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Causal relations between psychosocial conditions, safety climate and safety behaviour - a multi-level investigation

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Causal relations between psychosocial conditions, safety climate and safety behaviour - a multi-level investigation

Rather little is known about the role of occupational safety climate in a broader organisational context, its antecedents and the mechanisms for how it may impact safety outcomes. This study used a prospective longitudinal multi-level study design to examine the cause and effect relationships between psychosocial conditions, safety climate, and safety behaviour. Data were collected by means of questionnaires from 289 employees in 43 units at four occasions during a period of 21 months of the construction of a road tunnel. Data were analysed using two approaches for modelling change; an autoregressive latent variable model and a multi-level growth curve model. Results showed that individual perceptions of safety climate exerted a causal effect on individual safety behaviour, but we also found some evidence of a reversed relationship, where safety behaviour influenced safety climate. Furthermore, we found that work unit average perceptions of safety climate predicted the growth of the individual safety behaviour but this influence was mediated by the individual's perception of the safety climate. The results also indicate that supportive psychosocial conditions within an organisation influence individual safety perceptions but do not per se have an impact on safety behaviour.

Keywords: organisational climate; construction industry; safety performance; longitudinal design; multilevel analysis

1. Introduction

Awareness of the importance of organisational factors in occupational safety has encouraged a large amount of research into safety climate and safety culture in recent decades (Clarke, 2000; Clarke, 2006a; Glendon, 2008; Guldenmund, 2000). Recent meta-analyses suggest a positive relation between safety climate and safety outcomes (Beus, Payne, Bergman, & Arthur, 2010; Christian, Bradley, Wallace, & Burke, 2009; Kuenzi & Schminke, 2009). However, these conclusions rely largely on cross-sectional studies since longitudinal studies of these relations are few and, when present, often comprise only two measurement points. Causal relations between safety climate and safety outcomes are therefore not clear. For example Beus and co-workers (Beus, et al., 2010) found that injury rate was a stronger predictor of safety climate than the reverse. To better understand the causal relationships between safety climate and safety outcomes, longitudinal studies based on multiple measurement points are needed. The first aim of this study was therefore to investigate the causal relationships between safety climate and safety behaviour by means of a four wave longitudinal design. We also applied a multi-level approach to further investigate the causal relations at both the group and the individual level.

There is also a need to better understand the role of safety climate in a broader organisational context (Kuenzi & Schminke, 2009; Zohar, 2010) . Safety climate is often described as the organisational members' perceptions of the value placed on safety by management (Griffin & Neal, 2000). Zohar and co-workers suggest that, based on shared perceptions of management safety commitment, the employees infer the relative value of safety performance in the organisation. This informs employees' behaviour-outcome expectancies, and safety behaviour is contingent on beliefs that such behaviour is expected and will be rewarded (Zohar, 2008; Zohar & Erev, 2007). However, such a contingent reward perspective on safety behaviour does little to explain the aetiology and role of safety climate in a broader organisational context. In any production work the (at least short term) conflict between production and safety is continually present. The contingent reward perspective on safety climate requires that managers, to retain credibility in their demand for safety, should always prioritise safety in the large variety of work situations in order to clarify to the employees what type of behaviour is expected and will be rewarded. This is an over simplification of managers' work. The challenge for managers is rather to balance these priorities and still be able to encourage members' responsibility for safety in the organisation. To better understand psychological and social processes in relation to safety at work it is therefore important to investigate how safety climate relates to more generic psychosocial conditions in the organisation, which was the second aim of the present study. This calls for a relational rather than an instrumental perspective on safety climate. Theory of social exchange (Blau, 1986) suggests that if one party in a social interaction acts in a manner that benefits the other party, a mutual expectation will arise that this behaviour will be reciprocated at some later stage. In an organisational context this implies that management behaviour that in a variety of ways offers support to the employees in performing the job, for example by creating supportive psychosocial work conditions, would give rise to an obligation, as well as a wish, among the employees to reciprocate by contributing to the organisational goals. Eisenberger and co-workers (Eisenberger, Huntington, Hutchison, & Sowa, 1986) suggested that employees who develop global perceptions of organisational support (POS), i.e., that the organisation values their contributions and cares about their wellbeing, will develop an affective attachment toward the organisation which will contribute to positive interpretations of organisational actions and characteristics and a commitment to organisational values and norms. They gained empirical support for this theory and also found that the positive effects of perceived organisational support on work outcomes were reliant on a social exchange ideology (Eisenberger, et al., 1986). Supportive psychosocial conditions have been operationalized through conditions such as clear work roles, ample information for job performance and predictability in the working situation, opportunity for employee influence and for development at work, feedback on work performance, good leadership and social support, and a sense of community (Kristensen, Borg, & Hannerz, 2002; Nahrgang, Morgeson, & Hofmann, 2011). Such conditions, contributing to the individuals' resources to perform the job, may be viewed as a manifestation of leaders' benevolence, caring, and support toward their constituency, mirroring leader's concern for members' welfare. Employees who experience that their leaders are concerned about workers' welfare would be likely to infer that leaders are also concerned about workers' safety. Supportive psychosocial conditions would thus contribute both to employees' perceptions of organisational support and to a high safety climate. Through social exchange mechanisms this would then encourage employee safety behaviour. The psychosocial environment is broadly recognized to affect health (Bond et al., 2007) and positive relationships between aspects of general work climate and safety climate have received empirical support (Neal, Griffin, & Hart, 2000). Supportive psychosocial conditions relating to the aspects mentioned above have also shown to be related to safety behaviour (Nahrgang, Morgeson, & Hofmann, 2007; Parker, Axtell, & Turner, 2001). Still, due to the small number of longitudinal studies, the causal relations between psychosocial conditions and safety climate and safety outcomes are not clear.

Regarding the relation between psychosocial conditions and safety climate the following hypothesis was formulated:

Hypothesis 1:

Supportive psychosocial conditions will have a positive causal effect on safety climate. This relation may be observed as psychosocial conditions having a lagged effect on safety climate in a longitudinal autoregressive model.

Also the way that safety climate may impact on safety behaviour deserves more in depth study. The safety climate is considered a phenomenon at the group level, while behaviour is an individual level phenomenon. The mechanism for how these phenomena at different levels interrelate has not yet been studied. We propose that the shared component of the safety climate affects the individual perceptions of the safety climate, which in turn affect the individual behaviour. We may then expect that both the unit level safety climate, and the individual perceptions of the safety climate, will all have an impact on safety behaviour. We therefore formulated a second set of hypotheses:

Hypothesis 2a:

Safety climate will have a positive causal effect on safety behaviour, which may be observed as a lagged effect in a longitudinal autoregressive model.

The effect of safety climate on safety behaviour operates cross level, shown as a unit level as well as an individual level effect, thus:

Hypothesis 2b:

The average perception of the safety climate in the work unit predicts the growth of individual safety behaviour; and

Hypothesis 2c:

The individual perception of the safety climate in the work unit predicts the growth of individual safety behaviour.

According to Social Exchange Theory (Blau, 1986) supportive, non-exploitative management behaviour would also contribute to legitimizing leadership authority. Managers who provide good, supportive psychosocial working conditions may therefore gain more authority in their demand for safety, than managers who fail to provide supportive psychosocial conditions. This indicates that safety climate would have an intermediary function in the relationship between a supportive psychosocial conditions and safety performance. Wallace et al. (Wallace, Popp, & Mondore, 2006) empirically found safety climate to mediate a positive relation between foundation organisational climate and lower accident rates. These relations, and how they operate, need to be better understood. We therefore formulated a third set of hypotheses:

Hypothesis 3a:

Supportive psychosocial conditions have a positive causal effect on safety behaviour, and this effect is fully mediated through safety climate. This causal sequence may be observed in a longitudinal autoregressive model as the psychosocial conditions having a lagged effect on safety climate, which in turn will have a lagged effect on safety behaviour.

The influence of psychosocial conditions on safety behaviour operates cross level, shown as a unit level as well as an individual level effect, thus:

Hypothesis 3b:

The average perception of the psychosocial conditions in the unit predicts the growth of individual safety behaviour; and

Hypothesis 3c:

The individual perception of the psychosocial conditions in the unit predicts the growth of individual safety behaviour.

2. Methods

2.1. Study overview

This article presents the results of a prospective study of occupational safety in the Swedish construction industry, carried out during the construction of a 1.5 km road tunnel under central parts of a major Swedish city. The study had a non-experimental design, using self-reported questionnaire data from four measurement waves, T_1–T_4, performed with an interval of seven months from October 2002 to October 2004. The interval was chosen to counteract recall bias but still allow registration of fluctuations in the measures. To reduce systematic influence due to seasonal characteristics of the work, we preferred a seven-month to a six-month interval. The questionnaire was comprehensive, so feasibility, i.e., the number of measurement waves expected to be acceptable to the respondents with a maintained high response rate, was also taken into account. The parts of the questionnaire reported on here covered psychosocial conditions, safety climate, and safety behaviour. Members of the research team were present during data collection, which took place close to the construction site, during working hours. The respondents were informed of the purpose and procedures of the study, that participation was voluntary, and that strict confidentiality was guaranteed regarding individual responses outside the research team.

2.2. Participants

Five main construction contractors were engaged in this large construction project. Four of these were involved throughout the entire construction work, and were included in the present study. All personnel, i.e., employed or contracted blue- and white-collar workers, engaged by these contractors to work on the construction project were surveyed. The response rates T1 - T4 were 85-95%. At T1-T3 72% of the respondents were blue-collar workers, and at T4 75%. Mean age T1-T4 was 42.1 – 43.9 years; mean time in the present occupation at the corresponding times was 18.00-20.5 years. The sample mainly consisted of male respondents (T1-T4: 95-97%). At least 40% of the respondents at each time had senior high school education and 15–17% had university-level education. Responses from each participant were matched over time. To be included in the study, respondents must participate in at least two of the four waves of measurement. This resulted in data from 289 individuals, 162 of whom participated in at least three of the four measurement waves and 82 in all four waves. The participants were organized in 44 work units which were the bases for aggregation of climate measures to the second level. During the construction work the work organisation was sometimes modified, implying that all units were not present at all waves of measurement. Thirty-two units had data in at least three of the measurement waves, and 17 units had data in all four waves. The sample thus suffered from missing data at both the individual and the unit level, but the missing data were not due to a low response rate. They rather mirrored the evolving character of construction work. Due to progress in ability to deal with missing data using the full information maximum likelihood method (FIML), the use of all available data has been recommended in the structural equation modelling (Kline, 2005; Raykov, 2005). Multi-level regression models of longitudinal data do not assume an equal number of observations at each measurement occasion, so the mobility of the respondents is handled within the analysis in the maximum likelihood estimation (Hox, 2010). Thus, maximum likelihood estimation procedures were used for treating both internal missing data and data missing due to the inclusion criterion of the study.

2.3. Measures

2.3.1 Safety climate

In accordance with climate theory (James & Jones, 1974; Schneider, 1975; Schneider & Reichers, 1983), safety climate was treated as a perceptual measure, and in accordance with Neal and Griffin (Neal & Griffin, 2006), was defined as shared perceptions of policies, procedures, and practices related to workplace safety. Through a literature review, Seo et al. (Seo, Torabi, Blair, & Ellis, 2004) identified common themes in the operationalization of safety climate in previous research and categorized these as management commitment to safety, supervisor safety support, co-worker safety support, employee participation in safety-related decision making, and activities and competence level of employees with regard to safety. In another literature review Flin et al. (Flin, Mearns, O'Connor, & Bryden, 2000) found similar themes, and Cheyne et al. (Cheyne, Cox, Oliver, & Tomas, 1998) proposed a structure of safety climate based on similar core elements. In the present study, the safety climate measure was treated as a global measure and operationalized based on four of the five scales reported by Cheyne et al. (1998). The scales were somewhat further developed by the present authors, who have also presented empirical evidence on the justification for creating a global safety climate measure based on these scales (Pousette, Larsson, & Törner, 2008). The global safety climate latent variable applied here covered the aspects *management safety priority* (4 items, alpha T1 = .89, sample item: "Taking risks at work is tolerated in this company when the time pressure is high", reverse scored), *management safety commitment* (16 items, alpha T1 = .94, sample item: "Management takes the lead on safety issues"), *safety communication* (7 items, alpha T1 = .86, sample item: "There is free and open talk about safety issues at my work"), and *workgroup safety involvement* (8 items, alpha T1 = .77, sample item: "People at my site want to achieve the highest levels of safety performance"). Items from these dimensions were taken as indicators of the latent safety climate variable through a parcelling procedure recommended by Kishton and Widaman (1994) (a detailed description of the applied procedure can be obtained from the corresponding author). To capture the social characteristics of safety climate, a referent-shift approach was used, i.e., shifting the object of reference in the assessments from the individual to the collective, (Glisson & James, 2002) through instructions to the respondents and through the wording of the items.

2.3.2. Psychosocial conditions

In the present study the psychosocial conditions were specified through a parcelling procedure based on items representing eight dimensions from the Copenhagen Psychosocial Questionnaire (Kristensen, et al., 2002), capturing conditions providing resources to individuals in performing their job. These dimensions covered *role clarity* (4 items, alpha T1 = .73, sample item: "Does your work have clear objectives?"), *predictability/information* (3 items, alpha T1 = .73, sample item: "Do you receive all the information you need in order to do your work well?"), *influence at work* (5 items, alpha T1 = .71, sample item: "Do you have an influence on what you do at work?"), *possibilities for development* (3 items, alpha T1 = .70, sample item: "Does your work give you the opportunity to develop your skills?"), *sense of community* (3 items, alpha T1 = .73, sample item: "Is there a good co-operation between your colleagues at work?"), *social support* (4 items, alpha T1 = .76, sample item: "Do you get help and support from your colleagues?"), *feedback* (3 items, alpha T1 = .77, sample item: "Does your supervisor talk to you about how well you carry out your work?"), and *quality of leadership* (4 items, alpha T1 = .89, sample item: "Does your supervisor highly value a good atmosphere at work?"). In respect to the psychosocial conditions no referent-shift approach was applied.

2.3.3. Safety behaviour

The safety behaviour latent variable was specified with a parcelling procedure using items from a scale developed by the present authors (Larsson, Pousette, & Törner, 2008; Pousette, et al., 2008). This scale covered self-reports of various aspects of safety behaviour, namely, using available personal protection equipment, choosing safe working methods and procedures, taking no shortcuts with safety, prioritizing safety, and compliance with rules and procedures (6 items, alpha T1 = .88, sample items: "How often do you use all prescribed safety equipment, no matter what the work situation is?" and "How often do you work in the safest manner?"). Three parcelled safety behaviour indicators comprised two items each.

2.4. Statistical procedure

The longitudinal observations were modelled using two different statistical representations of the data. Although both approaches model change in the longitudinal data they do so in different ways and under different assumptions. The first approach was a recursive latent variable panel model (Kline, 2005; Martens & Haase, 2006) using structural equation modelling for estimation. This hypothetical model, shown in Figure 1 (in simplified form), shows the proposed relations among the three latent variables, i.e., psychosocial conditions (PC), safety climate (SC), and safety behaviour (SB), at four successive points in time. The model proposes that psychosocial conditions, treated as an independent variable, predicts future safety climate, and that safety climate predicts future safety behaviour and mediates the impact of psychosocial conditions on safety behaviour. The model was estimated based on the individual reports of the safety climate perceptions and safety behaviour. This approach was applied to address hypotheses 1, 2a, and 3a.

The second representation of the data was a linear growth model approach, where individual change in safety behaviour was represented as linear trends over time. The variation in slope between individuals (growth rate) was then predicted by the climate measures. The linear growth models were estimated accounting for the multilevel nature of the data with individuals nested within units. This approach was applied to address hypotheses 2b, 2c, 3b, and 3c.

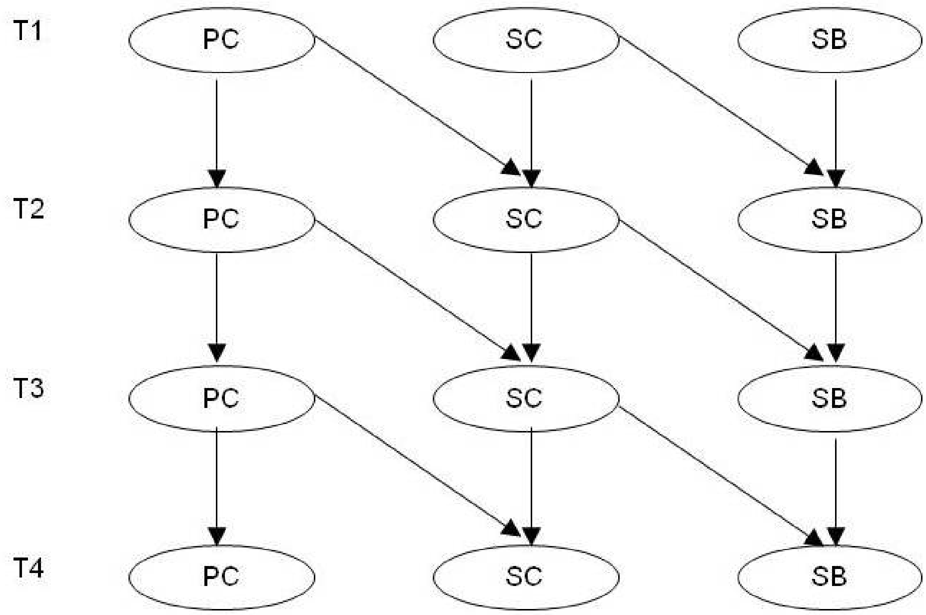

Figure 1.

The hypothetical model, specifying causal relationships between psychosocial conditions (PC), safety climate (SC), and safety behaviour (SB). The model proposes that safety climate fully mediates the lagged effect of psychosocial conditions on safety behaviour. The longitudinal prospective design included four measurement waves, T_1–T_4.

Note: Latent variable manifest indicators and their error terms, as well as the cross-time correlations between the error terms, together with the disturbances of the downstream latent variables, are omitted for the sake of clarity.

2.5. Statistical analysis

To test the hypothesized causal and mediated relationships, we specified an auto-regressive (Maxwell & Cole, 2007) path model with a latent variable approach within the structural equation modelling (SEM) framework. The correlated uniqueness model (Cole & Maxwell, 2003; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) was used to specify indicator measurement error correlations.

We employed the five-step procedure (Cole & Maxwell, 2003) to test mediated processes in longitudinal designs. This procedure included testing the measurement models, testing of equivalence of various parameters across waves, testing for added components, testing for omitted paths (including paths for reversed causality), and estimating mediating and direct effects. The structural equation models were calculated using maximum likelihood estimation as implemented in AMOS 7.0. The overall fit to the observed data of the various measurement and structural models was assessed using the model χ^2, the Steiger–Lind root mean square error of approximation (RMSEA) with its 90% confidence interval, and the Bentler comparative fit index (CFI) (Kline, 2005). Based on Kline (2005) values of the normed χ^2 statistics between 2.0, and 5.0, a CFI value greater than or equal to .90, and values of RMSEA below .08 were regarded to indicate reasonable model fit. When testing for factorial invariance, examining the hypothesis of equilibrium, and testing for added components and omitted paths, the relative fit of two or more models were decided by the χ^2 –difference statistics (Kline, 2005).

The growth curve models were estimated using multi-level modelling (MLM). The multi-level analysis was implemented with the MLwiN version 2.22 software using the iterative generalized least squares (IGLS) for the estimation process. The models had three levels representing occasions (time) at level 1, individuals at level 2 and units at level 3. We started by estimating the unconditional model, which decomposed the variation in within individual, between individual and between unit variances. This model was applied to both the psychosocial condition measure, the safety climate measure and to the safety behaviour, in order to assess the intra-class correlation. With safety behaviour as dependent variable, predictor variables were then entered sequentially. First, occasion (time, coded as 0, 1, 2, and 3) was entered as a fixed as well as a random variable at level 2. This represents a linear growth for each individual in safety behaviour, with the growth rate varying between individuals. Secondly, we entered the unit safety climate averaged over time as a predictor, and also the interaction between time and unit average climate. Thirdly, we entered the individual deviation in climate perception from the group centre averaged over time, together with the interaction term between time and individual deviation.

The models were set up separately with psychosocial conditions and safety climate, respectively, as predictors. All variables were standardized prior to the analysis. The significance levels of the parameter estimates in both the structural equation models and the multilevel models were assessed using the critical ratio (CR) or Wald test, i.e., the ratio between the parameter value and the standard error of the parameter, with a ratio greater than 1.96 indicating significance ($p < .05$) (Hox, 2010; Kline, 2005).

3. Results

3.1. The structural equation model approach

Step1. In the first step we examined, for each of the three key concepts separately, whether the basic measurement model was appropriate at all study occasions. This was indeed the case (details available from the first author). The three measurement models were then merged into one overall measurement model, which also fit the data well (χ^2 (492) = 646.9 ($p < .000$), normed $\chi^2 = 1.32$; CFI = .98; RMSEA = .033 (90% confidence interval .026–.040)). Correlations between latent variables within constructs (between waves) ranged .61–.84, and between constructs (within waves) .34–.73. Correlations between latent variables, between constructs and between waves, were in the .24–.64 range.

Step 2, *test of equivalence,* comprises the test for *factorial invariance* and *examination of the hypothesis of equilibrium.* The results showed that cross-time factorial invariance was supported since the indicator factor loadings were stable over time in all three latent variables. Therefore, the factor loadings in subsequent analyses were constrained to be equal over time. The examination of the hypothesis of equilibrium showed that the associations both between and within the latent variables were constant over time (covariances constrained: $\Delta\chi^2 = 6.3$ (cut-off = 16.9 with df = 9 and $p = .05$); variances constrained: $\Delta\chi^2 = 16.7$ (cut-off = 16.9 with df = 9 and $p = .05$)). This indicated that the system was in equilibrium, which justified further causal analysis.

The result of step 3, the *test for added components,* indicated that the hypothetical model was too parsimonious, i.e., important variables or parts were missing ($\Delta\chi^2 = 142.6$ (cut-off = 18.3 with $df = 10$ and $p = .05$)). Free covariances between the latent variable disturbances were therefore included in subsequent analyses to control for the influence of unmeasured variables. Correlations at T2; T3; T4 between PC and SC disturbances were: .49; .55; .44 (all $p<.001$), between PC and SB disturbances: .30; .33; -.10 ($p<.01$; $p<.01$; n.s.), and between SC and SB disturbances: .26; .48; .25 ($p<.01$; $p<.001$; $p<.05$).

The result of *step 4*, the *test for omitted paths,* to determine whether additional causal relationships should be included in the hypothetical structural model, showed a significant χ^2

difference test-value ($\Delta\chi^2$ = 102.5 (cut-off = 54.6 with *df* = 39 and *p* = .05)). This suggested that important paths were missing from the hypothetical model. To determine which paths were missing, follow-up tests were performed that indicated the presence of significant wave-skipping paths (PC_{T1} - PC_{T3}; PC_{T2} - PC_{T4}; SC_{T1} - SC_{T3}; SC_{T2} - SC_{T4}; SB_{T1} - SB_{T3}; SB_{T2} - SB_{T4}), as well as the presence of a significant reversed causal path between safety behaviour at T2 and safety climate at T3. Due to these results, the hypothesized model was extended by including the significant wave-skipping paths and the reversed causal path between SB_{T2} and SC_{T3}.

Step 5, the *estimation of the overall, mediating, and direct effects,* was based on the final model in Figure 2, where the overall total effect was equal to the estimated overall mediated effect (effect of psychosocial conditions on safety behaviour mediated by safety climate). Since there is no available method for testing mediation in four measurement waves, mediation was tested in each link of the causal chain (Taylor, MacKinnon, & Tein, 2007). The overall mediated effect between T1 and T4 consisted of three pathways, which were all significant. The sum of three products of the standardized regression weights in the three pathways was .047, constituting the overall mediated effect in the final model.

The final model. The final results are presented in the model in Figure 2 (unstandardized parameter estimates for this model can be obtained from the authors). Because of the results described above of the tests for factorial invariance, added components, and omitted paths, the hypothesized model (Figure 1) was extended by including significant wave-skipping paths, one reversed causal path between SB_{T2} and SC_{T3}, and covariances between the latent variable disturbances.

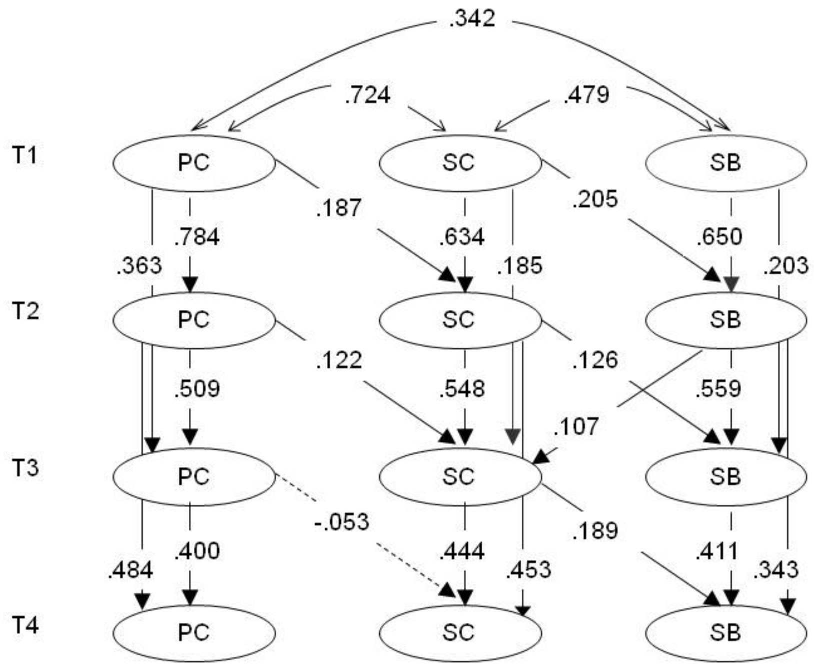

Figure 2.

The final model. Standardized regression weights for the longitudinal structural paths between the latent variables and the latent variable auto-regressive paths are included, as well as correlations between the exogenous variables.

Note: Latent variable manifest indicators and their error terms, as well as the cross-time correlations between the error terms, together with the disturbances of the downstream latent variables and the cross-sectional correlations between them, are omitted for the sake of clarity. Continuous arrows represent significant ($p < .05$) relationships and the dotted arrow represents a non-significant relationship.

The fit indices of the final model were: χ^2 (524) = 676.8 (p < .001), normed χ^2 = 1.29; CFI = .98, RMSEA = .032 (90% confidence interval .024–.039), which indicated good fit to the observed data. The first and the second of the three lagged paths between psychosocial conditions and safety climate had significant positive regression weights, whereas the third lagged path was close to zero (p = .44). This offers some support for hypothesis 1a that supportive psychosocial conditions have a positive causal effect on safety climate, but the support was not consistent since this influence decreased over time.

All three lagged paths between safety climate and safety behaviour were positive and significant, which offered full support for hypothesis 2a, that safety climate has a lagged effect on safety behaviour. In testing for the possibility of reversed causality relative to the hypothesized model (Cole & Maxwell, 2003), partial support was found for such an effect, indicating that an improvement in safety behaviour may, in turn, further improve safety climate.

3.2. The multilevel growth curve model approach

The proportion of the variance that was due to the unit level, the intra-class correlation, was 27% for the psychosocial conditions, 23% for the safety climate and 12% for the safety behaviour. Thus there was a considerable part of the variation in the psychosocial conditions and safety climate perceptions that could be attributed to the unit. The variation in safety behaviour that could be attributed to the unit was considerably lower but still significant.

Introducing time as a fixed explanatory variable, as well as a random variable, and with safety behaviour as the dependent variable, it was shown that safety behaviour on average was stable over time. The fixed effect of T was close to zero, -0.02 (0.02). However, there was significant variation in slope between individuals. Some individuals increased their safety behaviour and some individuals decreased it.

Table 1 shows the parameter estimates for the final model; with safety climate as predictor of growth rate in safety behaviour (parameter estimates for all models estimated can be obtained from the authors). The unit average safety climate significantly predicted the level of safety behaviour as well as the individual growth rate of safety behaviour. The individual deviation from the group centre in perception of the safety climate also predicted the level of the safety behaviour, as well as the growth rate. Thus, hypothesis 2b and 2c were supported since both the average perception in the unit of the safety climate, and the individual perception of this, predicted the growth rate of individual safety behaviour. The size of the regression parameters for the individual level effect and the unit level effect was about the same.

Table 2 shows the parameter estimates for the final model with psychosocial conditions as predictor of growth rate in safety behaviour. The unit average of the psychosocial conditions did not significantly predict either the level of safety behaviour or the individual growth rate of safety behaviour. The individual deviation from the group centre in perception of the psychosocial conditions predicted the level of the safety behaviour, but did not predict the growth rate. Thus, hypothesis 3b and 3c were rejected, since neither the average perception nor the individual perception of the psychosocial conditions predicted the growth rate of individual safety behaviour.

Table 1. Final multi-level growth curve model with safety climate as predictor of safety behaviour growth rate.

	b	SE
Fixed part		
Intercept	-0.080	0.062
Time (T)	-0.033	0.024
Safety climate (L3)	0.422*	0.100
T x Safety climate (L3)	0.097*	0.038
Safety climate (L2)	0.456*	0.076
T x Safety climate (L2)	0.095*	0.034
Random part		
Level three variation:		
Intercept	0.017	0.017
Level two variation:		
Intercept	0.530	0.075
Slope	0.030	0.013
Intercept – slope covariance	-0.059	0.027
Level one variation:		
Residual	0.258	0.022
Deviance	1809.6	

Note. b: parameter estimate; SE: Standard error for parameter estimate; L1: Level 1 (time); L2: Level 2 (individual); L3: Level 3 (work unit).
* $p < .05$.

Table 2. Final multi-level growth curve model with psychosocial conditions as predictor of safety behaviour growth rate.

	b	SE
Fixed part		
Intercept	0.016	0.075
Time (T)	-0.023	0.024
Psychosocial conditions (L3)	0.204	0.120
T x Psychosocial conditions (L3)	0.052	0.037
Psychosocial conditions (L2)	0.358*	0.080
T x Psychosocial conditions (L2)	0.017	0.035
Random part		
Level three variation:		
Intercept	0.067	0.036
Level two variation:		
Intercept	0.560	0.079
Slope	0.027	0.013
Intercept – slope covariance	-0.025	0.027
Level one variation:		
Residual	0.261	0.022
Deviance	1856.6	

Note. b: parameter estimate; SE: Standard error for parameter estimate; L1: Level 1 (time); L2: Level 2 (individual); L3: Level 3 (work unit).
* $p < .05$.

4. Discussion

The results of the present study showed that safety climate exerted a lagged effect on individual safety behaviour, but we also found some evidence of a reversed relationship, where safety behaviour influenced safety climate. This further reinforces previous research findings that a positive safety climate is an important prerequisite for good safety performance. In turn, high safety performance may further improve the safety climate, contributing to continuous safety improvement.

Hypothesis 1, that supportive psychosocial conditions will have a positive causal effect on safety climate, was partly supported since two of the three lagged paths in the longitudinal autoregressive model were significant. The regression weight magnitudes, however, decreased over time which could be due to the influence of time-specific events. Wave-skipping paths did suggest that the system had been disturbed at some point of time.

The residuals of the psychosocial conditions and safety climate, respectively, were highly correlated in the longitudinal autoregressive model. One interpretation of this is that the psychosocial conditions and the safety climate are parallel phenomena with common antecedents. During the construction work, specific events may have occurred that could explain instability in the causal system that affected both the psychosocial conditions and the safety climate. Indeed, diary notes taken by the research team regarding various occurrences during the construction work exposed several such events. Between T2 and T3 there was a conflict regarding salary systems between the trade union and the employer in the largest contracting company. This led one quarter of the workforce of this contractor to leave their jobs. Also, in two of the four main contractors, the work force grew considerably between T3 and T4. Such change exerts strain on an organisation and may have had an effect on both psychosocial conditions and safety climate. Between T3 and T4, an uncontrolled influx of water occurred in one of the work areas necessitating a sudden stop of the work due to workplace safety, among other things. This event may have had a direct effect on the safety climate perceptions. Thus, even though there was some support for a causal link between psychosocial conditions and safety climate, the impact of common antecedents affecting both these phenomena appears to be a more influential mechanism.

Hypothesis 2a, that safety climate will have a positive causal effect on safety behaviour, received robust and consistent support. All three of the lagged paths representing this relationship, at the three successive points in time in the longitudinal autoregressive model, were positive and significant. These results support previous research (Clarke, 2006a, 2006b; Neal & Griffin, 2006).

In addition to the hypothesized positive relationship, that a change of the safety climate (for better or worse) predicts corresponding change in safety behaviour, the results also indicated the possibility of reversed causality; so that when safety behaviour changes this will have a corresponding effect on the safety climate. Although Clarke (2006a) found no support for such reversed causality, Kuenzi and Schminke (Kuenzi & Schminke, 2009) suggested that a reciprocal relationship between safety climate and safety behaviour is quite feasible. Beus and co-workers (Beus, et al., 2010) actually found that occupational injuries were more predictive of safety climate than safety climate was of injuries. Indeed, organisational climate theory supports a reciprocal relation between climate and safety behaviour since a consistent and general change in safety behaviour would provide perceptual cues regarding safety-related practice and procedures. Such a change would initiate a reconstruction of the shared perceptions of safety policy, accompanied by further corresponding change of the safety climate.

Hypothesis 2b, that the work unit average perception of the safety climate predicts the growth of individual safety behaviour, received support. This cross level effect is in concordance with the dominating view that climate theoretically is a group phenomenon. However, Hypothesis 2c, that the individual perception of the safety climate in the work unit predicts the growth of individual safety behaviour, also received support. It has been argued that since climate is theoretically a group phenomenon, the only adequate level of analysis is the aggregated one. However, the multi-level approach applied in the present study showed that the individual level variation of climate was in fact important to consider since aggregation may hide presumptively important individual-level variation. These results are of theoretical importance since they contribute to a better understanding of the mechanism for how safety climate may play its role. The results indicate that the influence of safety climate on safety behaviour operates through the individual's processing of the perceived collective phenomenon, i.e. the effect of unit level safety climate is mediated through the individual's perception of the shared phenomenon. There was no evidence that the group level safety climate had any additional contribution to the growth of safety behaviour that could not be accounted for by the individual perception of the safety climate. Even though climate forms through social-level processes, the study thus indicated that individual perception of the climate constitutes the link to individual behaviour. This means that measuring safety climate solely at the collective level, which is often recommended in recent literature (e.g. Kuenzie and Schminke, 2009), will fail to take into consideration the influence on behaviour outcomes of individual processing of the individual perceptions of the social phenomenon. The present results indicate the importance of this cross-level path of influence. However, safety climate is a group phenomenon, and analysis solely at the individual level does not take into account that data are clustered. Analysis of safety climate *also* at the unit level is therefore motivated in order to avoid unwanted statistical effects leading to erroneous conclusions (see Study limitations).

Hypothesis 3a, that supportive psychosocial conditions have a positive causal effect on safety behaviour, and that this effect is mediated through safety climate, was partially supported based on the longitudinal autoregressive model. However, more than one indirect pathway, each including more than two paths, makes assessing the significance of the mediated effect a complex matter. We found significant paths connecting psychosocial conditions to safety behaviour mediated through safety climate but, as discussed above, the first link between psychosocial conditions and safety climate was not consistent over time. In addition, there was no evidence that the quality of the psychosocial conditions had any influence on the growth (represented as linear change) of safety behaviour over time, since no support was found either for the *individual* (Hyp 3c) or the work unit *average* (Hyp 3b) perception of the psychosocial conditions to predict the growth of individual safety behaviour. This is somewhat contrary to the results of the longitudinal autoregressive model where some support was found for the concept that psychosocial conditions have an effect on safety behaviour through the mediation of safety climate. Here it is important to note, firstly, that the models of change are different in the two types of analyses. In the autoregressive model (ARM), change is modelled as an effect of the predictor seven months before, thus taking into account that the nature of change (increase or decrease) may fluctuate during the study period due to various occurrences during the construction work. In the growth curve model (GCM), change is modelled as a linear trend during the entire study period determined by the average of the predictors during this period. This does not take into account the possibility of predictor fluctuations. Secondly, in the autoregressive model the relationship between psychosocial conditions and safety behaviour is mediated by safety climate. In the growth curve model, no such intermediate mechanism is assumed. It may be that the influence of psychosocial conditions on safety behaviour depends on the emphasis of safety in the workplace. This suggests that safety climate has a moderating rather than a mediating effect in this relation. This interpretation indicates that a mere contingent reward perspective on safety climate and safety behaviour is too meagre and that integrating a social exchange theoretical perspective (Blau, 1986) may help to develop the safety climate concept. It suggests that organisations providing supportive psychosocial working conditions would give rise to perceptions of organisational support and thus contribute to an obligation, as well as a wish, among the employees to reciprocate by contributing to the organisational goals. If then safety is perceived as a prime organisational goal, and supportive, non-exploitative psychosocial conditions contribute to legitimizing leadership authority (Blau, 1986), employees would be motivated to achieve high safety performance. This indicates that relational aspects of safety climate need to be more acknowledged and that the mechanisms of the influence of psychosocial conditions on safety behaviour deserve further research.

4.1. Study limitations

The sample size in the present study is relatively small in relation to the analyses performed in terms of complex models and the multi-level analyses treating each group as a single observation. The fact that we, in spite of this shortcoming, largely received significant results supports the validity of the results and conclusions.

As Martens and Haase (Martens & Haase, 2006) concluded, statistical methodology "provides a necessary, but not sufficient condition for interpreting causal relationship among constructs" (p. 905). Through the analysis procedure in the autoregressive model we were able to minimize the influence of unmeasured variables that remained stable over time (background variables) (Zapf, Dormann, & Frese, 1996). However, we cannot rule out that the causal system may be under the influence of one or more unmeasured variables asynchronously influencing the measured variables. This is something that deserves further study. Firm conclusions would however require an experimental study design controlling for all relevant factors, i.e., randomized control trials. This is seldom, if ever, possible in organisational research and the approach applied here does offer substantial support for the proposed causal mechanisms.

In the autoregressive model, the analysis was performed solely at the individual level. Since the observations were clustered in higher level units, this may have resulted in underestimated standard errors and thus inflated significance levels. However, the results from the growth curve model where the multi-level structure of the data were accounted for corroborated the influence of safety climate on safety behaviour.

Our use of the joint significance test approach to establish evidence of significant mediation effects has the serious flaw of not addressing the overall mediation effect in a complex, longitudinal model, but to the best of our knowledge, no test that does is available.

Although no firm conclusions regarding causality may be drawn from the present study, its longitudinal design, the dual analysis strategy applied, and systematic testing of alternative models rule out the most obvious threats to conclusions concerning causality and mediation.

5. Conclusions

The mechanism for the influence of the safety climate seems to proceed via the individual's perception of the shared climate. This finding has two practical implications. Firstly, if the individual worker notices few cues concerning the nature of the climate the influence of the climate on behaviour will be low. This implies that in efforts to improve safety it is important to provide a multitude of climate cues in terms of safety practice and procedures. This is not least important in the socialisation process of new members of the organisation. Secondly, we can expect that a weak climate, i.e. where the climate perceptions are less shared by the group members, will have less influence on safety behaviour than a strong climate. Schneider and Subirats (Schneider & Subirats, 2002) found that the climate strength had a moderating effect on climate related outcome. Therefore, in groups where the safety climate is perceived as high its impact on safety may be reinforced by a high degree of social interaction and increased group cohesion.

Part of the variation in ratings of psychosocial conditions and safety climate, and in behaviour at a certain time, were accounted for by the ratings two measurements previous. This may indicate a stabilizing mechanism regarding organisational climate and behaviour. Even if a change in safety climate influences safety behaviour, memory and habits of previous behaviour and climate may influence people to reassume previous behaviour, for better or worse. This indicates the importance of persistence in efforts to improve safety climate in order to attain a stable improvement in safety behaviour. This stabilizing mechanism may, however, also provide system robustness and resilience. Despite momentary conflicts and loss in trust that may negatively influence members' evaluation of psychosocial conditions as well as safety climate and, in turn, safety behaviour, the system may revert to an earlier state based on previously prevailing, more positive perceptions of policy and practice.

The results also indicate the importance of considering safety outcomes not solely from a contingent reward perspective but also from a more social relational perspective on the role and character of safety climate and its relation to safety performance.

5.1. Implications for future research

The results of the present study indicate that job resources in terms of supportive psychosocial conditions influences safety climate perceptions, which supports a social exchange perspective on the development of a good safety climate. We therefore suggest that future research should particularly focus on possible moderators of the influence of psychosocial conditions on safety. The results indicated the possibility that the psychosocial conditions and the safety climate are parallel phenomena with common antecedents. It is possible that supportive psychosocial conditions are indicators of underlying social mechanisms regarding the quality of relations between leaders and members, as well as between members of an organisation. In-depth study of such phenomena, not least through a qualitative approach, is therefore desirable.

Further study of the possible reversed causal relationships between safety behaviour and safety climate would also be of interest. This is particularly so in light of the results indicating a stabilizing mechanism regarding organisational climate and behaviour over time. Changes for better or worse in climate and behaviour may tend to return to previous levels and further research offering better knowledge on organisational attributes that may help to sustain positive development would be both theoretically interesting and practically useful.

To better understand the processes through which safety climate and other organisational phenomena influence individuals' safety performance, future research of such phenomena, including safety climate, should not solely focus at the social (unit) level, but also include analyses at the individual level.

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