 1*)					
Students (Study 2)	−0.233	−0.245	0.476*	−0.318*	−0.022
	(0.156)	(0.210)	(0.193)	(0.149)	(0.191)
BC riders (Study 3)	−0.108	−0.034	0.097	−0.080	−0.283+
	(0.131)	(0.176)	(0.162)	(0.124)	(0.160)
Formal avalanche training	0.098	0.324**	−0.288**	0.237**	−0.433**
	(0.090)	(0.115)	(0.109)	(0.083)	(0.108)
Up#Formal avalanche training	−0.173+	−0.349**	0.066	−0.196*	0.141
	(0.092)	(0.095)	(0.105)	(0.078)	(0.103)
Avg days in avalanche terrain	−0.003*	−0.005*	−0.001	−0.003	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Male	−0.241**	−0.320**	0.387**	−0.316**	−0.003
	(0.077)	(0.104)	(0.096)	(0.074)	(0.094)
Second scenario	−0.084+	0.055	0.126*	−0.052	−0.074
	(0.045)	(0.046)	(0.051)	(0.038)	(0.050)
Constant	6.121**	5.664**	1.707**	6.026**	4.861**
	(0.153)	(0.200)	(0.188)	(0.144)	(0.185)
No. of observations	1176	1176	1176	1176	1176
Chi-square	124.122	132.166	88.721	156.190	84.295

**$p < 0.01$.
*$p < 0.05$.
+$p < 0.10$.

TABLE B4 Level of perceived current and expected future avalanche risk. Estimated marginal effects, estimated at means, from panel regression

	Danger, other	Danger, self	Surprise	Danger, today (avg score)	Danger, tomorrow
Upward change	−0.436**	−0.447**	0.306**	−0.396**	0.272**
	(0.045)	(0.046)	(0.051)	(0.038)	(0.050)
Information treatment (*ref is only avalanche danger level*)					
Information	0.161	0.152	−0.160	0.158	−0.348**
	(0.102)	(0.137)	(0.126)	(0.097)	(0.124)
Scale	0.005	0.096	−0.139	0.080	−0.165
	(0.110)	(0.148)	(0.137)	(0.105)	(0.135)
Scale and information	0.114	0.203	−0.203	0.174+	−0.618**
	(0.109)	(0.147)	(0.135)	(0.104)	(0.133)
Sample (*Ref is Study 1*)					
Students (Study 2)	−0.233	−0.245	0.476*	−0.318*	−0.022
	(0.156)	(0.210)	(0.193)	(0.149)	(0.191)
BC riders (Study 3)	−0.108	−0.034	0.097	−0.080	−0.283+
	(0.131)	(0.176)	(0.162)	(0.124)	(0.160)
Formal avalanche training	0.012	0.150	−0.255**	0.139+	−0.363**
	(0.078)	(0.104)	(0.096)	(0.074)	(0.095)
Avg days in avalanche terrain	−0.003*	−0.005*	−0.001	−0.003	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Male	−0.241**	−0.320**	0.387**	−0.316**	−0.003
	(0.077)	(0.104)	(0.096)	(0.074)	(0.094)
Second scenario	−0.084+	0.055	0.126*	−0.052	−0.074
	(0.045)	(0.046)	(0.051)	(0.038)	(0.050)
No. of observations	1176	1176	1176	1176	1176
Chi square	124.122	132.166	88.721	156.190	84.295

**$p < 0.01$.
*$p < 0.05$.
+$p < 0.10$.

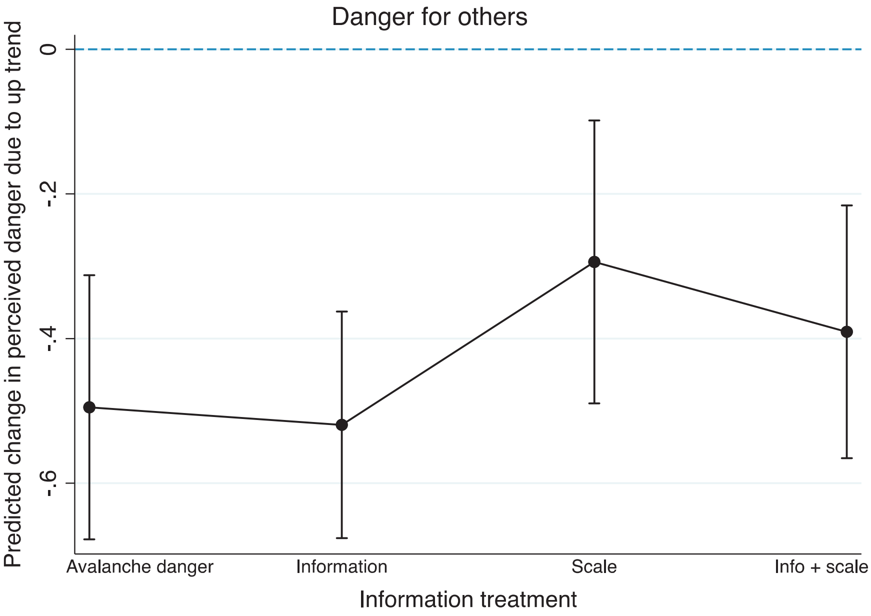

FIGURE B1 Merged sample: Studies 1–3. Conditional marginal effects of upward change in avalanche danger on **Danger, self**. Bars represent 95% confidence intervals. Estimation method: Random effects panel regression

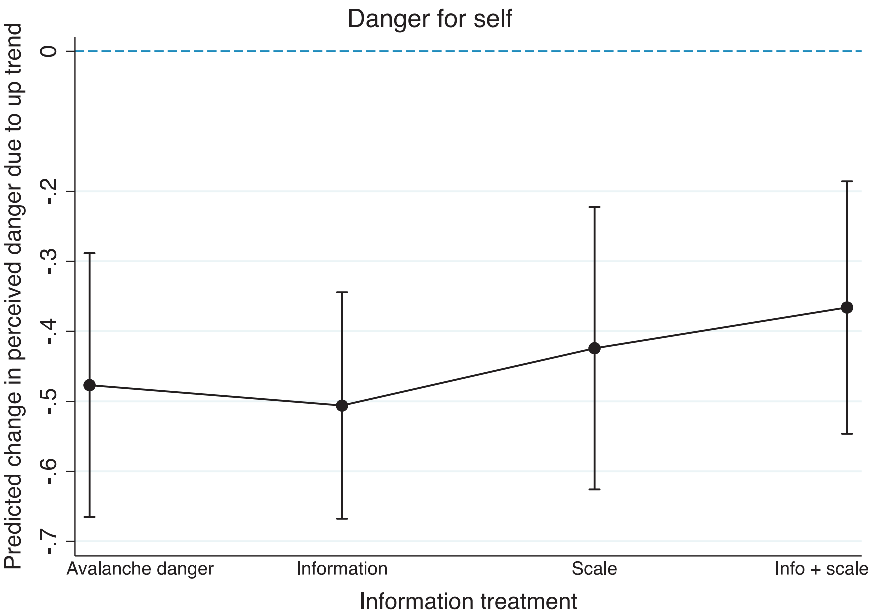

FIGURE B2 Merged sample: Studies 1–3. Conditional marginal effects of upward change in avalanche danger on **Danger, others**. Bars represent 95% confidence intervals. Estimation method: Random effects panel regression

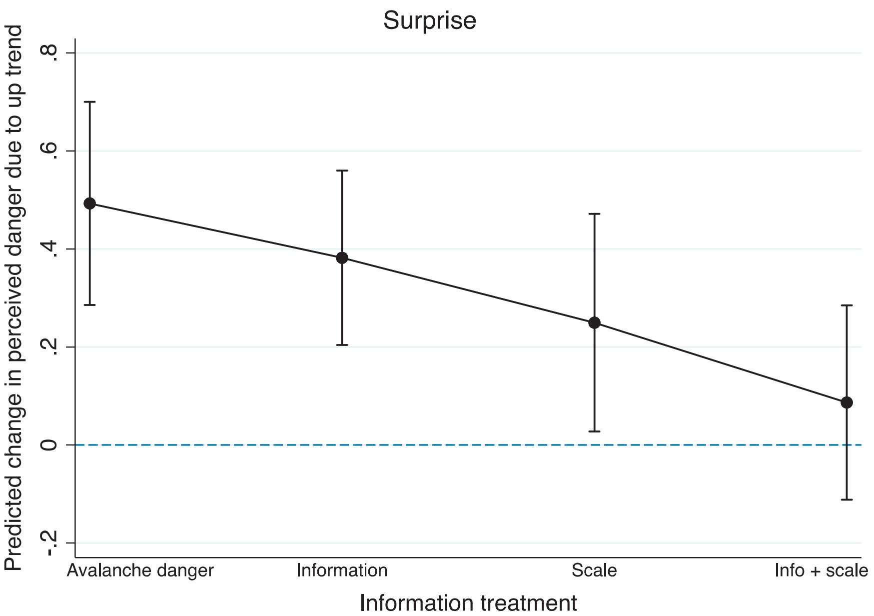

FIGURE B3 Merged sample: Studies 1–3. Conditional marginal effects of upward change in avalanche danger on **Surprise**. Bars represent 95% confidence intervals. Estimation method: Random effects panel regression