International Journal of Occupational Safety and Ergonomics (*JOSE*) 2013, Vol. 19, No. 1, 143–155

Validating a Safety Climate Model in Metal Processing Industries: A Replication Study

Paul Braunger

Faculty of Psychology, University of Vienna, Austria

Hermann Frank

Vienna University of Economics and Business, Vienna, Austria

Christian Korunka

Faculty of Psychology, University of Vienna, Austria

Manfred Lueger

Vienna University of Economics and Business, Vienna, Austria

Bettina Kubicek

Faculty of Psychology, University of Vienna, Austria

This paper attempts to replicate a safety climate model originally tested in Australia to assess its applicability in a different context: namely, across production workers in 22 medium-sized metal processing organizations in Austria. The model postulates that safety knowledge and safety motivation mediate the relation between safety climate on the one hand and safety compliance and participation on the other. Self-report data from 1075 employees were analyzed using structural equation modeling (SEM). The results of the replication study largely confirmed the original safety climate model. However, in addition to indirect effects, direct links between safety climate and actual safety behavior were found.

safety climate   safety climate model   safety performance   replication study
metal processing

1. INTRODUCTION

Research has increasingly demonstrated that the climate of organizational safety is a key concept in occupational health and safety (OHS) [1, 2, 3, 4, 5, 6]. Safety climate has received substantial attention due to its potential for explaining variation in safety-related outcomes in organizations [7, 8, 9] and has become an important indicator of safety performance[1] [2] as well as of the unsafe behavior of employees [10].

Safety climate refers to the employees' perceptions of the safety policies, safety procedures and safety practices, and of the value, importance and

[1] The term safety performance in the present study refers to a metric of safety-related behaviors of individuals.

This research was funded by the Austrian Social Insurance for Occupational Risks – Allgemeine Unfallversicherungsanstalt (AUVA).

Correspondence should be sent to Paul Braunger, Faculty of Psychology, University of Vienna, Universitaetsstrasse 7, A–1010 Vienna, Austria. E-mail: paul.braunger@univie.ac.at.

priority of safety within an organization. It relates to the motivation of employees to work safely, and affects the safety behaviors of employees and their experiences of injuries or incidents in workplaces [11, 12, 13]. There is evidence that a positive safety climate maintains safety-related behaviors, including involvement in safety activities [14] and safety participation of employees in an organization [7], reduces accidents and lost workdays [15]. A more positive climate encourages safe behaviors by means of organizational rewards (e.g., recognition or feedback for making safety suggestions), while a more negative safety climate reinforces unsafe behaviors by removing incentives to improving safety (e.g., downgrading of safety in favor of production interests) [16]. Measuring safety climate provides opportunities for change and improvement in the safety performance of organizations [17]. Thus, it is both practically and theoretically important for researchers and practitioners to develop a fuller understanding of the effects of safety climate on employees' behavior [16].

Given an assumed association connecting safety climate and safety behavior, a number of models have been postulated and further developed. In addition, developing and testing theoretical models of safety climate to ascertain determinants of safety behavior and accidents (e.g., Neal, Griffin and Hart [7], Griffin and Neal [11], Cheyne, Tomas, Cox, et al. [14], DeJoy, Gershon and Schaffer [18], Prussia, Brown and Willis [19], Thompson, Hilton and Will [20]) has become a significant direction in safety climate research [17]. However, so far there have been only relatively few attempts to relate findings to any underlying theoretical model [21] and systematic evidence in support of proposed theoretical models of the safety climate is scarce. Furthermore, few studies have successfully replicated safety climate dimensions found by other researchers [22].

The present paper, therefore, attempts to replicate the safety climate model proposed by Griffin and Neal [11], which was originally tested with Australian manufacturing and mining employees (see also Neal et al. [7], Neal and Griffin [23, 24, 25]). The Griffin and Neal model is one of first theoretical models to explain the relation between safety climate and safety performance [21]. The model defines safety climate in terms of perceptions of the working environment relating to safety. Safety climate in the model is treated as conceptually distinct from the individual antecedents of safety, including attitudes towards safety, attitudes towards the organization and personal dispositions. In a systematic review of the safety literature of the past 10 years, we found over 90 references to the model or to the proposed framework. Although various aspects of the basic assumptions underlying the model have been tested (e.g., DeJoy et al. [18], Guldenmund [26]), so far no replication study of the safety climate model has been undertaken. Unreplicated empirical findings may lead to solitary "one-shot" theories of unknown scope and restriction [27]. To make progress in research in this field, it is necessary to test the robustness of empirical findings. Confidence in empirical evidence in the social sciences will only develop with a well-established tradition of replication [28].

Despite the importance of replication studies, they do not play a prominent role in published empirical work [29] in the social sciences and its advancement [30]. There are several possible reasons for this fact. Replication studies are less likely to be published [31] owing to negative preconceptions among editors of first-tier journals [32] and researchers often see replication studies as less creative [33]. However, replication means the reproducibility or constancy of research results [34]. Replication contributes to the establishment of external validity, by enabling the generality of findings to other populations [35]. Three different types of replications can be distinguished: duplication, similar and modification, according to the extent to which the original study is followed. Monroe notes that replications can differ according to their timing, the researchers conducting the work and the level of planned similarity [34]. He argues that replications with modifications are preferable, such as those by different researchers at different times and locations. Based on these recommendations, the present study is a replication study designed to explore the robustness and the cross-cultural generality of the original Griffin and Neal safety climate model [11], by testing it in metal processing industries in Austria.

2. THE IMPORTANCE OF SAFETY CLIMATE

Labor law defines OHS as measures taken and activities engaged in to prevent risks and to protect life and health at work [36]. Technical safety-related aspects have played an important role in workplace safety at all times, particularly in manufacturing. Safety technology is continuously being improved through advancing industrialization and mechanization. As a result of these changing working conditions, accident risks have been reduced[1] [37].

Current approaches to safety research focus on safety climate as a central construct in current conceptualizations of OHS [5]. Over the past decades of safety research, safety climate has been shown to be an important indicator of positive safety performance [2] and the safety behavior of employees [10]. Recent meta-analyses revealed safety climate to be a powerful predictor of objective and subjective safety criteria across industries and countries (e.g., Guldenmund [26]). However, after 30 years of safety climate research, a lack of conceptual clarity remains. Zohar, in his review of safety climate research, therefore, regards efforts to further reduce the conceptual ambiguity as main direction in future research [38]. His suggestions include, i.a., more research concerning the differentiation of safety climate from other perception-based constructs and analysis of level-specific climate perceptions, such as the development of level-specific subscales.

Retrospectively, Zohar was also one of the first to postulate a link between safety climate and safety performance [6]. Zohar's model has received substantial attention due to its potential for explaining variation in safety-related outcomes in organizations [7, 8, 9]. Since then, growing interest has focused on mediator variables of safety performance. Griffin and Neal used structural equation modeling to set up a theoretical framework linking safety climate and safety performance, mediated by safety knowledge and safety motivation [11]. The model attempts the integration of two research streams [11, 23, 24]: theories of psychological climate in organizations (e.g., James and McIntyre [39]) and theories of individual performance (e.g., Campbell, McCloy, Oppler, et al. [40]). According to the authors' definition, safety climate can be seen as involving perceptions of safety policies, safety procedures and practices relating to safety [13, 41]. At the broadest level, this reveals employee's perceptions about the value of organizational safety [24]. The main aim of this paper is to replicate the Griffin and Neal safety climate model.

3. GRIFFIN AND NEAL'S SAFETY CLIMATE MODEL

Griffin and Neal define safety climate in terms of perceptions of the working environment and treat it as conceptually distinct from the individual antecedents of safety, including attitudes towards safety, attitudes towards the organization and personal dispositions [11]. Using structural equation modeling, the authors set up a theoretical framework linking safety climate and safety performance, mediated by safety knowledge and safety motivation.

The model distinguishes between determinants and components of safety performance. Safety performance refers to safety-related behaviors of employees [11, 24, 25]. The determinants of safety performance are safety knowledge and safety motivation. Safety knowledge is defined as the employees knowing how to perform safely (e.g., emergency procedures). Safety motivation

[1] In addition to these technical enhancements, an essential basis for ensuring safe situations and conditions in occupational settings has been the application and standardization of national and international health and safety regulations over recent decades. At the European Union (EU) level, Directive 89/391/EEC sets out general principles for the protection of workers' occupational health and safety and provides the enabling agenda for a number of other directives concerned with specific aspects of health and safety. In Austria, OHS is regulated via the Occupational Safety Act (ArbeitnehmerInnenschutzgesetz, AschG; Bundesgesetz über Sicherheit und Gesundheitsschutz bei der Arbeit, BGBl No. 450/1994). This law was reformed in the course of Austrian accession to the EU and came into force in 1995 [36].

reflects the employees' "willingness to exert effort to enact safety behaviors and the valence associated with those behaviors" (p. 934) [25]. The components of safety performance are safety compliance and safety participation. Both describe the actual behaviors that employees display at work [11]. Safety compliance refers to "generally mandated" safety behaviors [7]. It refers to the core activities that employees need to carry out to preserve safety in their workplace, including adhering to standard work procedures or wearing personal safety equipment [25]. The understanding of safety participation summarizes safety behaviors that are "frequently voluntary" [7]. To this end, safety participation behaviors do not directly contribute to an employee's personal safety but they do help to develop a safety-supporting environment.

These behaviors contain activities, such as participating in voluntary safety activities, helping co-workers with safety-related issues or attending safety meetings [25].

The main assumptions of Griffin and Neal's safety climate model [11] as shown in Figure 1 consist of two parts:

- a structural part of the model with the use of a higher order construct of safety climate of five specific first-order factors. These are management values (management concern for employee well-being), safety communication (communication concerning safety issues), safety practices (promptness and availability of safety practices), safety training (adequacy of safety training) and safety equipment (provision of safety equipment);
- a relational part of the model with the mediating role of the determinants of safety performance (safety motivation and safety knowledge) between safety climate and the components of safety performance (safety compliance and safety participation). Safety knowledge is postulated to have a strong positive relation with safety performance since knowledge is a direct determinant of performance behaviors. Safety motivation is expected to strongly relate to safety performance. Because of the motivation-related conceptualization of safety participation, safety motivation is also postulated to relate more stronglyto safety participation than to safety compliance.

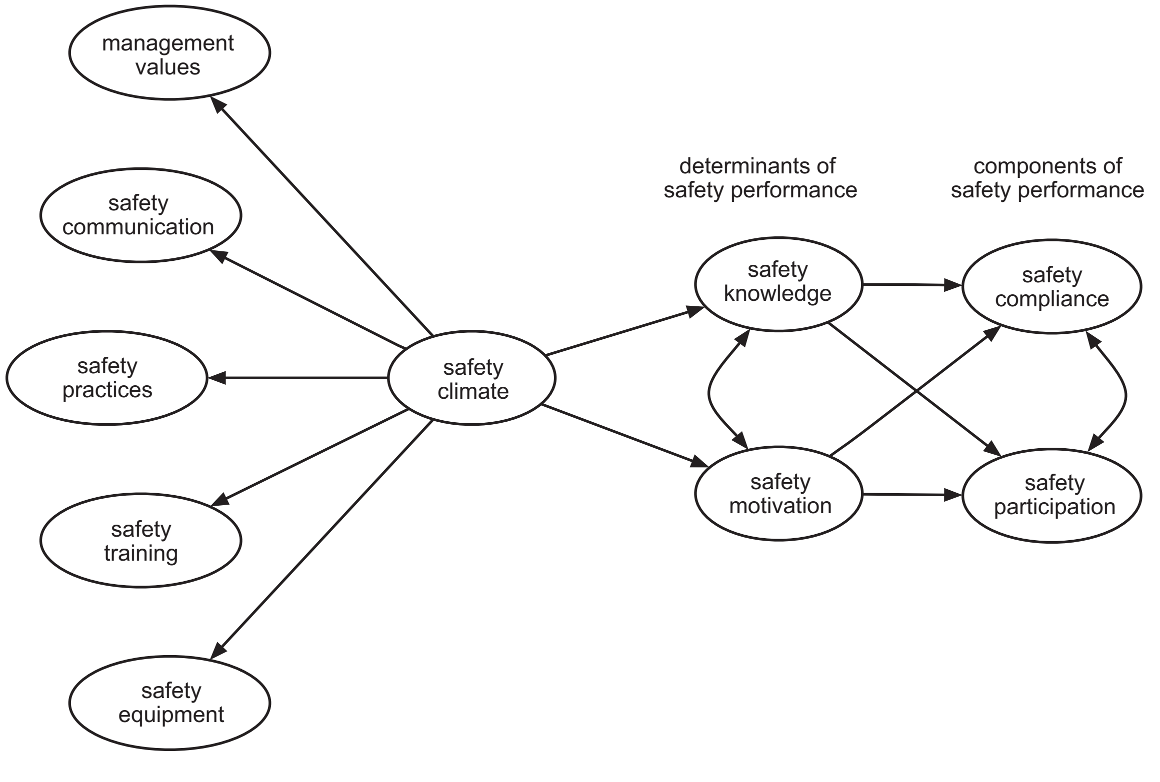

Figure 1. Replicated safety climate model.

Our hypotheses aiming to replicate these two main assumptions of the safety climate model can be defined as follows:

Hypothesis 1 (structural part of the model): Safety climate is a higher-order construct with the first-order-factors manager values, safety communication, safety practices, safety training and safety equipment.

Hypothesis 2 (relational part of the model): Safety knowledge and safety motivation fully mediate the relation between safety climate and the components of safety performance (safety compliance and safety participation).

4. REPLICATION OF THE MODEL

The present replication study examines the validity of Griffin and Neal's safety climate model [11] including the following modifications: the original items were translated into *another language* (German). The model was tested in a *different country* (Austria) and in a different *high-risk industry sector*, the metal processing industry. Jobs in metal production tasks are often stressful and highly physically demanding. Metal workers are significantly exposed to extended beating and cutting actions in excessive noise and with uncomfortable body postures. Furthermore, stressors from humidity and heat, welding fumes and metal dust often cause excess injury [42].

4.1. Procedure and Sample

In selecting the organizations to be used in the study, the national Social Insurance for Occupational Risks provided an exhaustive list of medium-sized companies (50–249 employees) in the Austrian metal processing industries. Following extensive analysis on these organizations (contact options, etc.), a target group of 120 organizations was determined and contacted by telephone and in writing. To achieve representativeness within this selection of companies, account was taken of the size of the organization, the number of accidents in the company (the accident risk) and the location of the companies. In total, 22 organizations agreed to take part in the study. A comparison of the participating organizations and those contacted revealed no differences with regard to the representativeness criteria.

In each of the organizations, employees were invited to participate in a confidential survey by placing their questionnaires in sealed boxes located at several sites throughout the organization. This procedure was chosen to guarantee anonymous and confidential data collection. The time taken to complete the survey was 3–14 days.

In total, 3906 employees in the 22 organizations identified were invited to participate in the study between January to March 2008. Overall, 2332 employees completed the survey. The completed questionnaires were manually checked for systematic response patterns and unanswered items. Only clean data were analyzed, leading to a response rate of 60%.

To achieve a high quality replication, two further restrictions were imposed. First, only employees working in production areas were included in the sample, excluding administrative staff. This restriction resulted in a reduced sample size of 2046 participants. Secondly, employees who neither had safety training nor needed to use safety protection equipment for their work were excluded from the data set. This led to a sample size of 1582 production workers in potentially hazardous jobs. These restrictions were set to guarantee that only employees who can answer the items of our safety climate questionnaire are in the analyzed sample to test the safety climate model. The final analytical sample consisted of those 1075 respondents who had no missing data on any of the study variables.

The number of completed questionnaires returned by the employees in each company ranged from 21 to 222 (*Mdn* 75). The response rate varied from 30% to 78% (*Mdn* 53%) and a mean of 57% (*SD* 19). Participants were mostly male (92%). Data on age was categorized at source. The mean age of the sample was between 31–40 years (6% were under 20, 29% were 21–30, 23% were 31–40, 28% were 41–50 and 15% were over 50 years old).

4.2. Measures

As a first step, Griffin and Neal's original items [11]were translated into German. Ninety-two employees in an Austrian metal processing company then participated in a pre-test using these questions (this company did not participate in the main study). After the resulting data had been analyzed, several items were excluded. This item reduction was based on reliability analyses and distribution. The participants' personal remarks on the comprehensibility as well as the textual aspects of the items were also taken into consideration. In the resultant short version employees responded on a 5-point scale ranging from 1 (*completely disagree*) to 5 (*completely agree*). Table 1 provides information about the scales and gives some sample items.

4.3. Data Analyses

To test the adequacy of the safety climate model given in Figure 1, we used structural equation modeling procedures, as implemented by AMOS 5 [43]. The exogenous safety climate variable was modeled as a latent second-order factor (comprising management values, safety communication, safety practices, safety training and safety equipment), while safety knowledge, safety motivation, safety compliance and safety participation were modeled as first-order latent factors. Estimation of parameters was determined using maximum likelihood (ML) estimation procedures. To assess the adequacy of the safety climate model we applied the following fit statistics [44]: the χ^2 goodness-of-fit statistic, the goodness-of-fit index (GFI), the root mean square error of approximation (RMSEA) and the comparative fit index (CFI). Indicative of a well-fitting model are CFI- and GFI-values higher than .95 and a RMSEA close to .06 [45].

5. RESULTS

5.1. Descriptive Analysis

Looking first at descriptive statistics, analyses reveal that safety compliance is relatively high, with workers on average agreeing strongly about adherence to safety regulations (M = 3.22, see also Table 2). Safety participation, by contrast, is somewhat lower on average than safety compliance (M = 2.51, t (1074) = 24.36; p < .001). As

TABLE 1. Scales and Items Used for Model Test

Dimension	Item Example	No. of Items
Safety climate		
First-order factors		
Manager values	The management in this company gives much time and energy to workplace safety.	3
Safety practices	The management in this company reacts quickly to solve the problem when told about safety hazards.	3
Safety communication	Consultation is adequate when changes in working practices are proposed.	2
Safety training	The safety training I receive helps me to do a safe job.	2
Safety equipment	I have the protective equipment or clothing required to do my job in a safe way.	2
Determinants of safety performance		
Safety knowledge	I know how to use my safety equipment properly.	3
Safety motivation	A strong emphasis on workplace safety is important for.	3
Components of safety performance		
Safety compliance	I always work according to safety rules, even under time pressures.	3
Safety participation	I voluntarily attend safety trainings.	3

can be seen from Table 2, relations among constructs were all significant and in the expected direction. Internal consistencies as indicated by Cronbach's α were, apart from safety compliance and safety equipment, satisfactory, with values higher than α = .65. Modest internal consistencies among the safety compliance and the safety equipment items may partly reflect the small number of items constituting the scales and the fact that the chosen items represent somewhat different aspects of the underlying construct, thus capturing the conceptual breadth within the constructs instead of maximizing internal consistency (e.g., Ryff and Keyes [46]).

5.2. Hypothesis 1: Analysis of the Factorial Structure of Safety Climate

To test the hypothesized factorial structure of safety climate, a confirmatory factor analysis (CFA) was performed. The exogenous safety climate variable was modeled as a latent second-order factor with 12 items measuring five first-order factors as proposed in the initial study: manager values (3 items), safety practices (3 items), safety communication (2 items), safety training (2 items), and safety equipment (2 items). The CFA yielded an acceptable fit [45] (χ_{α} (49) = 173.33, $p < .001$; GFI = .97, CFI = .98, RMSEA = .05). The standardized factor loadings were .66 for manager values, .92 for safety practices, .78 for safety communication, .74 for safety training and .75 for safety equipment. Cronbach's α values for these subconstructs were .86, .79, .76, .81, and .61, respectively (see Figure 2).

5.3. Hypothesis 2: Analysis of the Validity of the Relations in the Safety Climate Model

Turning to the test of the safety climate model, the hypothesized model resulted in a χ^2 estimate of 1080.24 (N = 1075, df = 262; $p < .001$), suggesting only moderate fit (Table 3; M1). Neither the CFI nor the GFI were within the recommended range of acceptability. Only the RMSEA provides evidence for a well-fitting model, as it lies below the cutoff value advised by Hu and Bentler [45]. Inspection of modification indices and standardized residual covariances suggested including an error covariance between two safety knowledge items. Both items asked to what extent workers knew how to use external safety devices, such as personal protection equipment

TABLE 2. Means, Standard Deviations, Correlations and Internal Consistencies of Study Constructs

Constructs	*M*	*SD*	α	1	2	3	4	5	6	7	8
1 Management values	2.93	0.90	.86								
2 Safety communication	2.81	1.07	.76	.43							
3 Safety practices	3.09	0.86	.79	.50	.56						
4 Safety training	3.14	0.91	.81	.38	.43	.52					
5 Safety equipment	3.39	0.74	.61	.38	.37	.49	.48				
6 Safety knowledge	3.60	0.56	.77	.23	.36	.26	.27	.31			
7 Safety motivation	3.40	0.71	.81	.27	.37	.34	.36	.35	.51		
8 Safety compliance	3.22	0.66	.57	.37	.34	.37	.37	.37	.43	.60	
9 Safety participation	2.51	0.97	.65	.27	.37	.33	.29	.22	.33	.43	.37

TABLE 3. Fit Indices for Safety Climate Models

Model	χ^2	*df*	χ^2/df	RMSEA	CFI	GFI	BIC	BIC_{diff}
M1 Safety climate model	1080.24	262	4.12	.054	.93	.92	1519.98	
M2 Re-specified model (safety knowledge <> safety motivation)	1058.45	261	4.06	.053	.93	.92	1505.17	14.81
M3 Re-specified model (error covariance safety knowledge)	1002.89	259	3.87	.052	.93	.92	1432.57	41.60

Notes. RMSEA = root mean square error of approximation, CFI = comparative fit index, GFI = goodness-of-fit index, BIC = Bayesian information criterion.

and safety devices at machines. The similarity in item content yielded a strong substantive rationale for adding this error covariance. As shown in the second row of Table 3 (M2), the modification resulted in a significant improvement of model fit (χ^2_{diff} (1) = 21.79; $p < .001$). Other model modifications suggested by the modification indices were not included because they were not theoretically reasonable.

To examine whether the hypothesized full-mediation model actually fits the data best, we compared the model fit of model 2 with that of a partial-mediation model. The partial-mediation model included direct paths from safety climate to safety participation and safety compliance. The χ^2 difference test provides positive evidence for the partial-mediation model, with model 3 yielding a significantly lower χ^2 estimate than model 2 (χ^2_{diff} (2) = 55.56; $p < .001$), suggesting that safety climate is not only indirectly but also directly related to the components of safety performance. Therefore, the partial-mediation model (M3) was used for the following examination of path weights, direct and indirect effects.

As shown in Table 4, the perceived safety climate of the organization related strongly to safety knowledge (β = .44) and safety motivation (β = .54), which represent determinants of safety behavior. Determinants of safety behavior, in turn, partially mediated the relation between safety climate and the components of safety behavior, namely safety compliance and safety participation.

When looking more thoroughly at the proximal determinants of safety behavior, the model indicates that safety motivation is more important a determinant of safety compliance than of safety participation. By contrast, associations between safety knowledge and the components of safety behavior are nearly equally strong (β = .11 and β = .22, respectively).

Turning to the correlations among determinants and components, respectively, results are only partially in concordance with initial assumptions. While the correlation between safety knowledge and safety motivation reached as high a value as r = .53, safety compliance was not significantly associated with safety participation.

Thus, taking together the results, the safety climate model was partially validated in our study: we replicated the higher-order factorial structure of safety climate (Hypothesis 1) and found support of the mediating role of safety knowledge and safety motivation. Yet in contrast to Griffin and Neal's original model [11], safety climate exerted not only an indirect effect (via safety knowledge and safety motivation), but also a direct effect on the components of safety performance (Hypothesis 2).

TABLE 4. Standardized Direct and Indirect Effects of Latent Variables (ML-Estimates)

Direct Effects	Safety Climate	Safety Knowledge	Safety Motivation	Safety Compliance
Safety climate	—	—	—	—
Safety knowledge	.44***	—	—	—
Safety motivation	.54***	—	—	—
Safety compliance	.19***	.22***	.71***	—
Safety participation	.30***	.11*	.38**	—
Indirect Effects				
Safety climate	—	—	—	—
Safety knowledge	—	—	—	—
Safety motivation	—	—	—	—
Safety compliance	.48***	—	—	—
Safety participation	.25***	—	—	—

Notes. Direct and indirect effects sum up to total effects; *$p < .05$; **$p < .01$; ***$p < .001$.

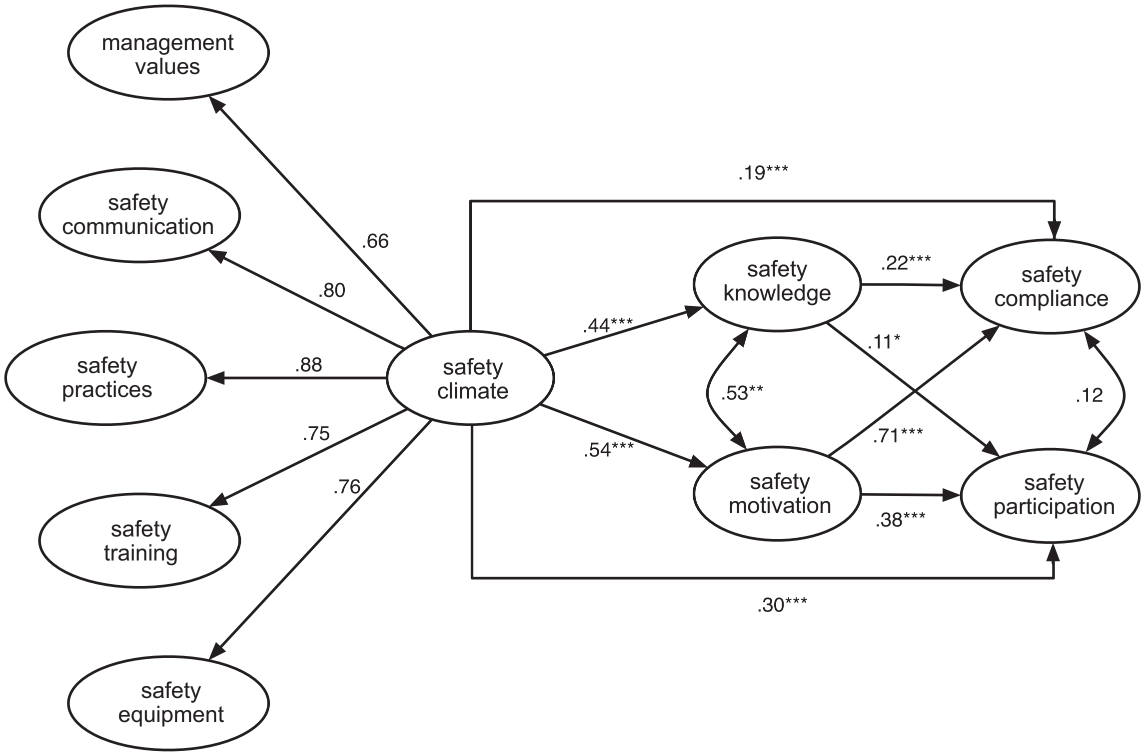

Figure 2. Final model. *Notes.* *$p < .05$; **$p < .01$; ***$p < .001$.

6. DISCUSSION

To replicate Griffin and Neal's safety climate model [11] including its further applications [7, 23, 24, 25] in a different country and industry sector, data from 1075 metal processing workers were analyzed using structural equation modeling. In accordance with previous studies, the present study shows that organizational safety climate has an important influence on ensuring adherence to procedures. In particular, it plays a significant role in the strengthening of employee commitment to and involvement in safety. These results are in accordance with Clarke [16]. She found moderate criterion-related validity on both aspects of performance, and a stronger effect with safety participation. Neal and Griffin found a significant lagged effect on safety participation, but not safety compliance [7]. It has been argued that a significant relation between safety climate and safety participation is discrepant with the emphasis within safety climate scales on rules and procedures (see Clarke and Flitcorft [47]). However, it is possible to offer an interpretation for this within a social exchange framework: organizations that are perceived to observe safety rules and procedures may represent employers that are committed to safety and accident prevention, a commitment which is matched by employees' motivation and compliance with safety-related actions (see Clarke [16]).

The results offer confirmation of the higher-order structure of safety climate, in line with a series of other studies within safety climate research. In relation to the specific debate on the selection of the safety climate dimensions at this point (e.g., Guldenmund [3], Zohar [6], Barling and Frone [48]), it may be concluded that five factors (management concern for employee well-being, communication concerning safety issues, the promptness and availability of safety practices, the adequacy of safety training and the provision of safety equipment) were confirmed as important concepts related to the safety climate in organizations.

The second focus of the model lies on the mediating role of safety knowledge and safety motivation (determinants of safety behavior) between safety climate and safety performance. "Safety performance" of employees is seen as a function of the organizational safety climate and, according to the model, subdivides into safety compliance (task performance) and safety participation (contextual performance) [7].

In regard to the significant correlation between the two determinants of safety behavior (safety knowledge and safety motivation), the results of the original study showed that interventions aimed at improving only one of the two determinants seemed to be less effective than interventions that targeted both. Although this finding is not contradicted in the present study, our findings raise the question of whether these two constructs are separable in the way proposed in terms of their specific impact on the components of safety behavior. One point that has been discussed earlier is the possible effect of safety skills as a third dimension within the determinants of safety behavior [11]. Another issue could be the possible division of the construct of safety motivation into participation motivation and compliance motivation. Griffin and Neal differentiated between these two motivation-constructs [11]. Despite a high correlation (r = .75) between the constructs, they found different effects on employees' safety performance. In later studies [7, 24, 25], safety motivation was not split up into two constructs. As a consequence, future research could focus on this matter by using a larger number of items for all safety constructs as well as a differentiation between participation and compliance aspects of safety motivation.

Comparability across industry sectors

Our study was realized in the Austrian metal industry. The original study was realized with Australian manufacturing and mining employees. Reviewing the relevant literature, Smith, Huang, Ho, et al. [49] found that safety climate, as a concept for capturing the prevailing state of safety of organizations, may be less adequate for the purpose of cross-industry safety comparisons, since the underlying safety hazards are dissimilar per industry and these may have an effect on employees' perceptions of the safety climate in their workplace. Differences in hazards between industry sectors, conceptualized as a single type of injury hazard, need to be considered when testing safety climate. On the other hand, coming back to the principal aim of the present study, the testing of the generality of the safety climate model, there are indications that the aspects of the theory apply to most industries and organizations and none are restricted to a specific industry or a particular organization. It seems reasonable to argue that the variables in the model may not be strongly affected by special industry-sector specific matters. For example, it can be presumed that the five safety climate subfactors (manager values, safety practices, safety communication, safety training, and safety equipment) as well as the other safety constructs investigated are important across industries. Hence, the results of the current study, which involved variation across industry sectors and into another (western) country, may indicate the strength of the safety climate model.

Limitations

Finally, the outcome of this study needs to be discussed in the light of the limitations shared by most studies relying upon self-report questionnaire data. The validity of the tested models may be challenged, given that all measures are based on self-reported instruments. Moreover, the cross-sectional design of the study hinders the determination of sequential relations connecting safety predictors and safety outcomes. The power of the safety climate concept lies in its prediction of safety performance. The use of cross-sectional data allows no conclusions on causality. In future, research further replications of the results based on longitudinal data are required to investigate the relation between organizational safety climate and employees' safety performance.

7. CONCLUSIONS AND IMPLICATIONS

In summary, the safety climate model [7, 11] provides a coherent model linking safety climate to safety performance in manufacturing organizations. The results underline the extensive role of the tested model within safety climate research, and indicate the transferability into different industry sectors. The, in the present replication study partly confirmed, model assumption that safety knowledge and safety motivation, as determinants of safety behavior, mediate the relation between safety climate on the one hand and employees' safety performance (safety compliance and safety participation) on the other hand leads to the conclusion that, if an organization has a problem with too little safety participation or safety compliance of the employees, it is important to implement purposeful interventions on aspects of safety climate. This can be seen as the main result of the current study. The extension of management values and practices to safety issues, the improvement of safety training, and the advancement of organizational safety communication are especially important to increase the safety climate in an organization.

The key assumption that the relation between safety climate and the specific safety performance outcomes is at least partly mediated through safety motivation and knowledge of employees was confirmed. Accordingly, safety climate improvements lead to an enhancement within safety knowledge and safety motivation, which then results in an improvement of the safety performance of employees. Even if these indirect effects are stronger than the direct ones, one main result of this study is that safety climate also shows a direct connection with safety performance variables.

REFERENCES

1. Coyle IR, Sleeman SD, Adams N. Safety climate. J Safety Res. 1995;26(4):247–54.
2. Flin R, Mearns K, O'Connor P, Bryden R. Measuring safety climate: identifying the common features. Saf Sci. 2000;34(1–3): 177–92.
3. Guldenmund FW. The nature of safety culture: a review of theory and research. Saf Sci. 2000;34(1–3):215–57.
4. Lee T, Harrison K. Assessing safety culture in nuclear power stations. Saf Sci. 2000; 34(1–3):61–97.
5. Mullen J. Investigating factors that influence individual safety behavior at work. J Safety Res. 2004;35(3):275–85.
6. Zohar D. Safety climate in industrial organizations: theoretical and applied implications. J Appl Psychol. 1980;65(1): 96–102.
7. Neal A, Griffin MA, Hart PM. The impact of organizational climate on safety climate and individual behavior. Saf Sci. 2000; 34(1–3):99–109.
8. Zohar D. A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. J Appl Psychol. 2000;85(4):587–96.
9. Zohar D, Luria G. A multilevel model of safety climate: cross-level relationships between organization and group-level climates. J Appl Psychol. 2005;90(4):616–28.
10. Tomas JM, Melia JL, Oliver A. A cross-validation of a structural equation model of accidents: organizational and psychological variables as predictors of work safety. Work Stress. 1999;13(1):49–58.
11. Griffin MA, Neal A. Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation. J Occup Health Psychol. 2000;5(3):347–58.
12. Huang YH, Ho M, Smith G, Chen PY. Safety climate and self-reported injury: assessing the mediating role of employee safety control. Accid Anal Prev. 2006; 38(3):425–33.
13. Zohar D, editor. Safety climate: conceptual and measurment issues. Washington, DC, USA: American Psychological Association; 2003.
14. Cheyne A, Tomas JM, Cox S, Amparo O. Modelling employee attitudes to safety: a comparison across sectors. Eur Psychol. 1999;4(1):1–10.
15. Johnson SE. The predictive validity of safety climate. J Safety Res. 2007;38(5): 511–21.
16. Clarke S. The relationship between safety climate and safety performance: a meta-analytic review. J Occup Health Psychol. 2006;11(4):315–27.
17. Cooper MD, Phillips RA. Exploratory analysis of the safety climate and safety behavior relationship. J Safety Res. 2004; 35(5):497–512.

18. DeJoy DM, Gershon RM, Schaffer BS. Safety climate. Assessing management and organizational influences on safety. Prof Saf. 2009;47(7):50–7.
19. Prussia GE, Brown KA, Willis PG. Mental models of safety: do managers and employees see eye to eye? J Safety Res. 2003;34(2):143–56.
20. Thompson RC, Hilton TF, Will LA. Where the safety rubber meets the shop floor: a confirmatory model of management influence on workplace safety. J Safety Res. 1998;29(1):15–24.
21. Flin R. Measuring safety culture in healthcare: a case for accurate diagnosis. Saf Sci. 2007;45(6):653–67.
22. Pousette A, Larsson S, Toerner M. Safety climate cross-validation, strength and prediction of safety behaviour. Saf Sci. 2008(3);46:398–404.
23. Neal A, Griffin MA. Safety climate and safety behaviour. Australian Journal of Management. 2002:27:67–75.
24. Neal A, Griffin, MA. Safety climate and safety at work. In: Barling J, Frone M, editors. The psychology of workplace safety. Washington, DC, USA: American Psychological Association; 2004. p. 15–34.
25. Neal A, Griffin, MA. A study of the lagged relationship among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. J Appl Psychol. 2006;91(4):946–53. Retrieved February 25, 2013, from: http://griffin.zydec.net.au/publications/neal_griffin_jap.pdf.
26. Guldenmund FW. The use of questionnaires in safety culture research—an evaluation. Saf Sci. 2007;45(6):723–43.
27. Hubbard R, Lindsay RM. How the emphasis on "original" empirical marketing research impedes knowledge development. Marketing Theory. 2002;2(4):381–402.
28. Tsang EWK, Kwan KM. Replication ant theory development in organization science: a critical realist perspective. Acad Manage Rev. 1999;24(4):759–80.
29. Baumgarth C, Evanschitzky H. Die Rolle von Replikationen in der Marketingwissenschaft [The role of replications in marketing science]. Marketing ZFP. 2005;27(4):253–62.
30. Hunter I. The desperate need for replications. J Consum Res. 2001;28(1): 149–58.
31. Eden D. From the editors. Replication, meta-analysis, scientific progress, and AMJ's publication policy. Acad Manage J. 2002;45(5):841–46. Retrieved February 25, 2013, from: http://www.aom.pace.edu/amj/editorials/Eden.2002.pdf.
32. Hubbard R, Vetter D, Little, EL. Replication in strategic management: scientific testing for validity, generalizability, and usefulness. Strategic Management Journal. 1998;19(3):243–54.
33. Hendrick C. Replications, strict replications, and conceptual replications: are they important? In: Neuliep JW, editor. Handbook of replication research in the behavioral and social sciences. Newbury Park, CA, USA: Sage; 1991. p. 41–50.
34. Monroe K. On replications in consumer research: part 1. J Consum Res. 1992;19:i–ii.
35. Easley RW, Madden CS, Dunn MG. Conducting marketing science: the role of replication in the research process. J Bus Res. 2000;48(1):83–92.
36. Rossmann M, Scheuch P. Arbeitsrecht [Labour law]. Vienna, Austria: WIFI Wien; 2008.
37. Ruppert F. Arbeitssicherheit und Gesundheitsschutz als Organisationsaufgabe [Workplace safety and health protection]. In: Hoyos C, Wenninger G, editors. Arbeitssicherheit und Gesundheitsschutz in Organisationen. Göttingen, Germany: Hogrefe; 1995. p. 41–62.
38. Zohar D. Thirty years of safety climate research: reflections and future directions. Accid Anal Prev. 2010;42(5):1517–22.
39. James L, McIntyre M, editors. Perceptions of organizational climate. San Francisco, CA, USA: Jossey-Bass; 1996.
40. Campbell JP, McCloy RA, Oppler SH, Sager CE. A theory of performance. In: Schmitt N, Borman WC, editors. Personnel selection in organizations. San Francisco, CA; USA: Jossey-Bass; 1993. p. 35–69.
41. Barling J, Loughlin C, Kelloway EK. Development and test of a model linking

safety-specific transformational leadership and occupational safety. J Appl Psychol. 2002;87(3):488–96.

42. Ahasan MR, Mohiuddin G, Väyrynen S, Ironkannas H, Quddus R. Work-related problems in metal handling tasks in Bangladesh: obstacles to the development of safety and health measures. Ergonomics. 1999;42(2):385–96.
43. Arbuckle JL, Wothke W. Amos 5.0 user's guide. Chicago, IL, USA: SmallWaters; 2003.
44. Hoyle RH, Panter AT. Writing about structural equation models. In: Hoyle RH, editor. Structural equation modeling. Concepts, issues, and applications. London, UK: Sage; 1995. p. 158–76.
45. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Modeling. 1999; 6(1):1–55.
46. Ryff CD, Keyes CLM. The structure of psychological well-being revisited. J Pers Soc Psychol. 1995;69(4):719–27.
47. Clarke S, Flitcorft C. An investigation into the generic facor strucutre of safety climate [unpublished presentation]. 21st Annual Conference of the Society for Industrial and Organizational Psychology. 2006.
48. Barling J, Frone MR, editors. The psychology of workplace safety. Washington, DC, USA: American Psychological Association; 2003.
49. Smith GS, Huang YH, Ho M, Chen PY. The relationship between safety climate and injury rates across industries: the need to adjust for injury hazards. Acc Anal Prev. 2006;38(3):556–62.