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Lessons learned from accident and near-accident experiences in traffic

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ABSTRACT

The focus of this article is risky behavior in traffic. What do people learn from accidents and near-accidents? Experience with accidents may demand increased caution. However, near-accidents are inherently ambiguous: On the one hand, they signal that margins were good enough, inspiring increased risk-taking; on the other hand, they signal danger that could induce increased caution. To explore these issues, participants ($N = 614$) answered 47 questions related to safe traffic behavior as well as reported on their experiences with traffic accidents and near-accidents, assessing changes in cautiousness as well as cognitive (i.e., counterfactual thinking) and emotional mechanisms possibly involved in learning from such experience. Results indicate that people do not become more cautious after accidents, whereas repeated experiences with near-accidents seem to foster less cautious traffic behavior. We discuss emotional and cognitive mechanisms related to these effects, and suggest that cautiousness after near-accidents is associated with assuming personal responsibility and upward counterfactual comparisons. We conclude that the mechanisms involved in learning from near-accidents are theoretically interesting, as well as important for the understanding of safe driving behavior.

1. Introduction

Individuals and organizations learn from obvious failures (e.g., Ellis et al., 2014; Reason, 2016), but less is known about the lessons learned from mere incidents and near-accidents. There are more incidents than accidents, and therefore incidents could be a potent source of learning. However, incidents and near-accidents are inherently ambiguous and can be interpreted both as a wakeup call highlighting a potential source of danger (McMullen and Markman, 2000) or as a success indicating that margins were good enough (Dillon and Tinsley, 2008, Plous, 1991; Tinsley et al., 2012). We investigate this dilemma by asking participants about thoughts and emotions following accidents and near-accidents in traffic, and by assessing whether prior incidents inspire caution or confidence.

We start with a brief review of research exploring the role of thoughts and feelings related to accidents and near-accidents, using counterfactual thinking as a theoretical framework. Then we present results from drivers reporting on their safety-related traffic behavior as well as cognitions and feelings associated with accidents and near-accidents.

2. Learning from accidents

Often accidents lead to increased caution. Negative events tend to grab attention, lead to more thorough and detailed-oriented processing of information, and motivate cognitive activity aimed at understanding what went wrong (Lieberman et al., 2002; Markman et al., 2007). Whereas the hindsight bias (Fischhoff and Beyth, 1975; Roese and Vohs, 2012) sometimes leads to overconfidence and complacency (Wilson and Gilbert, 2008), negative events typically trigger counterfactual thinking and corrective action (Epstude and Roese, 2008; Roese, 1997; Roese and Epstude, 2017). Thus, failures tend to activate feelings, thoughts, and mindsets that help improve future performance and thereby increase caution.

3. Learning from near-accidents

Learning from near-accidents is less straightforward. We discuss two models that demonstrate some of the complexity involved in such learning, one suggesting that near-accidents sometimes inspire more confidence than caution, the other suggesting the opposite.

3.1. Counterfactual thinking: Outcome bias and affective contrast

In order to determine whether a given outcome is a success or failure, we must rely on some reference information for the evaluation, typically social (Festinger, 1954), temporal (Albert, 1977; Wilson and Ross, 2000), or counterfactual (Kahneman and Miller, 1986; Markman

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and McMullen, 2003). In counterfactual thinking, comparing reality to a better alternative (upward comparison) typically results in negative affect signaling that corrective action is required. In contrast, thinking that things could be worse (downward comparison) results in positive affect and indicates that margins were good enough. Consequently, whether an outcome is considered a success or failure is influenced by the counterfactual alternative to which it is compared, and negative outcomes (e.g., spraining your arm) might be evaluated positively if it is easy to imagine a counterfactual that is even more negative (breaking your arm) (e.g., Teigen, 1995). This can even lead to a *satisfaction reversal* in that people who are objectively worse off feel better about the outcome (Medvec et al., 1995; McMullen and Markman, 2002), and are more optimistic about future success (Clark et al., 2013; Wohl and Enzle, 2003; Zhang and Covey, 2014). Accordingly, a problem with learning from near-accidents is that they might not even trigger the attentional, cognitive, and attributional resources required to search for and detect the warning signals embedded in a near-miss.

Results from research on near-misses in organizational decision making (Dillon and Tinsley, 2008) provide an even stronger argument for why near-accidents do not foster increased caution. Consistent with an outcome bias (Baron and Hershey, 1988), Dillon and Tinsley reported that the evaluations of decision outcomes were heavily dependent on final outcomes. Near-misses, situations where a negative outcome is feared but avoided, were evaluated similarly to successes and significantly more favorable than failures. This was true both for final outcomes and of the decisions leading up to it (see Svartdal, 2011, for similar results). Dillon and Tinsley (2008) termed this effect a near-miss bias and reported that exposure to certain types of near-miss experiences not only fail to act as a warning signal but may even promote risky decision-making. This increased willingness to take risk seem to relate to the process by which people update risk estimates, and appears to be affective rather than cognitive. A near-miss event contains case-specific information that triggers associative reasoning and an update of the relevant hazard category in memory. Consequently, we subsequently perceive the category to which the risk belongs as less affectively threatening and become more risk-accepting in future decision making. A potential consequence of this process is that repeated experience with near-accidents will serve to increase one's sense of safety, as each additional experience confirms the safety of the situation or hazard.

3.2. Counterfactual thinking and avoidance motivation

Alternatively, near-accidents could increase caution, as is indicated from studies investigating the motivational effect of downward counterfactuals for avoidance motivation (e.g. Markman and McMullen, 2003; McMullen and Markman, 2000; Pennington and Roese, 2003; Svartdal, 2011). For example, in the Reflection and Evaluation Model (REM), Markman and McMullen (2003) distinguish between two processing modes: reflection and evaluation. The evaluation process involves using a counterfactual outcome as a standard of comparison to evaluate the factual outcome, which typically leads to the affective contrast effect described previously. Reflection, on the other hand, involves mentally simulating and experientially reflecting on the counterfactual as if it were true, thereby assimilating the negative feelings associated with that outcome. This assimilation effect could be an important component in avoidance motivation, as is at least implicitly suggested by studies of people having experienced accidents and near-accidents (e.g., Teigen, 1995).

People who have been in dangerous situations appear to be quite insistent on rather dramatic downward counterfactuals and tend to imagine that the outcome could have been much worse (Teigen, 1995, 1996, 2005; Teigen et al., 2011). Consequently, reports of good luck, relief, and even gratefulness are particularly frequent in situations characterized by risk and hazards (Teigen, 1997, 1998; Teigen and Jensen, 2011). However, the positive emotions in such situations could still represent a functional mechanism to the extent that such incidents represent "close calls" that one should try to avoid in the future. Here one must differentiate between the affect activated by situational cues that trigger immediate counterfactual thinking (Roese, 1994; Russell, 2003), and the full-blown conscious emotions (relief, gratitude) that stimulate further counterfactual analysis and elaboration over behaviour and possible outcomes in the aftermath of the situation (Baumeister et al., 2007; Epstude and Roese, 2008; Roese, 1994). For avoidance motivation, downward counterfactuals and the emotions that accompany them may be particularly useful for driving home lessons for the future after near-accidents, indicating that close calls in fact foster increased caution.

4. The present study

The research discussed indicates (1) that accidents tend to foster increased caution, and (2) that near-accidents might sometimes inspire confidence and sometimes caution. This ambiguity makes near-accident experiences particularly interesting, both theoretically as discussed, but they may also be important for learning in real-life settings. To our knowledge, no previous research has addressed what and how individuals might learn from near-accidents that are relevant to one's personal safety.

The traffic domain is particularly well suited to examine learning from accidents and near-accidents, as it represents a domain where experience with such events are both frequent and potentially of high consequence (World Health Organization, 2013). Furthermore, whereas improvements in road and vehicle safety has lead to a reduction in fatal traffic accidents, the number of non-fatal accidents have not been decreasing at the same rate and have in some countries even increased, indicating a need for studies addressing behavioral aspects of road safety (Berecki-Gisolf et al., 2013; Weijermars et al., 2016; Williams et al., 2006). For example, young drivers, and young men in particular, are overrepresented in accidents statistics (e.g., Clarke et al., 2005; Gheorghiu et al., 2015), also in rural areas of Norway (Bakke et al., 2013). These findings have been linked to high involvement in risky behaviors, such as speeding, driving under the influence, and other forms of sensation seeking (Bakke et al., 2013; Cestac et al., 2011; Iversen and Rundmo, 2002). Consequently, understanding how traffic accidents and incidents affect subsequent driving behavior is both practically and theoretically important, particularly among younger drivers.

In the present study, respondents first answered questions addressing safe driving behavior, enabling us to obtain an index reflecting our primary outcome variable: *Safe driving*. Then participants reported on their experience with accidents and near-accidents as well as thoughts and feelings associated with such events. As an *accident* signals that an important barrier has been crossed, experience with accidents should be associated with increased caution, and even more so with repeated experiences. In contrast, as repeated experience with *near-accidents* signal both resilience and vulnerability, two outcomes are possible: On the one hand, repeated experiences may induce increased caution, or alternatively, repeated experience with near-accidents may have an opposite effect, as each additional experience confirms that margins were good enough.

At least two factors may modulate such learning effects. First, experiencing an accident or near-accident may promote learning depending on prior accidents/near-accidents history. For example, a possible scenario would be that experiencing a near-accident would promote learning given a prior history of accidents, but not in the absence of prior accident history. To assess such interactions, we examined possible main as well as interaction effects in changes in our safe driving index. We also assessed the possible modulating effect of gender and age, as research on road safety behavior has linked young age (particularly for men) to risky traffic behavior. Second, whether near-accidents are associated with increased caution or not may depend on emotional and/or cognitive reactions associated with these incidents. We therefore explored the role of counterfactual thoughts and emotions for learning after accidents and near accidents. Specifically, we expected that dramatic downward counterfactuals – imagining that an experienced outcome could have turned out much worse - should foster learning. Furthermore, learning from accidents and near accidents should depend on the specific emotions elicited by such experiences. For instance, if learned cautiousness depend on downward counterfactual comparisons, learned cautiousness should also be associated with positive emotions such as relief and gratitude. In contrast, if learned cautiousness depend on upward counterfactual thinking, cautiousness should be associated with the negative emotions of unpleasantness and regret. Finally, learning from accidents and near-accidents should depend on causal attributions. We therefore explored if-then-statements generated by participants for the direction of comparison (upward vs. downward) and focus (self-focused vs. other-focused), expecting that self-focused counterfactuals should promote learning.

5. Method

5.1. Participants

The sample consisted of 614 participants (367 women). Participants were recruited through a mailing list at UiT The Arctic University of Norway and through snowballing in two social media platforms: Facebook (www.facebook.com) and Reddit (www.reddit.com/r/norge). Data from 17 respondents were removed prior to analysis due to incomplete responses on key variables, leaving a final sample of 597 participants. Participants were primarily of Norwegian nationality living in one of the three northernmost counties of Norway. The majority were aged 18–23 (34%) and 24–29 (44%), 21% were aged 30–38, and 1% were 39 or older, indicating that we have primarily recruited a sample of Norwegian students. As is seen in Table 1, both accidents and near-accidents were quite common in our sample, with near-accidents reported by 74% of participants and accidents reported by 43% of participants. The Norwegian Public Roads Administration does not collect data on near-accidents, but estimates indicate 9000–40,000 road-accident injuries annually (Norwegian Public Roads Administration, 2018), suggesting that near-accidents are even more common.

5.2. Material and procedure

We developed and distributed a questionnaire using Qualtrics (Qualtrics, Provo, UT). All participants received the same questionnaire, introduced as a study "…aimed at understanding risk behavior and accident experiences among drivers." Participants read that the survey would take approximately 15–20 min to complete, that participation was voluntary, and that one could exit the survey at any time. Participants were asked to provide demographic information on (sex, age, place of residence, and year of driving after requiring a license). To ensure participant's anonymity, we collected information about age in five-year intervals, and residency was only specific to county and country. We did not collect IP-addresses.

Table 1
Number of participants experience with accidents and near-accidents.

	Experience with accidents and near-accidents					
	Zero	One	Two	3–4	5+	Total
Accidents	341	152	77	25	2	597
Near-accidents	156	141	112	108	80	597

Note. The two participants having experienced 5+ accidents were moved to the 3–4 accidents category in all analyses.

5.3. Safe driving behavior

Participants first answered 47 questions concerning safe driving behaviors. Items were included to reflect important aspects of safe driving, including speed, safety-relevant car maintenance, and caution in traffic. Examples are "I follow scheduled services on my car;" "I make sure my tires have the recommended tire pressure" (safety); "I always check my vehicle's blind spot before switching lanes;" "I always maintain a safe distance to other vehicles on the road" (caution in traffic); and "I often driver more than 10 km/t above the speed limit in residential areas;" "I often drive more than 20 km/t above the speed limit on the highway" (speed). Participants rated all items on a 7-point interval scale (1 = not at all descriptive of me, 7 = very descriptive of me). Before analysis, items describing risky driving behaviors were reverse coded, higher scores indicating safe driving behavior.

5.4. Accidents

Participants were then asked whether they had previously been in a traffic accident. Predefined alternatives were provided at an ordinal level as: "never, once, twice, 3–4 times or five-or-more". Participants who had experienced at least one accident were then asked to think of a specific accident and evaluate the valence of (a) what *actually* happened and (b) what *could* have happened on separate six-point interval scales (1 = very negative, 6 = very positive). The scales were reverse-coded into negativity scales prior to analysis. Participants also rated their feelings of unpleasantness, anger, regret, relief, joy, and gratitude during the incident on five-point interval scales (1 = not at all, 5 = very much). Unpleasantness and relief were intended as measures of general affect, regret, and anger as measures of specific self-focused and other-focused negative emotions, and joy and gratitude as self-focused versus other-focused positive emotions. Participants were then asked to which degree the accident had contributed to making them a more cautious driver on a five-point interval scale (1 = not very much, 5 = very much).

5.5. Near-accidents

Next, participants were asked to indicate previous experience with near-accidents, to evaluate both the factual and counterfactual outcome on separate six-point interval scales, and to rate their feelings of unpleasantness, anger, regret, relief, joy, and gratitude during the incident, in the same manner as for the previous question about accidents. As we were particularly interested in *near-accidents* in this study, we also asked participants to evaluate the degree to which they felt (a) personally responsible for causing the incident, (b) that someone else was responsible for causing the incident, (c) causally responsible for resolving the situation, and (d) that someone else was responsible for resolving the situation. Answers were given on four separate five-point interval scales (1 = not at all, 5 = very much). Furthermore, participants were asked to consider how the incident could have turned out differently, and formulate the considered sentiment with an if-then statement in an open-ended sentence completion task. Participants were also asked to indicate the degree to which the near-accident had contributed to making them a more cautious driver on a five-point interval scale (1 = not very much, 5 = very much). Finally, participants were thanked for their participation and debriefed.

5.6. Statistical analysis

The items measuring safe driving (47 in total) were averaged into a safe driving index. In addition, we computed subscales to assess *compliance with speed limits*, *cautious driving under winter conditions* (an issue highly relevant in the region of data collection) *attention to vehicle maintenance,* and *attention to traffic*. The Cronbach alphas for the subscales were 0.82 (*compliance with speed limits;* 7 items*)*, 0.73 (*attention to* *vehicle maintenance;* 6 items*),* 0.74 (*cautious driving under winter conditions;* 3 items*),* and 0.55 (*attention to traffic;* 3 items*).* The individual subscales correlated highly with the composite index of all four subscales ($r = 0.58 - r = 0.75$) as well as with the mean of all the 47 safe driving items ($r = 0.46 - r = 0.75$). The correlation between the mean of all safe driving items and the mean of the subscales was $r = 0.92$. Consequently we focused on the Safe driving index in the analyses reported here.

To assess factors associated with safe driving, the Safe driving index was subjected to analysis of variance (ANOVA) with number of accidents and near-accidents as predictors. In these analyses, years of driving after obtaining a driver's license, gender, and age were also entered in the model, testing main effects of accidents and near accidents as well the accident * near-accident interaction. We also tested the interaction between near-accident experiences and gender, age and years of holding a drivers license, as reviewed research indicate that experience, age and gender are risk factors in road safety.

Self-reported changes in cautiousness after accidents and near-accidents were limited to participants having experienced at least one accident/near-accident. As is seen in Table 1, 341 participants reported having had zero accidents, whereas 156 participants reported zero near-accidents. Also, note that these estimates reflect relative rather than absolute estimates ("increased caution"). We subjected these estimates to Spearman rank-order correlational analyses, as accident and near-accident experiences were ordinal variables and changed cautiousness was measured at an interval level.

In exploring possible mechanisms involved in learning from accidents and near-accidents, Pearson correlations were used to test the specific expectation that changes in cautiousness was related to downward counterfactual comparisons. Ordinary least squares regressions were used to further explore the relation between self-reported changed carefulness and the specific emotions experienced after accidents and near-accidents. Finally, the relation between perceived causal responsibility and learned carefulness were explored with ordinary least squares regression models and by participants' counterfactual thoughts as measured with an If-then sentence completion task. Mean scores on the self-reported changed cautiousness measure were analyzed with ANOVA models, with direction of comparison (upward vs. downward) and focus (self-focused vs. other-focused) as between group factors.

We used G*Power 3.1.9.2 to calculate the required sample size. Assuming medium effect sizes (0.25), alpha levels of 0.05, and power = 0.95, ANOVAS testing main effects between up to five groups (as was the case of near-accidents) required a sample size of 400. Testing interactions, with $df = 12$ at the most, required a sample size of 425. For the regression analyses, assuming the same parameters, five predictors on a single dependent variable required a sample size of 45.

For all statistical analyses, we used Statistica 13.4 (TIBCO Software, Inc.).

6. Results and discussion

6.1. Safe driving behavior

To assess the potential effect of experience with accidents and near-accidents on overall *Safe driving,* we entered these two predictors as well as gender, age intervals and years holding a driver's license as categorical predictors in a mixed ANOVA. The analysis indicated a significant effect of near-accidents, $F(4, 514) = 3.93$, $p = .004$, partial eta squared = 0.03, a nonsignificant effect of accidents, $F(3, 514) = 0.94$, p = ns, and a significant effect of gender, $F(1, 514) = 4.45$, $p = .04$, partial eta squared = 0.01. The effect of gender reflected that women demonstrated a higher mean Safe driving score compared to men. Importantly, no significant accidents * near-accidents interaction was observed, $F(12, 514) = 0.87$, $p = .583$, indicating that experience with different numbers of accidents did not affect near-accidents, and vice versa. The complete results are presented in Table 2.

Table 2
Mixed ANOVA model predicting score on Safe driving index based on experience with accidents, near-accidents, gender, age and years of driving.

	Sum of Squares	df	Mean Square	*F*	*sig*	Partial η^2
Intercept	3321.90	1	3321.90	5746.73	0.001	0.918
Accidents	1.64	3	0.55	0.94	0.420	0.005
Near-accidents	9.09	4	2.27	3.93	0.004	0.030
Accident * Near-Accident	5.99	12	0.50	0.87	0.583	0.020
Gender	2.57	1	2.57	4.45	0.035	0.009
Age	0.01	2	0.01	0.01	0.993	0.001
Years of driving	0.68	2	0.34	0.59	0.556	0.002
Error	297.12	514	0.58			

Table 3
Mean and standard deviation of safe driving behavior for accidents and near-accidents depending on the number of accidents and near-accidents.

	Safe driving following accidents and near-accidents				
	Zero	One	Two	3 or 4	5 or more
Accidents	N = 303 5.35 (0.76)	N = 137 5.21 (0.76)	N = 72 5.26 (0.81)	N = 27 5.26 (0.91)	*Na.** *Na.**
Near-accidents	N = 129 5.42 (0.74)	N = 129 5.36 (0.70)	N = 102 5.39 (0.71)	N = 102 5.24 (0.77)	*N = 77* 4.94 (0.92)

As can be seen from Table 3, the significant effect of near-accidents was due to the fact that an increased number of near-accidents was associated with a lower *Safe driving* score (4.94 in the 5+ group). Also, note that the transition from zero to one accident/near-accident was not accompanied with any change in the safe driving index.

To explore potential factors modulating the relation between *Safe driving* and near-accident experiences, both the near-accident * gender and near-accident * years holding a certificate interactions were analyzed, demonstrating nonsignificant effects. The near-accident * age interaction (age recoded to three levels, 18–23, 24–29, and > 30 years) was significant, $F(8, 524) = 2637$, $p = .008$, partial eta squared = 0.04. As can be seen in Fig. 1, and as predicted, the interaction effect reflects that the reduction in scores on *Safe driving* seems to be more pronounced in the two youngest age groups.

Overall, these results indicate that an increased number of accidents was not associated with changes in the *Safe driving* score, whereas

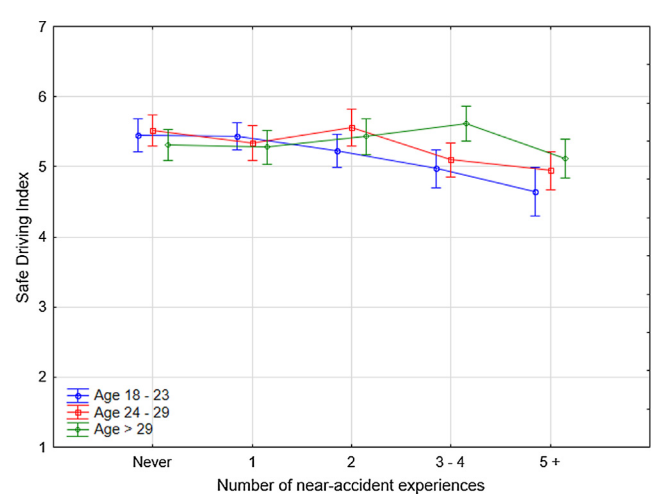

Fig. 1. Scores on *Safe Driving* depending on age group and number of near-accident experiences.

Table 4
Mean and standard deviation of self-reported changed cautiousness for accidents and near-accidents depending on the number of accidents and near-accidents.

Changed cautiousness following accidents and near-accidents					
	One	Two	3 or 4	5 or more	Total
Accidents	N = 152 3.00 (1.35)	N = 77 3.68 (1.38)	N = 27 3.59 (1.44)	*Na.** *Na.**	*N = 256* 3.27 (1.38)
Near-accidents	N = 140 3.08 (1.42)	N = 108 3.19 (1.27)	N = 104 3.14 (1.38)	N = 80 2.84 (1.35)	*N = 432* 3.07 (1.36)

increased number of near-accidents was associated with a reduction in safe driving scores. Note that there were no changes between not having had accidents/near-accidents and having had one. Women demonstrated an overall higher safe driving score compared to men, but no modulating effect of gender was found on the relation between repeated near-accident experiences and safe driving. Age appeared to modulate the relation between near-accident experiences and safe driving, reflecting that near-accidents inspired less caution in the younger age groups.

6.2. Self-reported changed caution following accidents and near-accidents

When participants were asked specifically about increased caution after a particular accident or near-accident, both seemed to induce increased caution. The mean caution estimates are displayed in Table 4. A Spearman rank-order correlation showed a significant positive association between number of accidents and changed cautiousness after accidents, $rs(254) = 0.232$, $p < .05$, but no significant association between experience with near-accidents and changed cautiousness, $rs(430) = -0.042$, $p > .05$, indicating that only experience with accidents foster increased caution.

Using the subjective estimates of increased cautiousness and number of incidents as predictors, and *Safe driving* as the dependent variable, the ANOVA indicated no effect of the increased cautiousness * accidents interaction, nor of the increased cautiousness * near-accidents interaction. Thus, the subjective changes in cautiousness were not reflected in the *Safe driving* index, indicating a dissociation between a more “objective” measure of driving safety and subjective changes. Even participants reporting having been “much” or “very much” more careful after near-accidents demonstrated marked *reduction* in their *Safe driving* scores after 3–4 and 5+ near accidents.

6.3. Possible mechanisms

In examining possible mechanisms involved in learning from accidents and near-accidents we found little support for the hypothesis that downward counterfactual comparison would inspire caution, as correlations between the valence of the counterfactual outcome and learned cautiousness were low, for both accidents ($r(256) = -0.14$, $p < .05$) and near-accidents ($r(423) = -0.06$, $p > .05$).

Rather, learned carefulness appeared to be related to upward counterfactual comparisons, as the negative emotions of regret (Accidents: $\beta = 0.28$, $p < .001$; Near-accidents: $\beta = 0.20$, $p < .0001$) and unpleasantness (Accidents: $\beta = 0.22$, $p < .001$; Near-accidents: $\beta = 0.36$, $p < .0001$) significantly predicted increased cautiousness. Relief (Accidents: $\beta = 0.07$, *ns*; Near-accidents: $\beta = 0.03$, ns) and gratitude (Accidents = $\beta = 0.11$, ns; Near-accidents: $\beta = 0.11$, ns) did not.

Turning to the four variables measuring perceived causal responsibility, only the statement assessing personal responsibility for *causing* the near-accident predicted changed cautiousness ($\beta = 0.31$, $p < .0001$). Importantly, there was no association between changed cautiousness and the degree to which participants themselves ($\beta = -0.05$. $p = .40$) or someone else ($\beta = 0.06$, $p = .23$) were responsible for avoiding a more serious incident, again suggesting that upward rather than downward comparisons inspire caution.

A similar pattern was found analyzing the if-then statements generated after near-accidents. Participants reported higher caution following upward ($M = 3.32$; $SD = 1.37$) compared to downward comparisons ($M = 2.83$; $SD = 1.39$), $F(1, 244) = 7.60$, $p < .01$, and following self-focused ($M = 3.91$; $SD = 1.09$) compared to other-focused counterfactuals ($M = 2.76$; $SD = 1.38$), $F(1, 208) = 24.52$, $p < .0001$. Learned cautiousness after near-accidents appeared to be contingent on assuming personal responsibility and on self-focused, upward counterfactuals.

7. General discussion

The present research investigated thoughts and feelings associated with accidents and near-accidents in traffic, investigating if and how such experiences affect cautiousness in traffic. Cautiousness was measured by an index for safe driving behavior, as well as a measure reflecting self-reported increase in caution following accidents and near-accidents. We expected accidents to increase caution, and existing literature suggests two alternative effects of near-accidents: Near-accidents may increase caution (i.e., scare people straight) or boost confidence (i.e., a near-miss bias).

The results showed that repeated experience with near-accidents was associated with a significant *decrease* in the safe driving behavior score, whereas no learning occurred after accidents. As for self-reported change in cautiousness, no learning effect occurred after repeated experiences with near-accidents, but increased caution was reported after two or more accidents. These results may indicate a dissociation between our measure of safe driving safety and subjective report of increased caution. Examining possible mechanisms involved in such incidents, changes in cautiousness was primarily determined by how unpleasant the situation had been, and by how much regret participants felt about the situation, indicating that upward rather than downward counterfactual thinking promotes learning. Finally, analysis of near-accident experiences demonstrated that self-focused upward counterfactuals were associated with learned cautiousness.

We now first discuss how our results relate to earlier research on the near-miss bias, before turning to the relation between downward counterfactual thinking and avoidance motivation.

7.1. Increased caution vs. boosted confidence

The finding that experience with near-accidents is associated with a decrease in safe driving behaviors is consistent with previous studies demonstrating a near-miss bias following near-accidents (Dillon and Tinsley, 2008; Tinsley et al., 2012). The near-miss bias occurs when near-misses are not recognized as such and consequently motivate increased risk taking in subsequent decision-making (Dillon and Tinsley, 2008; Tinsley et al., 2012). The near-miss bias has previously been demonstrated in both scenario-type studies (e.g., Tinsley et al., 2012) and in laboratory experiments (e.g., Tinsley et al., 2012). The present research relied on an index of safe driving over independent groups of respondents with increasing numbers of near-accidents experienced, the results indicating that increased exposure to near-accidents is associated with complacency rather than urgency, thus extending the scope of near-miss bias to a new domain with potentially high importance.

On the increased cautiousness measure, participants seemed to demonstrate a somewhat different pattern, with increased caution following repeated accidents and no change following near-accidents. This discrepancy could indicate a dissociation in safety perception, participants believing they change whereas in reality, they do the opposite. However, we tend to believe that these measures address different aspects of driver safety, one focusing on respondents' typical safety behavior, the other on increased caution linked to self-selected episodic memories of examples of incidents. For instance, participants may have adjusted a safety relevant behavior based on a particular episode (skidding on the ice), such as changing to better tires or being more mindful when driving, but that behavior modification may not significantly impact the overall score on the safe driving measure. It is also potentially important to note that the safe driving index is an absolute measure, whereas self-reported change is a relative measure. In either case, both measures agree that near-accidents do not increase caution.

Age appeared to be a factor modulating the relation between near-accidents and safe driving, indicating that younger drivers may be particularly inclined to ignore the warning signals imbedded in a near miss. This is consistent with research showing that younger drivers are more frequently involved in accidents (e.g., Bjørnskau, 2000; Clarke et al., 2005; Gheorghiu et al., 2015), particularly accidents involving driving under the influence, speeding and other forms of sensation seeking behavior (Bakke et al., 2013; Cestac et al., 2011; Iversen & Rundmo, 2002; Tränkle et al., 1990). The present study did not include any measure of sensation seeking, or other measures of motivation in relation to driving. Future studies could include such measures, as younger drivers may have a more promotion (i.e., focus on technical skills) rather than prevention (i.e., safety concerns) oriented approach to driving, something that could be expected to modulate how near-accident experiences are interpreted.

7.2. Possible mechanisms in learning from accidents and near-accidents

Although our results are broadly consistent with an impact bias, the present results qualify the impact of such a bias, as they demonstrate that taking personal responsibility for causing an incident leads to increased caution. This finding was supported by an analysis of the counterfactual statements generated in response to the near-accident: participants were more inclined to learn when they responded to the incident with self-focused counterfactuals, and when they responded with upward as opposed to downward counterfactuals. This is consistent with previous findings indicating that self-focused upward counterfactuals are beneficial for learning, as such thoughts both increase motivation to improve and specify how change should be implemented (Epstude and Roese, 2017; Morris and Moore, 2000). However, it is not consistent with our expectation that downward counterfactual thinking would "scare people straight", and therefore impact safety relevant behavior.

In light of this, it is paradoxical that both previous research (Teigen, 1995, 1996, 1998; Teigen and Jensen, 2011) and the present results indicate that people often engage in downward counterfactual thinking after accidents and near-accidents. Why spend time thinking about worse case scenarios, if one learns more from thinking about how the incident could have been avoided (an upward counterfactual)? It is possible that the primary function of downward counterfactuals is not to motivate behavior directly, but rather motivate deliberate analysis and reflection that then, in turn, promotes insight and learning. Several researchers have proposed such a link between conscious emotion and behavior (Baumeister et al., 2007; Epstude and Roese, 2008). This would indicate that time should be an important variable prediction upward versus downward comparisons after accidents and near-accidents, such that the immediate reaction is a downward counterfactual that may subsequently motivate upward counterfactual thoughts about how a negative incident could have been avoided. Future research should address this question.

7.3. Implications and limitations

This study is based on a convenience sample consisting of mostly young, college educated drivers from Northern Norway. Our prime aim was to explore a theoretically grounded research question, and in this respect, the generalizability of the results should be further explored in future studies. Still, the results should be interpreted with care, as they may be influenced by traffic conditions and culture found in Northern Norway. For example, darkness during much of the winter, harsh driving conditions, and long driving distances between cities may not be comparable to other parts or Norway or other countries. The present study focused on a few key demographic variables believed to be of particular relevance for learning from accidents and near-accidents. Future studies should explore the effect of other demographic variables that may be of importance. For instance, living in densely populated cities may promote different traffic habits than livining in rural areas (Bakke et al., 2013). Also, differences in income or education could be expected to influence both attitudes to driving and the make or model of car one normally drives, which again might influence traffic behavior.

The present study asked participants about their experience with accidents and near-accidents, but no clear definitions of such events were given. Thus, although having participants sample experiences from memory may add ecological validity, differences in understanding of what was meant by "accidents" and "near-accidents" may have induced higher variability in evaluations, which again makes it harder to detect effects of such experiences. Future research should apply clear criteria for differentiating between accidents and near-accidents. It should also be noted that we relied on self-report measures of both safe driving behavior and learned cautiousness, and hence do not know whether these measures connect with actual behavior. Future research would benefit from measuring the effect of near-accidents on actual driving behavior.

8. Author notes

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssci.2019.07.040.

References

Albert, S., 1977. Temporal comparison theory. Psychol. Rev. 84, 485–503.
Bakke, H.K., Hansen, I.S., Bendixen, A.B., Morild, I., Lilleng, P.K., Wisborg, T., 2013. Fatal injury as a function of rurality-a tale of two Norwegian counties. Scandinavian J. Trauma, Resuscitation Emergency Med. 21 (1), 14.
Baron, J., Hershey, J.C., 1988. Outcome bias in decision evaluation. J. Pers. Soc. Psychol. 54, 569.
Bjørnskau, T., 2000. Road Traffic Risk in Norway 1997/98 (report no. 483). Institute of Transport Economics, Oslo.
Baumeister, R.F., Vohs, K.D., DeWall, C.N., Zhang, L., 2007. How emotion shapes behavior: Feedback, anticipation, and reflection, rather than direct causation. Personal. Soc. Psychol. Rev. 11, 167–203.
Berecki-Gisolf, J., Collie, A., McClure, R., 2013. Work disability after road traffic injury in a mixed population with and without hospitalisation. Accid. Anal. Prev. 51, 129–134.
Cestac, J., Paran, F., Delhomme, P., 2011. Young drivers' sensation seeking, subjective norms, and perceived behavioral control and their roles in predicting speeding intention: How risk-taking motivations evolve with gender and driving experience. Saf. Sci. 49 (3), 424–432.
Clark, L., Liu, R., McKavanagh, R., Garrett, A., Dunn, B.D., Aitken, M.R., 2013. Learning

and affect following near-miss outcomes in simulated gambling. J. Behav. Dec. Making 26, 442–450. https://doi.org/10.1002/bdm.1774.
Clarke, D., Ward, P., Truman, W., 2005. Voluntary risk taking and skill deficits in young driver accidents in the UK. Accid. Anal. Prev. 37 (3), 523–529.
Dillon, R.L., Tinsley, C.H., 2008. How near-misses influence decision making under risk: A missed opportunity for learning. Manage. Sci. 54, 1425–1440.
Ellis, S., Carette, B., Anseel, F., Lievens, F., 2014. Systematic reflection: implications for learning from failures and successes. Curr. Directions Psychol. Sci. 23, 67–72.
Epstude, K., Roese, N.J., 2008. The functional theory of counterfactual thinking. Personal. Soc. Psychol. Rev. 12, 168–192.
Festinger, L., 1954. A theory of social comparison processes. Human Relat. 7, 117–140.
Fischhoff, Beyth, 1975. I knew it would happen: Remembered probabilities of once - future things. Organ. Behav. Human Perform. 13 (1), 1–16.
Gheorghiu, A., Delhomme, P., Felonneau, M.L., 2015. Peer pressure and risk taking in young drivers' speeding behavior. Transport. Res. Part F: Traffic Psychol. Behav. 35, 101–111.
Iversen, H., Rundmo, T., 2002. Personality, risky driving and accident involvement among Norwegian drivers. Personal. Individ. Differences 33 (8), 1251–1263.
Kahneman, D., Miller, D.T., 1986. Norm theory: Comparing reality to its alternatives. Psychol. Rev. 93, 136–153.
Lieberman, M.D., Gaunt, R., Gilbert, D.T., Trope, Y., 2002. Reflection and reflexion: A social cognitive neuroscience approach to attributional inference. In: Zanna, M. (Ed.), Advances in Experimental Social Psychology. Academic Press, New York, NY, pp. 199–242.
Markman, K.D., Lindberg, M.J., Kray, L.J., Galinsky, A.D., 2007. Implications of counterfactual structure for creative generation and analytical problem-solving. Pers. Soc. Psychol. Bull. 33, 312–324.
Markman, K.D., McMullen, M.N., 2003. A reflection and evaluation model of comparative thinking. Personal. Soc. Psychol. Rev. 7, 244–267.
Medvec, V., Madey, S.F., Gilovich, T., 1995. When less is more: Counterfactual thinking and satisfaction among Olympic athletes. J. Pers. Soc. Psychol. 69, 603–610.
McMullen, M.N., Markman, K.D., 2000. Downward counterfactuals and motivation: The "wake-up call" and the "Pangloss" effect. Pers. Soc. Psychol. Bull. 26, 575–584.
McMullen, M.N., Markman, K.D., 2002. Affective impact of close counterfactuals: Implications of possible futures for possible pasts. J. Exp. Soc. Psychol. 38, 64–70.
Morris, M.W., Moore, P.C., 2000. The lessons we (don't) learn: Counterfactual thinking and organizational accountability after a close call. Adm. Sci. Q. 45, 737–765.
Norwegian public Roads Administration, 2018. Accident statistics. Retrieved from: https://www.vegvesen.no/fag/fokusomrader/trafikksikkerhet/Ulykkesdata/om-ulykkesstatistikk.
Pennington, G.L., Roese, N.J., 2003. Regulatory focus and temporal distance. J. Exp. Soc. Psychol. 39, 563–576.
Plous, S., 1991. Biases in the assimilation of technological breakdowns: Do accidents make us safer? J. Appl. Soc. Psychol. 21, 1058–1082.
Reason, J., 2016. Managing the Risks of Organizational Accidents. Ashgate, Aldershot.
Roese, N.J., 1994. The functional basis of counterfactual thinking. J. Personal. Soc. Psychol. 66, 805–818.
Roese, N.J., 1997. Counterfactual thinking. Psychol. Bull. 121, 133–148.
Roese, N.J., Epstude, K., 2017. The functional theory of counterfactual thinking: New evidence, new challenges, new insights. Adv. Exp. Soc. Psychol. 56, 1–79.
Roese, N.J., Vohs, K.D., 2012. Hindsight bias. Perspect. Psychol. Sci. 7 (5), 411–426.
Russell, J.A., 2003. Core affect and the psychological construction of emotion. Psychol. Rev. 110, 145–172.
Svartdal, F., 2011. The reward value of near-miss situations. Scand. J. Psychol. 52, 209–217.
Teigen, K.H., 1995. How good is good luck? The role of counterfactual thinking in the perception of lucky and unlucky events. Eur. J. Soc. Psychol. 25, 281–302.
Teigen, K., 1996. Luck: The art of a near miss. Scand. J. Psychol. 37 (2), 156–171.
Teigen, K.H., 1997. Luck, envy, and gratitude: It could have been different. Scand. J. Psychol. 38, 313–323.
Teigen, K.H., 1998. Hazards mean luck: Counterfactual thinking and perceptions of good and bad fortune in reports of dangerous situations and careless behaviour. Scand. J. Psychol. 39, 235–248.
Teigen, K.H., 2005. The proximity heuristic in judgments of accident probabilities. Br. J. Psychol. 96, 423–440.
Teigen, K., Jensen, T.K., 2011. Unlucky victims or lucky survivors?: Spontaneous counterfactual thinking by families exposed to the Tsunami disaster. Eur. Psychol. 16, 48–57.
Teigen, K.H., Kanten, A.B., Terum, J.A., 2011. Going to the other extreme: Counterfactual thinking leads to polarized judgments. Thinking Reasoning 17, 1–29.
Tinsley, C.H., Dillon, R.L., Cronin, M.A., 2012. How near-miss events amplify or attenuate risky decision making. Manage. Sci. 58, 1596–1613.
Tränkle, U., Gelau, C., Metker, T., 1990. Risk perception and age-specific accidents of young drivers. Accid. Anal. Prev. 22, 119–125.
Weijermars, W., Bos, N., Stipdonk, H.L., 2016. Serious road injuries in the Netherlands dissected. Traffic Inj. Prev. 17, 73–79.
Williams, A.F., Kyrychenko, S.Y., Retting, R.A., 2006. Characteristics of speeders. J. Saf. Res. 37, 227–232.
Wilson, T., Gilbert, D., 2008. Explaining away a model of affective adaptation. Perspect. Psychol. Sci. 3 (5), 370–386.
Wilson, A.E., Ross, M., 2000. The frequency of temporal-self and social comparisons in people's personal appraisals. J. Pers. Soc. Psychol. 78, 928–942.
Wohl, M.J., Enzle, M.E., 2003. The effects of near wins and near losses on self-perceived personal luck and subsequent gambling behavior. J. Exp. Soc. Psychol. 39, 184–191.
World Health Organization, 2013. Global Status Report on Road Safety 2013: Supporting a Decade of Action: Summary. World Health Organization, Geneva, Switzerland.
Zhang, Q., Covey, J., 2014. Past and future implications of near-misses and their emotional consequences. Exp. Psychol. 61, 118–126.