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Safety culture transformation—The impact of training on explicit and implicit safety attitudes

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Abstract

The present paper investigates the changeability of safety culture elements such as explicit and implicit safety attitudes by training. Therefore, three studies with different time frames, training durations, and settings will be presented. In the first study, the short-term attitude change of students from an international environmental sciences study program was measured after safety training in a chemical laboratory. In the second study, the medium-term attitude change was assessed after a Crew Resource Management training for German production workers in the automotive industry. In the third study, the long-term attitude changes were measured after safety ethics training in a sample of German occupational psychology and business students. Different self-report measures were used to evaluate the training effectiveness of explicit safety attitudes. The change of implicit safety attitudes was assessed by Implicit Association Tests. The results of all three studies revealed a significant training effect on the explicit safety attitudes, but not on the implicit ones. Besides the training effect on the explicit attitudes, there was no effect of time frame (short-, medium-, long-term), training duration (2 h, 2 days, 12 weeks), and setting (chemical laboratory, automotive industry, safety ethics study program) on the attitude change. Based on the results, conceptual, methodological, and practical implications for training effectiveness and safety culture transformation are discussed.

KEYWORDS
attitude change, Crew Resource Management training, evaluation, Implicit Association Test, implicit attitudes, safety culture, safety training, social cognition

1 | INTRODUCTION

Safety attitudes of workers and managers have a large impact on safety behavior and performance in many industries (Clarke, 2006, 2010; Ford & Tetrick, 2011, Ricci et al., 2018). They are an integral part of an organizational safety culture and can therefore influence occupational health and safety, organizational reliability, and product safety (Burns et al., 2006; Guldenmund, 2000; Marquardt et al., 2012; Xu et al., 2014).

There are different forms of interventions for safety culture and safety attitude change, trainings are one of them. Safety trainings seek to emphasize the importance of safety behavior and promote appropriate, safety-oriented attitudes among employees (Ricci et al., 2016, 2018).

However, research in the field of social cognition has shown that attitudes can be grouped in two different forms: On the one hand, there are conscious and reflective so-called *explicit attitudes* and on the other hand, there are mainly unconscious *implicit attitudes* (Greenwald & Banaji, 1995). Although there is an ongoing debate whether implicit attitudes are unconscious or partly unconscious (Berger, 2020; Gawronski et al., 2006), most researchers affirm the existence of these two structurally distinctive attitudes (Greenwald & Nosek, 2009). Traditionally, researchers have studied explicit attitudes of employees by using questionnaires (e.g., Cox & Cox, 1991; Rundmo, 2000). However, increasingly more researchers now focus on implicit attitudes that can be assessed with reaction time measures like the Implicit Association Test (IAT; Greenwald et al., 1998; Ledesma et al., 2015; Marquardt, 2010; Rydell et al., 2006). These implicit attitudes could provide better insights into what influences safety behavior because they are considered to be tightly linked with key safety indicators. Unlike explicit attitudes, they are considered unalterable by social desirable responses (Burns et al., 2006; Ledesma et al., 2018; Marquardt et al., 2012; Xu et al., 2014). Nevertheless, no empirical research on whether implicit and explicit safety attitudes are affected by training could be found yet. Therefore, the aim of this paper is to investigate the effects that training may have on implicit and explicit safety attitudes. The results could be used to draw implications for the improvement of safety training and safety culture development.

1.1 | Explicit and implicit attitudes in safety contexts

Explicit attitudes are described as reflected which means a person has conscious control over them (Strack & Deutsch, 2004). In their associative–propositional evaluation (APE) model, Gawronski and Bodenhausen (2006) assume that explicit attitudes are based on propositional processes. These consist of evaluations derived from logical conclusions. In addition, explicit attitudes are often influenced by social desirability, if the topic is rather sensitive such as moral issues (Maass et al., 2012; Marquardt, 2010; Van de Mortel, 2008). This has also been observed in safety research where, in a study on helmet use, the explicit measure was associated with a Social Desirability Scale (Ledesma et al., 2018). Furthermore, it is said that explicit attitudes can be changed faster and more completely than implicit ones (Dovidio et al., 2001; Gawronski et al., 2017).

On the other hand, implicit attitudes are considered automatic, impulsive, and widely unconscious (Rydell et al., 2006). According to Greenwald and Banaji (1995, p. 5), they can be defined as "introspectively unidentified (or inaccurately identified) traces of past experience" that mediate overt responses. Hence, they use the term "implicit" as a broad label for a wide range of mental states and processes such as unaware, unconscious, intuitive, and automatic which are difficult to identify introspectively by a subject. Gawronski and Bodenhausen (2006) describe implicit attitudes as affective reactions that arise when stimuli activate automatic networks of associations. However, although Gawronski and Bodenhausen (2006) do not deny "that certain affective reactions are below the threshold of experiential awareness" (p. 696), they are critical towards the "potential unconsciousness of implicit attitudes" (p. 696). Therefore, they use the term "implicit" predominantly for the aspect of automaticity of affective reactions. Nevertheless, research has shown that people are not fully aware of the influence of implicit attitudes on their thinking and behavior even though they are not always completely unconscious (Berger, 2020; Chen & Bargh, 1997; De Houwer et al., 2007; Gawronski et al., 2006). Many authors say that implicit attitudes remain more or less stable over time and are hard to change (Charlesworth & Banaji, 2019; Dovidio et al., 2001; Wilson et al., 2000). In line with this, past studies in which attempts were made to change implicit attitudes often failed to achieve significant improvements (e.g., Marquardt, 2016; Vingilis et al., 2015).

When trying to measure implicit attitudes, researchers most commonly use reaction time measures such as priming tasks (Burns et al., 2006) and the IAT (Greenwald et al., 1998; Hofmann, Gawronski et al., 2005). The IAT, for instance, uses the varying degrees of association strengths between concepts and then evaluates the reaction times in computer-administered categorization tasks (Greenwald et al., 1998, 2009). Although there is some controversy whether the IAT can really assess unconscious attitudes (Gawronski & Bodenhausen, 2006), one of its main advantages is the sensitivity to measure automatically activated associations which makes the IAT scores relatively resistant to faking (Greenwald et al., 2009). Thus, the IAT represents an appropriate method to get access to sensitive data such as safety-critical attitudes where faking and social desirable responses can be expected (Adachi et al., 2016; Burns et al., 2006; Marquardt et al., 2012; Molesworth & Chang, 2009; Xu et al., 2014).

The connection between implicit and explicit attitudes, and human behavior in safety settings are very complex and therefore difficult to define. In respect of the implicit–explicit attitude relationship, most studies in safety research have found very small and even nonsignificant correlations (Adachi et al., 2016; Burns et al., 2006; Ledesma et al., 2015; Marquardt et al., 2012; Molesworth & Chang, 2009; Xu et al., 2014) between implicit and explicit measures. The range of correlations was from $r = -.02$ (Burns et al., 2006) to $r = .22$ (Ledesma et al., 2018). However, the sample sizes in these studies were very diverse, ranging from small ($n = 35$; Molesworth & Chang, 2009) to large ($n = 376$; Marquardt et al., 2012). The more representative studies due to larger sample sizes (>100 participants) showed small correlations ranging from $r = .11$–.16 (Ledesma et al., 2015; Marquardt et al., 2012; Xu et al., 2014). There was only one empirical study in the context of ergonomics ($n = 68$) that revealed a higher and significant correlation ($r = .38$) between implicit safety attitudes toward back posture and lifting with a roundback (Caneiro et al., 2018).

According to the attitude–behavior relationship, the empirical results are also different. For instance, the study on attitudes towards nursing safety protocol violations (Adachi et al., 2016) with 68 Japanese nursing students revealed a significant correlation between the explicit attitude and safety protocol violations ($r = -.47$) but not for the implicit attitude ($r = -.05$). On the contrary, studies in the context of traffic safety conducted by Ledesma et al. (2018, 2015) presented significant correlations both between implicit attitudes and safety behavior. For example, in their study on implicit attitudes toward helmet use and actual helmet wearing among 194 motorcyclists in Argentina (Ledesma et al., 2015), the correlation between these two variables was even larger ($r = .25$) than for the explicit one ($r = .20$). Moreover, in the study among 100 Argentinian car drivers (Ledesma et al., 2018), the implicit attitude toward seatbelt use was the best predictor for seatbelt use ($\beta = .30$) in a complex regression model, which also included explicit attitudes ($\beta = .25$) and theory of planned behavior constructs (e.g., social norms, perceived behavioral control, and intentions). In addition, a path model showed that the implicit attitude was not related to the theory of planned behavior components and therefore represents an independent construct which provided significant and incremental predictive validity (the implicit attitude increased the overall R^2 from .36 to .44, ebd.). Finally, the study among 35 Australian pilots (Molesworth & Chang, 2009) reported a significant and large correlation between the pilot's implicit risk preference attitude and risk-taking behavior such as low flying ($r = .42$). Consequently, it has to be concluded that both types of attitudes play an important role in safety contexts.

1.2 | Explicit and implicit attitudes in safety culture

While some explicit and implicit attitudes are related to individual safety behavior such as flying (Molesworth & Chang, 2009), driving (Ledesma et al., 2018, 2015), or lifting (Caneiro et al., 2018), most of them refer to organizational safety behavior (Adachi et al., 2016; Burns et al., 2006; Marquardt et al., 2012; Xu et al., 2014). Consequently, they can be regarded as a key element of an organizational safety culture in many industries such as aviation, hospitals, chemical industry, nuclear power, and gas plants (Burns et al., 2006; Guldenmund, 2000; Marquardt et al., 2012; Xu et al., 2014). Most models of safety culture refer to Schein's (1992) three-layer model of organizational culture (Burns et al., 2006). For instance, Marquardt et al. (2012) transformed Schein's (1992) model into an implicit social cognition model of safety culture which proposes three different levels of consciousness within an organizational safety culture. In short, the model consists of the most visible outer layer of *artifacts* (e.g., safety behavior, near misses, accidents), the middle layer of *espoused values* containing explicit safety attitudes, and the core layer of *basic underlying assumptions* which are equated with implicit safety attitudes.

Since the integration of implicit attitudes in safety culture models is a relatively novel approach, there are only a few empirical studies with different results in this context. As mentioned in the last section, the study by Adachi et al. (2016) on nursing safety protocol violations revealed a significant correlation for the explicit but not for the implicit safety attitude. However, in the safety culture study in a UK gas plant by Burns et al. (2006) the implicit measure had shown strong differences in the implicit trust of 53 plant workers for their workmates compared to their supervisors. Moreover, in the empirical study of 376 German employees from different hazardous industries (e.g., chemical industry, metal industry, automotive) higher human error rates corresponded with lower implicit carefulness (Marquardt et al., 2012). Furthermore, there was a significant prediction ($\beta = .38$) of implicit carefulness to safety performance indicators (e.g., risk awareness) but not for explicit attitudes of carefulness ($\beta = -.05$). Finally, the study among 108 Chinese control room operators of a nuclear power plant (Xu et al., 2014) presented results of a significant prediction of safety compliance only by implicit ($\beta = .22$) but not by explicit safety attitudes ($\beta = .12$).

To sum up, explicit and implicit safety attitudes have to be regarded as important elements of a safety culture. Consequently, changing these attitudes in a positive way also means a transition of the safety culture from the poor to more mature (Marquardt, 2019).

1.3 | Training and safety attitude change

As mentioned in the introduction, the main question of this paper is to find out whether training can change implicit and explicit safety attitudes. Safety training can improve a person's ability to correctly identify, assess, and respond to possible hazards in the work environment, which in turn can lead to better safety culture (Burke et al., 2006; Duffy, 2003; Wu et al., 2007). Besides individual safety training increasingly more industries such as aviation, medicine, and offshore oil and gas industry implement group trainings labeled as Crew Resource Management (CRM) training to address shared knowledge and task coordination in dynamic and dangerous work settings (Salas et al., 2006).

There are many different factors, which determine the effectiveness of safety trainings (Burke et al., 2006; Ricci et al., 2016) such as the *training method* (e.g., classroom lectures) and *training duration* (e.g., 8 h). In a meta-analysis including 95 studies about safety trainings, Burke et al. (2006) found that highly engaging training methods (e.g., behavior modeling) led to higher knowledge gain and preservation ($d = 1.46$) as well as lower numbers of safety-critical errors ($d = .74$). For instance, behavior modeling involves observing a (positive or negative) role model, practicing (e.g., within a safety simulation), and feedback designed to modify behavior. On the contrary, another meta-analysis by Robson et al. (2012) which included randomized controlled trials ($k = 20$) found unsatisfactory evidence about more engaging trainings being more effective than lower engaging trainings.

However, the latest meta-analysis on safety training ($k = 21$) by Ricci et al. (2016) confirmed that the level of trainee's engagement (e.g., classroom training with active learning, structured group discussions, self-learning elements) has a positive effect on attitudes in particular. In respect of the training duration, similar to Burke et al. (2006) the meta-analysis of Ricci et al. (2016) revealed mixed results. While for behavior change longer training duration (>8 h) is better, for attitude change the opposite seems to be true (<1 h). Furthermore, the meta-analysis by Ricci et al. (2016) was the only one that specifically calculated the overall effect size of training on safety attitudes, which was estimated as large ($g = 1.26$).

Nevertheless, all these meta-analytic results refer to the effect of training, if at all on safety attitude changes in general. Hence, there is no agreement on how training changes explicit and implicit safety attitudes. Likewise, there are only a few studies that evaluated trainings based on implicit and explicit attitude change and if there are, they are usually not in a safety context. The only study that has measured the impact of an intervention on implicit safety attitudes was conducted by Vingilis et al. (2015). Yet, the intervention was not a training per se, but televised advertising on risky driving, which had no effect on the implicit risk attitude.

In contrast, outside of the safety context, in the field of prejudice and stereotype research, there are some studies, which aimed at measuring the implicit and explicit attitude change after different forms of interventions. For instance, in two studies with more than 6000 US American participants, all interventions (e.g., evaluative conditioning, implementation intentions) immediately reduced implicit but not explicit racial preferences (Lai et al., 2016). Implementation intentions are “if-then” plans that increase the automaticity of behavior by linking a situational cue (“if”—component of a plan) to a behavioral response (“then”—component of a plan; Mendoza et al., 2010). Even though some interventions obtained immediate significant medium to large effect sizes (e.g., implementation intentions, $d = 0.43$), none were effective after a short delay of several hours to several days. Except for one intervention (implementation intentions, $d = 0.12$), the effect sizes of all other interventions after a follow-up measure (2–4 days) were close to zero (e.g., evaluative conditioning $d = 0.01$). The correlations between the implicit and explicit measures were also very low ($r = .06–.10$). Hence, only short-term effects on implicit attitude change were revealed. Therefore, the temporal stability of implicit and explicit attitude change seems to be an important issue for sustainable training effectiveness. Furthermore, in a study on diversity trainings the participants' implicit attitudes towards women in science, technology, engineering, and mathematics (STEM) changed significantly, but only for the male subjects (Jackson et al., 2014). Discussing these outcomes for the female participants, the authors suspect ceiling effects as a possible cause. Similar to the results in the safety context, the correlations between implicit and explicit attitudes were very small and nonsignificant ($r = .04–.07$).

However, such divergences between implicit and explicit attitude measures can make an important contribution in detecting differences in the change rates as well as in the direction of change of implicit and explicit attitudes (McKenzie & Carrie, 2018). Specifically, the more rapidly obtained explicit attitudes might change faster than more slowly acquired implicit attitudes. Consequently, any implicit–explicit attitudinal discrepancy (IED) can thus be interpreted as an attitude change in progress measured at a given point in time (Karpen et al., 2012).

As a consequence, based on the theoretical assumptions of the APE model (see Section 1.1) and the above-mentioned IED approach for different attitudinal change rates an *Explicit and Implicit Safety Attitude Change* (EISAC) model was derived. As can be seen in Figure 1, it can be stated that associative evaluations (process) can be activated by different safety intervention stimuli such as training

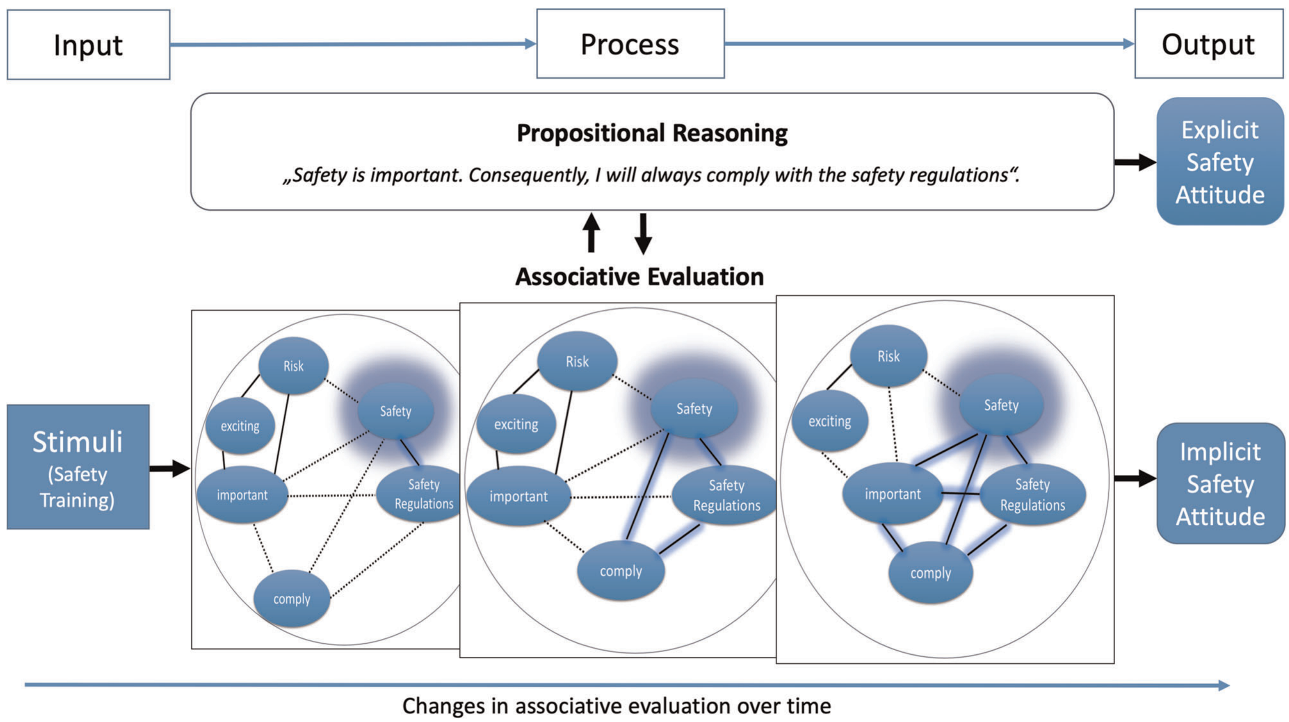

FIGURE 1 Explicit and Implicit Safety Attitude Change (EISAC) model. Bold lines represent spreading activation and dotted lines inhibitory processes within an associative memory network. The figure illustrates the change of associative safety evaluations from risk-oriented to more safety-oriented over time

(input). These associative evaluations are the foundation for implicit safety attitudes (output) and propositional reasoning (processes), which in turn form the explicit safety attitudes (output). In addition, associative evaluations and propositional reasoning processes affect each other in many complex conscious and unconscious ways (Gawronski & Bodenhausen, 2006). However, change rates might be different. While the propositional processes adapt very quickly to the input (e.g., safety training), the associative evaluations might need longer periods of time for restructuring the associative network (Karpen et al., 2012). Therefore, divergences in the implicit and explicit measures resulting in inconsistent attitudes (output) can occur (McKenzie & Carrie, 2018).

1.4 | Hypotheses and overview of the present studies

Based on the theories and findings introduced above, two main hypotheses are presented. Since previous research describes that explicit attitudes can be changed relatively quickly (Dovidio et al., 2001; Karpen et al., 2012), the first hypothesis states that:

H1: Explicit safety attitudes can be changed by training.

Even though implicit attitudes are said to be more stable and harder to change (Dovidio et al., 2001; Gawronski et al., 2017; Wilson et al., 2000), changes by training in implicit attitudes can be expected too, due to changes in the associative evaluation processes (Lai et al., 2013) which affect the implicit attitudes (see EISAC model in Figure 1). Empirical research on the subject of implicit attitudinal change through training is scarce (Marquardt, 2016), however, it was shown that an influence on implicit attitudes is possible (Charlesworth & Banaji, 2019; Jackson et al., 2014; Lai et al., 2016; Rudman et al., 2001). Therefore, the second hypothesis states that:

H2: Implicit safety attitudes can be changed by training.

However, currently, there is a lack of empirical studies on implicit and explicit attitude change using longitudinal designs in different contexts (Lai et al., 2013). Also, in the field of safety training research, studies are needed to estimate training effectiveness over time (Burke et al., 2006). Therefore, to address the issues of time and context in safety attitude change by training, three studies with different training durations and measurement time frames in different safety-relevant contexts were conducted (see Table 1). In the first study, the short-term attitude change was measured 3 days prior and after a 2-h safety training in a chemical laboratory. In the second study, the medium-term attitude change was assessed 1 month prior and after a 2 days of CRM training for production workers. In the third study, the long-term attitude changes were measured within an advanced experimental design (12 months between pre- and postmeasure) after a 12 weeks of safety ethics training in an occupational psychology student sample. To make this paper more succinct and to ease the comparability of used methods and reveled results, all three studies will be presented in parallel in the following method, results, and discussion sections. A summary table of all the studies can be seen in Table 1.

2 | METHODS

2.1 | Sample

2.1.1 | Study 1

Fifteen participants (eight female and seven were male; mean age = 22.93 years; *SD* = 2.74) were recruited for the first study. The participants were from different countries with a focus on east and south Asia (e.g., India, Bangladesh, and China). They were enrolled in one class of an international environmental sciences study program

TABLE 1 Overview of the main characteristics of the three studies presented here

	Study 1	Study 2	Study 3
Time frame for attitude change (interval between pre- and postmeasurement)	Short term (1 week)	Medium term (8 weeks)	Long term (12 months)
Training duration	Short (2 h)	Medium (2 days)	Long (12 weeks)
Domain (safety context)	Chemical laboratory	Automotive production unit	Safety Ethics study program
Type of training	Safety training	Crew Resource Management training	Safety Ethics training
Research design	Pre- and postdesign	Pre- and postdesign	Solomon four-group design
Explicit attitude measure	Explicit Safety Attitudes Scale (ESAS)	Complacency Scale	Semantic Differential Scale
Implicit attitude measure	Safety Attitude-IAT (SA-IAT)	Safety Culture-IAT (SC-IAT)	Safety Ethics-IAT (SE-IAT)

Abbreviation: IAT, Implicit Association Test.

with a major focus on practical experimental work in chemical and biological laboratories in Germany. Participation in regular safety training was mandatory for all participants to be admitted to working in these laboratories. To ensure safe working in the laboratories, the environmental sciences study program has traditionally small classes of 15–20 students. Hence, the sample represents the vast majority of one entire class of this study program. However, due to the lockdown caused by the COVID-19 pandemic, there was no opportunity to increase the sample size in a subsequent study. Consequently, the sample size was very small.

2.1.2 | Study 2

A sample of 81 German assembly-line workers of an automotive manufacturer participated in Study 2. The workers were grouped into self-directed teams responsible for gearbox manufacturing. Hence, human error during the production process could threaten the health and safety of the affected workers and also the product safety of the gearbox which in turn affects the health and safety of prospective consumers. The gearbox production unit encompassed roughly 85 workers. Thus, the sample represents the vast majority of the production unit's workforce. Due to the precondition of the evaluation being anonymous, as requested by the firm's work council, personal data such as age, sex, and qualification could not be collected.

2.1.3 | Study 3

In Study 3, complete data sets of 134 German participants (mean age = 24.14; *SD* = 5.49; 92 female, 42 male) could be collected. All participants were enrolled in Occupational Psychology and International Business study programs with a special focus on managerial decision making under uncertainty and risks. The sample represents the vast majority of two classes of this study program since one class typically includes roughly 60–70 students. Furthermore, 43 of these students also had a few years of work experience (mean = 4.31; *SD* = 4.07).

2.2 | Safety training

2.2.1 | Study 1

The mandatory safety training was a two-tiered training that is repeated every year. The training can be described as follows: In a first step, general safety instructions are given, such as basic behavior in emergencies, accidents, or fires, but also information on escape routes, and first-aid responders. The aim is to sensitize participants to emergency situations and safe operation procedures in general. In a second step, specific hazards of the intended experiments are collected and participants are asked to come up with safe working procedures for these specific experiments. Together with the participants, safety instructions are developed interactively on how to handle the hazardous substances and the devices which are needed. This also includes the recognition of safety symbols and associated with special handling procedures.

2.2.2 | Study 2

The safety training was delivered by a CRM training program. CRM trainings are designed to increase safety by reducing human error through improved teamwork, communication, situation awareness, decision making, leadership, and stress management (Salas et al., 2006). CRM trainings were traditionally used in high-risk industries such as aviation, nuclear power, offshore oil and gas, and medicine to improve safety performance (O'Connor et al., 2008). The CRM training in this study focused on four CRM competency areas: situation awareness, communication, teamwork, and stress management. It involved a 2-day training course, including interactive tutorials, lectures, case analyses, role plays and debriefs on attitudinal, behavioral and organizational aspects of human error, risks, and safety.

2.2.3 | Study 3

The safety training was delivered in form of business ethics training with a special focus on safety ethics such as product safety as well as workplace health and safety issues. The primary goal was to sensitize students in their understanding of ethical issues in safety settings and to expose them to ethical theories and concepts that help to analyze and solve ethical safety problems. The training program had a duration of 12 weeks. A mix of instructional methods (e.g., lectures, simulations in managerial decision making, role plays with feedback, dilemma discussions, cooperative learning phases) with an emphasis on student–lecturer communication and medium training group sizes (group size was around 45–50 people) were used.

2.3 | Materials

2.3.1 | Study 1

Explicit safety attitude measure

The survey of the explicit safety attitudes was conducted by using the Explicit Safety Attitude Scale (ESAS). This scale was specifically designed for this training evaluation due to a lack of appropriate self-report measures for explicit safety attitudes. This scale contains ten statements, such as: “When I have a lot to do, it makes sense to compromise safety standards” or “I always pay attention to risk factors in my work environment” which are then to be evaluated on a 5-point Likert scale ranging from *strongly disagree* to *strongly agree* (see Appendix). The item development was inspired by other questionnaires in the safety attitudes and human factors domain such as the *Scale of Safety Attitudes* (Diaz & Cabrera, 1997), the *Automation-Induced Complacency Potential-Revised Scale* (Merritt et al., 2019), and the *Safety Attitudes Questionnaire Ambulatory Version* (Smits et al., 2017).

Implicit safety attitude measure

The implicit safety attitudes were measured by a Safety Attitude-Implicit Association Test (SA-IAT) which was specifically designed for this study (see Table 2). The IAT (Greenwald et al., 1998) is the most frequently used test in science for recording implicit attitudes (Hofmann, Gschwendner et al., 2005). It is designed to measure implicit attitudes by using five different reaction times tasks. In the first task, the participant was confronted with a target word (e.g., danger) on the computer screen and instructed to sort it into one of two possible categories ("safety" or "risk") by pressing the designated response key as fast as possible. Within the first task, 20 trials of randomly selected target words (see Appendix) were used. The second step was also a form of two-category discrimination task (20 trials) in which the participant had to classify verbs (e.g., avoid) into two categories ("preserve" or "prevent"). The third step (Block 3 = 20 and Block 4 = 40 trails) was to combine the categories of the former two discrimination tasks to be more congruent (e.g., safety + preserve/risk + prevent) or incongruent (e.g., risk + preserve/safety + prevent) with existing attitudes. In the fourth step (Block 5), the participants do a reverse version of the response assignment (20 trials) for the two target categories. Finally, the fifth step (Block 6 = 20 and Block 7 = 40 trials) combines the reversed target categories from Step 4 with the unchanged attribute categories from Step 2.

The items used in this SA-IAT were selected to maximize comparability between the implicit and explicit safety attitude measures (ESAS). Therefore, key-items of the ESAS (e.g., safety, risk, danger, comply, prevent) were chosen for the SA-IAT based on informal content analysis and combined with associated terms (e.g., protection, harm, sustain, avoid). The terms "safety" and "risk" were used as the opposing main object categories due to their eminent role and salience in the context of safety training. The terms "preserve" (comply, sustain, achieve) and "prevent" (hinder, stop, avoid) were selected as the main labels for opposing discriminating attributes as they can be linked to concepts of approach–avoidance behavior (Corr, 2013). Therefore, short reaction times in the congruent condition within the SA-IAT represent an indication of a positive implicit attitude towards safety-approaching and risk-avoidance-behavior. No pictures were used as stimuli in the SA-IAT. Consequently, all IAT stimuli were text-based.

The idea behind the IAT is that of an associative network in which some concepts and words are more closely connected than others. Subsequently, it is assumed that a person can match certain words better or worse to different target concepts, depending on the strength of the associative connection between them. Accordingly, a subject with a positive implicit safety attitude should be able to handle the congruent condition ("safety" and "preserve" on one key) more easily than the incongruent condition ("risk" and "preserve" on one key). This in turn leads to the assumption the reaction times in the incongruent condition would have to be longer than in the congruent one. After a participant finishes the test the resulting IAT D-score is computed. It can be interpreted similarly to standard effect sizes (Greenwald et al., 2003). Hence, scores over 0.2 mark a small effect, scores over 0.5 show a medium effect, while scores over 0.8 show a large effect (Cohen, 1988).

2.3.2 | Study 2

Explicit safety attitude measure

The explicit safety attitudes were measured with a Complacency Scale, which was used in safety culture studies and CRM training evaluations before (Marquardt et al., 2012, 2011). Within this scale, five items were used to reflect attitudinal aspects of complacency and carelessness in safety issues (see Appendix). These items had specifically been selected for their eminent role in safety attitudes and safety culture literature (Fernández-Muniz et al., 2007;

TABLE 2 Safety Attitude-IAT used in Study 1

Block	Number of trials	Task	Left key "A"	Right key "L"
1	20	Discriminating object categories	Safety	Risk
2	20	Discriminating attributes	preserve	prevent
3	20	Initial combined task	Safety + preserve	Risk + prevent
4	40	Initial combined task	Safety + preserve	Risk + prevent
5	20	Discriminating inverted object categories	Risk	Safety
6	20	Inverted combined task	Risk + preserve	Safety + prevent
7	40	Inverted combined task	Risk + preserve	Safety + prevent

Abbreviation: IAT, Implicit Association Test.

Harvey et al., 2002; International Nuclear Safety Advisory Group, 1991; Jeffcott et al., 2006; Lee, 1994). For all items a 5-point Likert scale with the anchors "agree" and disagree" was applied. For this Complacency Scale, lower mean values are an indication of higher explicit safety-oriented attitudes.

Implicit safety attitude measure

An IAT was used again to assess implicit safety attitudes (see Table 1). Therefore, a Safety Culture-Implicit Association Test (SC-IAT) was selected for this study (Marquardt et al., 2012). To maximize comparability between the implicit and explicit safety attitude measures, precisely two categories were used to make sure that the aspect of carefulness versus carelessness was considered. Since the explicit attitude measure referred mostly to the self-concept ("I") and workmates-category (colleagues), these two concepts were used as object categories (see Appendix). The IAT items were based on an informal content analysis combined with an analysis of associated terms. Just like in Study 1, all IAT stimuli were text-based. A high positive IAT D-score would be an indication of a positive implicit safety attitude (positive association between carefulness attributes and the self-concept). The SC-IAT had the same number of trials in each block like the SA-IAT in Study 1. Items used for the SC-IAT can be seen in the Appendix.

2.3.3 | Study 3

Explicit safety attitude measure

In the experimental study (see Table 1), a managerial decision scenario was introduced. The real case scenario described the story of a corporate manufacturer of chain saws. The company had to decide whether to improve the safety standards of its chain saws voluntarily (Option 1) or to ignore the fact that they were responsible for a lot of accidents caused by chain saws (Option 2).

The explicit attitudes towards the two options of the experimental scenario (increasing product safety vs. cutting costs) were measured by means of a six-item 7-point Semantic Differential Scale (Marquardt, 2010). Following common approaches of explicit moral attitude measurement (see Reidenbach & Robin, 1990; Tetlock et al., 2000) each 7-point item consisted of polar-opposite adjective pairs (e.g., moral–immoral). All items (see Appendix) had adequate means and item-total correlations above .90. In addition, a factor analysis (PCA) of all items was performed. The factor analysis yielded one factor (moral evaluation) with a eigenvalue bigger than one and 83% explained variance. The factor loading of all items was above 0.90 (Marquardt, 2010).

Implicit safety attitude measure

A Safety Ethics-Implicit Association Test (SE-IAT) was used to assess implicit attitudes towards the two scenario options (Marquardt, 2010). Hence, the two scenario options (Option 1: increasing product safety vs. Option 2: cutting costs) were selected as opposing object categories. The SE-IAT items were based on an informal content analysis combined with an analysis of associated terms. The discriminating attributes were based on the item and factors analysis as described in the explicit attitude measure. Therefore, these attributes represent evidence-based moral evaluations. Just like in Study 1 and Study 2, all IAT stimuli were text-based. Except for Block 4 and Block 7 (both 60 trials), the SC-IAT had the same number of trials in each block like the IAT in Study 1 and Study 2. Items used for the SE-IAT can be seen in the Appendix. A high positive IAT D-score would be an indication of a positive implicit safety attitude (positive association between Option 1 "increasing product safety" and moral attributes).

2.4 | Design and procedure

2.4.1 | Study 1 and Study 2

As can be seen in Table 1, the data was collected in a pre- and postdesign (Study 1: 2 days/Study 2: 1 month before and after the safety training). All materials were presented in English in Study 1 and in German in Study 2. The data collection of the implicit attitudes with randomized IAT items was conducted with each participant individually on a laptop computer in both studies. The explicit attitudes data collection was conducted individually too in the first study, and collectively with groups of 15 workers each at the end of every shift in the second study. For the measurement, the participants were invited into a quiet room, where there were no distractions while the experiment was conducted. Because the safety training was mandatory for all subjects who have to work in the laboratory (Study 1) or the production unit (Study 2) no control group could be included in these studies.

2.4.2 | Study 3

As mentioned earlier in this paper (see Table 1), the long-term effects of the training should be tested by using an advanced experimental design (*Solomon four-group design*). In a Solomon four-group design, there are two groups with a pre- and posteasurement (one training group with pre- and postmeasurement and one control group with pre- and postmeasurement) and two groups with a posttest-only-measurement (one training group with posttest-only-measurement and one control group with posttest-only-measurement). The premeasurement (Group 1 = training group; Group 2 = control group) was conducted 5 months prior to the training, which in turn lasted 12 weeks. The postmeasurement was conducted 4 months after the training (Group 1 = pre- and posttraining group; Group 2 = pre-and post-control group; Group 3 = posttest-only-training group; Group 4 = posttest-only-control group). The temporal difference between pre- and postmeasurement was 1 year. This was done to decrease the likelihood of carry-over-effects.

The hypotheses of Study 3 are framed within the study's design (*Solomon four-group design).* In short, there are two groups with a pre- and postmeasurement (one training group with pre- and postmeasurement = Group 1 and one control group with pre- and postmeasurement = Group 2) and two groups with a posttest-only-measurement (one training group with posttest-only-measurement = Group 3 and one control group with posttest-only-measurement = Group 4). The hypotheses (a) refer to the effects of the training group with pre- and postmeasurement (Group 1). The subhypotheses (b) represents the comparison of the training group and control group with pre- and postmeasurement (Group 1 vs. Group 2). The subhypotheses (c) represent the comparison of all training groups and all control groups (Groups 1 and 3 vs. Groups 2 and 4).

The main two hypotheses of this paper are divided into the following subhypotheses:

H1 (a): The *explicit attitude* of the training group (Group 1) increases after the training (pre-and postcomparison).

H1 (b): The explicit attitude of the training group (Group 1) is higher than of the control group (Group 2; pre- and postcomparison).

H1 (c): The explicit attitudes of the training groups (Groups 1 and 3) are higher than those of the control groups (Groups 2 and 4; post-only-comparison).

H2 (a): The *implicit attitude* of the training group (Group 1) increases after the training (pre- and postcomparison).

H2 (b): The implicit attitude of the training group (Group 1) is higher than of the control group (Group 2; pre- and postcomparison).

H2 (c): The implicit attitudes of the training groups (Groups 1 and 3) are higher than those of the control groups (Groups 2 and 4; post-only-comparison).

3 | RESULTS

3.1 | Data reduction

3.1.1 | Study 1

In general, data reduction according to Greenwald et al. (2003) was considered and following the authors' advice, people with particularly high error rates were excluded. Accordingly, subjects who exceeded the limit of 25% errors in the combined tasks should have been excluded. The IAT D-score or IAT-effect was calculated from the average latency differences of the incongruent condition compared to the congruent conditions, by dividing them by their general standard deviation. The way this study was conducted, higher IAT scores indicate that the tested individual has a stronger association between safety and preserve which means that, for example, more safety behavior is expected.

3.1.2 | Study 2

Like in study one, the IAT data reduction was conducted according to Greenwald et al. (2003). Due to the longitudinal design, there was a loss of participants in the postmeasure. In the explicit safety attitude measure (Complacency Scale), there were only 61 participants in the postmeasure. Moreover, in the implicit safety attitude measure (SC-IAT), there were only 46 participants in the postmeasure. There are several reasons for the loss of participants such as sickness, vacations, lack of time due to indispensability in the production process. The loss of participants in the IAT data collection was even larger because of a more time consuming single individual measure compared to the explicit attitude measure, which was conducted in groups of 15 workers.

3.1.3 | Study 3

The group sizes were unequal (Group 1 $n = 31$; Group 2 $n = 14$; Group 3 $n = 29$; Group 4 $n = 60$). The main reason for the unbalanced group sizes was probably the long span of 12 months between the first and the second measurement. The problem to motivate participants to return for a postmeasurement 12 months after the premeasurement occurred in the pre- and post-control group (Group 2) in particular. Due to the fact that the participants in the control group did not receive the training, they were probably less involved and bound to this study. In contrast, recruiting the posttest-only measurement groups was much easier because they had to attend only once. Consequently, drop-out effects due to students who studied abroad did an internship or had left the university for other reasons affected the pre- and postmeasurement groups much stronger than the posttest-only measurement groups. Another reason for the odd group sizes resulted from methodological drop-out effects such as missing data or high error rates in the IAT, which affected the four groups inconsistently. Accordingly, the group sizes varied. However, when the total sample size of training group participants (Group 1 + Group 3 = $N = 60$) is compared to the total sample size of control group participants (Group 2 + Group 4 = $N = 74$), the size difference seems acceptable.

According to other studies that addressed the correspondence between implicit and explicit attitudes, both explicit attitude measures were combined in a difference score (Park & Schaller, 2005; Perugini, 2005). The difference score was calculated by subtracting the mean of the Semantic Differential Scale for the option "cutting costs" from the mean of the Semantic Differential Scale for the option "increasing product safety." Positive values on the difference score indicate an ethically favorable rating of the option "increasing product safety."

3.2 | Reliability of measures

3.2.1 | Study 1

The IAT's internal consistency for all three studies was calculated by the correlations between the practice and the test trials of the combined tasks (Greenwald et al., 2003). The IAT showed good internal consistency values of 0.85 (premeasure) and 0.89 (postmeasure). The internal consistency of ESAS was much weaker but sufficient in the first measurement (α = .68) and relatively high in the second measurement (α = .84).

3.2.2 | Study 2

The SC-IAT showed internal consistency values of 0.92 (premeasure) and 0.93 (postmeasure) which can be classified as excellent (Tavakol & Dennick, 2011). The internal consistency of the explicit safety attitude measure (Complacency Scale) was weak but sufficient in the pre- and postmeasure (α = .67).

3.2.3 | Study 3

The internal consistency measure of the IAT yielded a value of 0.87 in the pre- and postmeasure. The reliability of the explicit attitude measure (Semantic Differential Scale) for the first option "increasing product safety" was α = .77 and α = .87 for the option "cutting costs" in the pre- and postmeasure.

3.3 | Descriptive statistics and hypothesis testing

3.3.1 | Study 1

The first hypothesis (H1) stated that explicit safety attitudes could be changed by training. As can be seen in Table 3, the analysis of the first hypothesis revealed higher mean values for ESAS (5-point Likert scale) in the second measurement than in the first. As described in the method section, higher mean values in the ESAS, are an indication of more positive explicit safety attitudes. The difference between the two was significantly based on a *t*-test for paired samples showing a medium effect according to Cohen (1988). Therefore, the first hypothesis can be confirmed, as the study shows that safety training leads to a change in participants' explicit attitudes.

The second hypothesis (H2) stated that the implicit attitudes of the safety training's participants could be changed through the training. High mean values in the IAT, are an indication of more positive implicit safety attitudes. Even though the IAT effect in the second measurement showed higher mean values than in the first, the difference was not significant. The effect size can be considered as small. The mean values of both IAT D-scores correspond to

TABLE 3 Means and standard deviations of explicit and implicit safety attitudes among all groups and hypothesis testing of Studies 1–3

		Explicit attitude premeasure		Explicit attitude postmeasure		Implicit attitude premeasure		Implicit attitude postmeasure				*t*	Effect size	
Study	Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Hypothesis	*df*	*F*	η^2	*p* Value
Study 1 (short term)	Training group	3.65	0.50	3.88	0.64	0.58	0.63	0.73	0.28	H1	14	2.31	0.73	.04
										H2	14	−0.94	0.18	.37
Study 2 (medium term)	Training group	2.15	0.51	1.99	0.51	0.36	0.32	0.40	0.31	H1	60	3.15	−0.38	.00
										H2	45	−0.80	0.10	.43
Study 3 (long term)	Training group (G 1)	2.37	1.51	3.39	1.41	0.75	0.30	0.76	0.29	H1 (a)	1, 43	41.53	0.49	.00
										H1 (b)	1, 43	0.35	0.01	.56
	Control group (G 2)	1.68	1.20	3.63	1.05	0.80	0.25	0.78	0.30	H1 (c)	3, 130	2.38	0.05	.07
										H2 (a)	1, 43	0.01	0.00	.92
	Training group (G 3)			2.99	1.48			0.65	0.43	H2 (b)	1, 43	0.25	0.01	.62
										H2 (c)	3, 130	0.94	0.02	.42
	Control group (G 4)			2.70	1.57			0.64	0.46					

Note: Study 1: Training group (pre- and postmeasure) *N* = 15, explicit attitude measure (5-point Likert scale).

Study 2: Training group (pre- and postmeasure) explicit attitude measure (5-point Likert scale) *N* = 61, implicit attitude measure *N* = 46.

Study 3: Groups 1–2 (pre- and postmeasure). Training group (G 1) *N* = 31; control group (G 2) *N* = 14. Groups 3–4 (posttest-only measure). Training group (G 3) *N* = 29; control group (G 3) *N* = 60; explicit attitude measure (7-point Semantic Differential Scale); ANOVA (repeated measures) for treatment (pre- and postmeasure: Group 1–2) on explicit [H1 (a-b)] and implicit attitudes [H2 (a-b)]. ANOVA for treatment (posttest-only-measure: Groups 1–4) on explicit [H1 (c)] and implicit attitudes [H2 (c)]. No significant post hoc comparisons (based on Bonferroni) between the four groups for H1 (c) and H2 (c).

Abbreviation: ANOVA, analysis of variance.

medium effect sizes (Cohen, 1988). Consequently, the second hypothesis is rejected.

Finally, to test for IED (McKenzie & Carrie, 2018) the correlation between the implicit (IAT) and explicit attitude measure (ESAS) was calculated. The analysis revealed a marginal and nonsignificant correlation in the premeasure ($r = .05$) and in the postmeasure ($r = .08$).

3.3.2 | Study 2

As described in Section 2, lower mean values on the Complacency Scale (5-point Likert scale), are an indication of more positive explicit safety attitudes. The analysis of the first hypothesis (H1) revealed lower mean values for the Complacency Scale in the postmeasure than in the premeasure. The difference between the two could be demonstrated as significant with the help of a *t*-test for paired samples showing a small effect according to Cohen (1988). Therefore, the first hypothesis can be confirmed, as the study shows that safety (CRM) training leads to a change in participants' explicit safety attitude.

The second hypothesis (H2) stated that the implicit attitudes of the safety training's participants could be changed through the training. A higher mean value is an indication of a positive implicit safety attitude towards carefulness. Even though the IAT effect in the second measurement showed higher mean values than in the first, the difference could not be proven to be significant. Consequently, the second hypothesis must be rejected. Hence, it can be stated that there was no effect or a marginal training effect only in the implicit safety attitude change.

Finally, the correlation between the implicit (IAT) and explicit attitude measure (Complacency Scale) was small and nonsignificant for both measures ($r = .12$).

3.3.3 | Study 3

Like in Study 1, higher mean values are an indication of a positive explicit and implicit safety attitude. As can be seen in Table 3, the data for the *explicit attitude measure* (7-point Semantic Differential Scale) revealed a slight to a medium ethical preference for the option ("increasing product safety") among all groups. The IAT latencies of all four groups showed medium to large effect sizes. Thus, the *implicit safety attitude* data indicates a moderate to a strong ethical preference for the option "increasing product safety."

As was described in the method section (design and procedure), the hypotheses of Study 3 are framed within the study's design (*Solomon four-group design*). To test hypotheses 1 and 2 (a) and (b), repeated-measures analyses of variance (ANOVA) were employed to examine the serial trend (pre- and postmeasurement) in Group 1 (training group) and Group 2 (control group). In addition, ANOVA with post hoc comparisons (based on Bonferroni postmeasurement of Groups 1–4) were calculated to test hypotheses 1–2 (c). Table 3 summarizes the hypotheses and results of hypothesis testing.

As can be seen in Table 3, hypothesis H1 (a) was supported by empirical evidence. The results indicate that the training significantly increased the explicit safety-oriented attitudes of the training group (Group 1 with pre- and postmeasurement). According to Cohen (1988), effect sizes for group comparisons and repeated measures, which are expressed with η^2 can be classified as small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$), and large ($\eta^2 = 0.14$). Hence, the training effect for training Group 1 on explicit attitudes can be regarded as large.

On the other hand, when comparing the training (G 1) and control groups' (G 2) pre- and postmeasures, there was no significant difference between these two groups (see Table 3). Accordingly, hypothesis H1 (b) was rejected. Furthermore, in contrast to H1 (c), there was no significant difference between the training and the control groups with posttest-only-measures (G 3 and G 4) based on post hoc comparisons. In addition, all hypotheses H2 (a–c) had to be rejected (Table 3). Therefore, these data suggest that implicit safety-oriented attitudes have not been affected by the training.

Finally, the correlation between the implicit (IAT) and explicit attitude measure (Semantic Differential Scale) was small and nonsignificant for the premeasure ($r = .15$) and small, but significant for the postmeasure ($r = .23$, $p < .05$).

4 | DISCUSSION

4.1 | Discussion of results

The overall research objective of this paper was to find out about the possibility of explicit and implicit safety attitude changes by training. Therefore, two hypotheses were created. H1 stated that explicit safety attitudes can be changed by training. H2 stated that implicit safety attitudes can be changed by training. Based on the results of Studies 1–3, it can be concluded that explicit safety attitudes can be changed by safety training. In respect of effect sizes, significant small effects (Study 2), medium effects (Study 1), and even large effects (Study 3) were observed. Consequently, the first hypothesis (H1) was supported by all three studies. Nevertheless, compared to the meta-analytic results by Ricci et al. (2016) who obtained very large effect sizes, the effects of training on the explicit safety attitudes were lower in the present studies. In contrast, none of the three studies revealed significant changes in the implicit safety attitudes after the training. Even though there were positive changes in the post-measures, the effect sizes were marginal and nonsignificant. Accordingly, the second hypothesis (H2) was not confirmed in any of these three studies. In addition, it seems that the duration of safety training (e.g., 2 h, 2 days, or even 12 weeks) has no effect on the implicit attitudes. However, the effect sizes of short-term and medium-term training of Studies 1 and 2 were larger than those obtained in the study by Lai et al. (2016), whose effect sizes were close to zero after the follow-up measure 2–4 days after the intervention.

The results obtained in these studies differ with regard to effect size. This can partly be explained by the characteristics of the sample.

For instance, in Studies 1 and 3, the participants of the training, as well as the control groups (Study 3 only), were students from occupational psychology and environmental sciences degree programs. Therefore, all students—even those of the control groups—are familiar with concepts of health and safety issues, sustainability, and prosocial behavior. Consequently, the degree programs could have had an impact on the implicit sensitization of the students which might have caused high values in implicit safety attitudes even in the control groups. The relatively high IAT-effects in all four groups prior and after the training are therefore an indication of a ceiling effect in the third study (see Table 3). This is line with the few empirical results gained by previous research in the field of implicit and explicit attitude change by training (Jackson et al., 2014; Marquardt, 2016). Specifically, Jackson et al. (2014) have also found a ceiling effect in the favorable implicit attitudes towards women in STEM of female participants, who showed no significant change in implicit attitudes after a diversity training.

Another explanation for the pattern of the similar results of the training and control groups pre- and postmeasures in Study 3 is a methodological one. Although the temporal distance between the premeasure and the postmeasure was 12 months, it is possible that a carry-over-effect of the premeasure has influenced the quality of the postmeasure. Hence, the premeasurement might have caused an increase in the control group's postmeasurement.

Finally, it seems that the implicit attitudes were mainly unaffected by the training. The IAT data have shown no significant impact in any group comparison or pre- and postmeasure comparison. To conclude, based on the current results it can be assumed that when there is a training effect, then it manifests itself in the explicit and not the implicit safety attitudes. One explanation might be that implicit safety attitudes are more stable unconscious dispositions which cannot be easily changed like explicit ones (Charlesworth & Banaji, 2019; Dovidio et al., 2001; Wilson et al., 2000). In respect of the EISAC model (see Section 1.3), unconscious associative evaluations might be activated by safety training, but not sustainably changed. A true implicit safety attitude change would refer to a shift in associative evaluations that persist across multiple safety contexts and over longer periods of time (Lai et al., 2013).

Another explanation for the different results on implicit and explicit attitude change can be derived from the IED approach (see Section 1.3; Karpen et al., 2012; McKenzie & Carrie, 2018). In addition, the low correlations match with the results obtained in previous studies (Adachi et al., 2016; Burns et al., 2006; Ledesma et al., 2015; Marquardt et al., 2012; Molesworth & Chang, 2009; Xu et al., 2014).

4.2 | Strengths, weaknesses, and future research

The presented studies have some methodological as well as conceptual strengths. One of the main strengths refers to the novelty of the approach as well as internal and ecological validity. In fact, this was the first application of a combined implicit and explicit attitude change measure after a safety training specifically designed for different safety contexts. Never before an evaluation was carried out of the impact of CRM training on explicit and implicit safety attitudes in the automotive industry as was shown in the second study. Moreover, the systematic consideration of different training durations and time frames for attitude change (see Table 1) is another advantage of the present studies (Burke et al., 2006; Lai et al., 2013). In addition, Study 3 used an advanced experimental design (Solomon four-group design) and counterbalanced designs to check for order effects in the IAT-tasks to maximize internal validity. Furthermore, most explicit and implicit attitude measures revealed acceptable to good internal consistency. Finally, the sample of Studies 1 and 3 consisted of young (both studies) and partly international participants (Study 1). According to one of the latest meta-analyses in the field of safety training (Ricci et al., 2016) there is a lack of research for younger participants under 30 years.

However, some limitations of the current study are noteworthy. The sample size of Studies 1 and 2 were rather low. As mentioned in Section 2, due to the lockdown of laboratories and respective safety trainings caused by the COVID-19 pandemic, there was no opportunity to increase the sample size in the first study. Nevertheless, many empirical studies in the field of implicit safety attitudes faced the problem of small sample sizes (see Adachi et al., 2016; Burns et al., 2006; Caneiro et al., 2018; Molesworth & Chang, 2009). Next, the evaluation of safety training effectiveness in Studies 1 and 2 faced the general problem of a missing control group that is used as a comparison. Moreover, the reliability of the explicit attitude measure (Complacency Scale) in the second study was rather low and must be improved in future research. Another limitation was the odd group size of the four groups in Study 3. Finally, defining and measuring implicit and explicit safety attitudes is also a matter of concern, since the concepts used for the IATs refer to different psychological constructs (e.g., Study 1: associations on behavioral intentions; Study 2: associations on self-concept; Study 3: moral evaluative associations).

Based on a thorough analysis of methodological strengths and weaknesses of Studies 1–3, the flowing lessons learned for future studies can be derived: First, in contrast to Study 3, future studies should use nonstudent samples. According to the EISAC model (see Section 1.3), the altering of associative evaluations (process) which are the mental foundation of implicit safety attitudes (output) could be more sustainable in safety trainings (input) for samples consisting of professionals due to higher practical relevance. Second, the use of control groups would highly recommend also in field studies. However, when using an experimental design with pre- and post-measurements (e.g., Solomon four-group design), the span between the first and the second measurement should be narrowed. A very long temporal distance (such as 12 months) can cause too many drop-out effects. A combination of a Solomon four-group design and a time series design with short temporal distances (e.g., every 2 or 3 months) can be a sufficient solution for evaluating training effects continuously, even though the methodological workload is very high. Third, on the one hand, reaction-time measures such as the IAT should be used to track changes in underlying mental processes more often. On the other hand, direct measures such as questionnaire scales should be included to check differences in explicit safety attitudes. Combined with an experimentally repeated measures design, a time series design, in particular, the mean duration for implicit and explicit attitudinal changes could be revealed. This could be a promising strategy to learn more about the different change rates of implicit and explicit safety attitudes according to the IED approach (Karpen et al., 2012; McKenzie & Carrie, 2018). Another challenge for future research will be to test alternative latency-based methods (e.g., priming task, see Burns et al., 2006) or physiological measures (e.g., functional magnetic resonance imaging) to get better access to the underlying affective aspects of implicit attitudes. The focus on the affective nature of implicit safety attitudes could be promising since empirical results of previous studies have revealed strong correlations between IAT-scores and brain structures associated with emotion (Phelps et al., 2000; Stanley et al., 2008).

5 | PRACTICAL IMPLICATIONS AND CONCLUSION

What do the current empirical results mean for safety culture and training development? Based on the assumption that the implicit attitudes are harder to change (Gawronski et al., 2017) and thus may require active engagement via the central route of conviction (Petty & Cacioppo, 1986), this could be an explanation why there was no change in Study 1. This assumption is supported by the meta-analysis of Burke et al. (2006), who found large effect sizes for highly engaging training methods (e.g., behavior modeling, feedback, safety dialog) in general, and by the meta-analysis of Ricci et al. (2016) who obtained large effect sizes on attitudes in particular. However, the more engaging training methods such as interactive tutorials, case analyses, cooperative learning phases, role plays, and debriefs (structured group discussions)—which have proved strong meta-analytic effects (Ricci et al., 2016)—used in Studies 2 (CRM training) and 3 (Safety ethics training) did have a significant impact on the explicit but not implicit attitude change. In addition, it seems that more intense training with longer duration (e.g., such as 12 weeks in Study 3) has again no effect on the implicit attitude change. Therefore, maybe other approaches can be more promising.

Although the presented studies represent a novel approach with relatively small samples the following tentative conclusions and practical implications can be outlined. For instance, Baumeister et al. (2007) could show that feeling threat led to more safe behavior, as risk and negative feelings like fear were more strongly associated with each other. Thus, the demonstration of realistic dangers in a work environment seems essential for safety training. From a neuropsychological point of view, addressing the participants of safety trainings effectively could also make sense, to influence implicit attitudes, and thus strengthen automatically safe actions. Specifically, as mentioned earlier, the amygdala, the human emotional brain center, is related to implicit associations (Phelps et al., 2000; Stanley et al., 2008). Thus, if safety trainings evoke emotions in their participants, it may in turn have an impact on implicit attitudes. For instance, the study of Ricci et al. (2018) has shown that the emotional attitude component serves as a mediator between safety knowledge and safety behavior. Hence, safety knowledge that was taught in a training can only be successfully transferred to safety behavior, if it is mediated by affective attitudinal processes. Consequently, simulating safety-critical and affect-inducing situations could result in a sustainable training effect. Simulations could help to create an emotional connection between the possibility of an accident happening and safety-critical work behavior. In this way, the employees' implicit safety attitudes could be addressed effectively and modified by cognitive interventions such as implementation intentions which were effective at least in short-term implicit attitude change (Lai et al., 2016). As described in the introduction section (see Section 1.3), implementation intentions are “if-then” plans that increase the automaticity of behavior by linking a situational cue (“if,” e.g., accident) to a behavioral response (“then,” e.g., provide first-aid; Mendoza et al., 2010). Thus, simulations can offer a safe environment in which participants can make mistakes to analyze their causes, use effective countermeasures, and prevent them in the future (Aggarwal et al., 2010). In medicine and aviation, simulations have been a standard part of CRM training for many years and show promising results (Aggarwal et al., 2010, Salas et al., 2006). Barsuk et al. (2009) could, for example, show that residents made significantly fewer mistakes when inserting a venous catheter if they had previously received several simulation trainings, compared to participants who received traditional trainings.

To sum up, even though the outlined conclusions are tentative, it could be very useful in the future to design realistic and affect-inducing training simulations via emergency simulators or virtual reality approaches (Sacks et al., 2013; Seymour et al., 2002) for all highly hazardous industries. If these simulations are accompanied by highly engaging *behavioral* (e.g., behavioral modeling; Burke et al., 2006, 2011), *social* (e.g., debriefs/structured group discussions; Ricci et al., 2016), and *cognitive* (e.g., implementation intentions; Lai et al., 2016) training methods, then they might facilitate a positive explicit and even implicit safety attitude change and finally a sustainable safety culture transformation.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

ETHICS STATEMENT

All procedures performed in studies involving human participants were in accordance with the Ethical Standards of the Institutional and/or National Research Committee and with the Declaration of Helsinki 1964 and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the studies.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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APPENDIX

Explicit Safety Attitudes Scale (ESAS) (Study 1)

Explicit Safety Attitudes Scale

	strongly disagree	disagree	neutral	agree	strongly agree
I rarely care about dangers in my work environment.	☐	☐	☐	☐	☐
It is too time consuming to think about risk prevention in my daily work.	☐	☐	☐	☐	☐
I think it is always better to comply with the safety regulations, even when time is short.	☐	☐	☐	☐	☐
When I have a lot to do, it makes sense to compromise safety standards.	☐	☐	☐	☐	☐
Carefully following safety instructions takes time away from more important things.	☐	☐	☐	☐	☐
Safety is the most important issue in hazardous work environments.	☐	☐	☐	☐	☐
Efficiency is more important than safety.	☐	☐	☐	☐	☐
I always pay attention to risk factors in my work environment.	☐	☐	☐	☐	☐
My motto is always "safety first".	☐	☐	☐	☐	☐
Working with high risks makes tasks more interesting.	☐	☐	☐	☐	☐

Items used in the Safety Attitudes-IAT (Study 1)

Concept category "Safety": safety, protection, reliability, health.

Concept category "Risk": risk, danger, threat, harm.

Attribute/verb category "preserve": preserve, comply, sustain, achieve.

Attribute/verb category "prevent": prevent, avoid, hinder, stop.

Items of the non-Complacency Scale (Study 2)

I rarely seek my colleagues' opinions at work, because they do not know better than I do.

If I am uncertain I willingly take advice from others.

I sometimes do not check my work, because I am convinced of my own infallibility.

I willingly implement suggestions for improvement.

I always take care to only use approved materials.

Items used in the Safety Culture-IAT (Study 2)

Concept category "I": I, me, mine, my.

Concept category "workmates": workmates, mates, colleagues, fellows.

Attribute category "careful": careful, reliable, precise, cautious, thoughtful.

Attribute category "careless": careless, unreliable, imprecise, incautious, thoughtless.

Items used in the Semantic Differential Scale (Study 3)

Moral–immoral, social–unsocial, fair–unfair, considerate–inconsiderate, decent–indecent, responsible–irresponsible.

Items used in the Safety Ethics-IAT (Study 3)

Concept category "increasing product safety": safety, health, protection, life, product safety, health protection.

Concept category "cutting costs": money, shareholder value, profitability, sales, market shares, profit.

Attribute category "moral": moral, social, fair, considerate, decent, responsible.

Attribute category "immoral": immoral, unsocial, unfair, inconsiderate, indecent, irresponsible.