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Multilevel Models in the Explanation of the Relationship between Safety Climate and Safe Behavior

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Abstract. This study examines the relationships between components of organizational safety climate, including employee attitudes to organizational safety issues; perceptions of the physical working environment, and evaluations of worker engagement with safety issues; and relates these to self-reported levels of safety behavior. It attempts to explore the relationships between these variables in 1189 workers across 78 work groups in a large transportation organization. Evaluations of safety climate, the working environment and worker engagement, as well as safe behaviors, were collected using a self report questionnaire. The multilevel analysis showed that both levels of evaluation (the work group and the individual), and some cross-level interactions, were significant in explaining safe behaviors. Analyses revealed that a number of variables, at both levels, were associated with worker engagement and safe behaviors. The results suggest that, while individual evaluations of safety issues are important, there is also a role for the fostering of collective safety climates in encouraging safe behaviors and therefore reducing accidents.

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The characterization and analysis of safety climate is a non-trivial task that touches on many contemporary issues within safety management. It specifically focuses on the identification of key variables, and the quantification of the impact of those key variables on safety outcomes. Safety climate may be viewed as one subsystem of occupational climate and refers to shared perceptions among members of groups or organizations with regard to safety policies, procedures and practices (Zohar, 2000). Safety climate can be, and has been, considered as a social environmental factor that has the potential to directly influence safe behaviors through the development of subjective, social norms. A large body of research has demonstrated that evaluations of safety climate are positively correlated with self-reported safety behaviors and that these variables are related to accidents (for example Neal, Griffin, & Hart, 2000), giving rise to the proposition that a deficient safety climate results in poor behaviors, and, therefore, an increase in accidents.

More recent theoretical contributions to safety climate research have stressed the multilevel nature of the concept (Zohar, 2000; 2003). Given the potential shared nature of safety climate at the organization and work group level, there is a need to analyze the effects on safety outcomes at different levels to further appreciate its effects. Neal and Griffin (2006) suggest that individual perceptions of policies and practices relating to safety in the workplace can be termed "perceived safety climate", while shared perceptions within the work group can be referred to as "group safety climate" (p. 946). Measures of group safety climate have been derived by aggregating individual perceptions to the group level, provided these perceptions reflect evaluations of relevant unit level procedures, and practices (Kozlowski & Klein, 2000). Any research on safety climate should, therefore, consider levels of analysis, specially the work-team level of analysis, but only if empirical conditions, or validation criteria, for such levels are met, specifically within-group homogeneity and between-group variability as measured by indices of agreement (such as intraclass correlation coefficients, ICC). Significant and relatively large ICC's have been found in the safety climate literature (see for example, Wallace, Popp, & Mondore, 2006; Zohar & Luria, 2005). Therefore, in order to correctly analyze safety outcomes when climate is a potential explicative factor, several levels of analysis should be considered.

In this vein, Zohar (2003) has argued that climate at the organizational or work team level can be described in terms of two parameters: level and strength. On one hand, safety climate level (low to high) is usually measured at the group level by the mean. On the other hand, the strength of climate (weak to strong)

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is typically operationalized as the group standard deviation, with lower standard deviations reflecting stronger climate perceptions. Zohar (2003) argues that these two climate parameters are important and may have different effects on safety outcomes. In particular, Zohar (2003) advanced a hypothesis about the specific role of climate strength as a moderator: units with a strong climate will have stronger relationships between safety variables and outcomes than units with a weak climate. This would be due to stronger climates reflecting a more powerful social norm within the group.

A multilevel model of safety climate that specifies links between safety climate and safety outcomes can address both level and strength: safety climate perceptions are related to accidents through their influence on individual expectancies, responsibility, involvement, motivation and behaviors, and safe behaviors in turn affect company safety records such as injury rates, or health problems (Cheyne, Oliver, & Tomás, 2005; Neal, et al., 2000; Neal & Griffin, 2003; Zohar, 2003). While many authors recognise the multilevel nature of safety climate research, the key levels of analysis are still the source of some debate. However, Zohar and Luria (2005) have suggested that differences between work groups in the same organization might be attributable to supervisory discretion within those groups. Therefore, the differing social atmosphere that can exist within separate work groups, would suggest that the work group is an important level of analysis to consider, particularly given the potential power of social norms to influence behavior (Terry & Hogg, 2001).

The aim of this paper is to present evidence of the influence of safety climate and perceptions of the work environment on a series of safety outcomes (in particular workers' involvement in safety and safe behaviors). It is possible to frame a number of sequential hypotheses based on previous work in this area. The first hypothesis relates to the relationship between climate for safety and behaviors, consistently found in previous research (for example Neal et al., 2000, Oliver, Cheyne, Tomás, & Cox, 2002; Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás 2007):

> *H1a:* Safety climate dimensions will be predictors of safety outcomes and specifically safe behavior, even after statistically controlling for the working environment.

The shared nature of climate within groups (Zohar, 2003, Neal & Griffin, 2006) would also suggest that climate dimensions may be more influential at the group level, as suggested by Cheyne, Oliver, and Tomás (2008), giving rise to an ancillary hypothesis:

> *H1b:* Safety climate dimensions, as a shared concept, will have larger contributions to the explanation of group level outcomes than at individual level outcomes.

Evidence of the relationship between climate and behaviors is considered here at two levels of analysis, the individual and work group. If work group social norms have an influence on individual behaviors, as proposed by Zohar (2003), then a second hypothesis can be examined:

> *H2a:* Safety climate strength (at the group level) will moderate the relationships between safety climate and outcomes, such as behavior.

Such relationships are also plausible at the individual level, given that a substantive part of the variance in climate dimensions is not shared. If this is the case, then cross-level interactions are possible, suggesting a final moderation hypothesis relating to the level of climate in the group:

> *H2b:* There will be a moderation effect of group level dimension norms (the level of climate in the group) on the individual level relationship among predictors and outcomes.

Method

Participants

The study represents a survey of the total population of 3129 workers in a UK based Distribution Company with 33 worksites. The response rate was 38%, or 1189 workers. There were three main job categories: delivery (47.7%), warehouse (31.6%) and administrative (20.7%) workers. 10.2% of the workers were less than 25 years old; 26.5% were between 26 to 35 years old; in the 36-45 years range there were 33.7% of the workers; 22.7% were 46 to 55 years old, and finally 6.8% of the workers were over 56 years old. With respect to job tenure, 5.8% had been in their position for less than one year; 34.1% had been working for the company for between one and five years; 21.6% between six and ten years; and 38.6% for more than ten years. Given that two levels of analyses are involved in the statistical models, the effective sample size was 1189 at level one (individual), and 78 groups at level two (work-group level). Work groups were identified according to worksite and job grouping by type of work. The average number of people per group was 15.34; median of 10.5; standard deviation of 15.49.

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Measures

The survey instrument comprised three sections. Section 1 gathered the demographic and job position information described above. Section 2 focused on assessing individual safe behaviors. Ten items with a 4 point response scale were included here (responses on this scale ranged from *Never* to *Often*). These items were based on safe behavior questionnaires utilized by García, Boix, and Canosa (2004); and Mearns, Whitaker, and Flin (2003). Items were selected to reflect the behavioral components of safety performance, compliance with safety procedures and participation in safety-related activities suggested by Neal, et al. (2000): Active Safety Behavior (ASB), analogous to participation in safety activities (an example item is "I have contacted my team leader about health and safety problems") and Risk Taking (RT), reflecting non-compliance with safety procedures (an example item being "I ignore safety regulations in my job").

Section 3 of the survey instrument included 45 attitude and perception items (each with a 5 point Likert response scale, ranging from *Strongly Disagree* to *Strongly Agree*). These items were designed to capture views in three areas: Safety Climate, the Working Environment and the Workers' own Role in safety issues. The Safety Climate (SC) section included a total of 24 items derived from previous work by Cox and Cheyne (2000), Zohar (2000), and Zohar and Luria (2005). Items were selected to reflect the main primary themes commonly assessed in relation to safety climate (Flin, Mearns, O´Connor, & Bryden, 2000). The a priori dimensions for this part of the scale included: Management Commitment (MC) with an example item being "Management in this organisation acts decisively when a safety concern is raise"; Team Leader Actions (TLA) with items such us "My supervisor discusses how to improve safety with us", Priority of Safety (PS) with "Management considers safety to be equally as important as production" as example of question and, Communication (COM) with items such as "Relevant health and safety issues are communicated".

The Work Environment (WE) section included 14 items used previously by Cooper, Phillips, Sutherland, and Makin (1994) and Cox and Cheyne (2000). The a priori dimensions for this part of the scale included: Work Resources (WR) with items as "I cannot always get the equipment I need to do the job safely", Workplace Risk Perception (WRP) with questions as "In my workplace the chances of being involved in an accident are quite large" and Safety Rules (SR) "Some health and safety rules and procedures are not really practical".

Finally Workers Role (WoR) included 9 items, selected from previous work by Cheyne, Cox, Oliver, and Tomás (1998) and Cox and Cheyne (2000), and broadly reflecting employees' engagement with safety issues. The a priori dimensions for this part of the scale included: Involvement (INV) ("We are all involved with safety issues at work") and Personal Responsibility (PR) "I understand how to do my job safely".

Procedure

Paper questionnaires were distributed to all company sites and returned anonymously in batches corresponding to individual work groups at each worksite. Work groups were identified as those who shared a job type (for example 'Driver' or 'Warehouse worker' and worked together at individual worksites. The field work spanned a period of three months.

Statistical analyses

Confirmatory Factor Analysis (CFA), was employed to test the relationships among the items and a-priori factors free of error of measurement. Each latent variable, or factor, comprises several indicators or measures, as described in the previous section. The CFAs described in this study were estimated using maximum likelihood techniques using EQS 6.1. The overall fit of the resultant models was assessed using a number of goodness-of-fit indices, specifically: Chi-square, comparative fit index (CFI), adjusted goodness-of-fit index (AGFI), the root mean squared error of approximation (RMSEA) and the Standardized Root Mean Squared Residual (SRMR).

The shared nature of the variables under study was examined using the intraclass correlation coefficient (ICC). The statistical model used to calculate the ICC in this study is the intercept-only model, containing no explanatory variables. The intercept-only model splits the variance into two independent components, the variance of the lowest level errors (individual level) and the variance of the highest-level errors (group level). These two components are used to define a formula of the ICC that indicates the proportion of the variance explained by the grouping structure in the population (see for example Hox, 2002). The need for a multilevel analysis strongly depends on the size of the ICC for the variables in the study. If the ICC is low, there is no meaningful average difference among groups on the variables, and data may be analyzed at the individual level. Additionally, the estimation of the ICC's for the variables under study makes theoretical as well as statistical sense, because it is a test of the shared nature of safety climate measures.

Multilevel regression models were estimated in order to simultaneously address the effects of level-one (individual) predictors and level-two (group) predictors, as well as their interactions, on safety outcomes. Specifically, the safety outcomes were Workers

Involvement (WI), Personal Responsibility (PR), Active Safety Behavior (ASB) and Risk Taking (RT). The multilevel regression models were estimated in the linear mixed models module of SPSS 17 (Bickle, 2007). Restricted maximum likelihood (REML) estimation method was chosen for parameter estimation (Tabachnick & Fidell, 2007). R-squares at both levels of analyses were calculated with the formulae proposed by Snijders and Bosker (1999) to correct for unequal groups sizes. Outcomes at multilevel models are measured at level one (individual), but the multilevel model estimates between-groups variability, or second level variability. This variability may be explained for by explanatory variables, and it allows the estimation of level two (group) R-squares. The estimate for the second level R-square used in this study has been recommended for two-level designs (Hox, 2002).

The main dependent variables were Active Safety Behavior and Risk Taking. To predict these two dependent variables, a number of predictors were used. The predictors, at the first level of analysis were: four measures of safety climate (Management Commitment, Team Leader Actions, Priority of Safety and Communication); three measures of work environment (Safety Rules, Work Resources and Workplace Risk Perception); and two measures of individual workers' role (Involvement and Personal Responsibility). The predictors at level two were the same aforementioned safety variables aggregated at the group level. Additionally, multilevel models were calculated to predict two other, more individually focussed, variables (Involvement and Personal Responsibility). The same predictor variables (safety climate and work environment scales) were used in this analysis.

The justification and meaning of this aggregation relies both on the multilevel statistical literature and the specific safety climate theoretical and empirical research. On one hand, the aggregation of individual scores, when statistical conditions are met, is a way to test for contextual effects (e. g. Goldstein, 1987; Harnqvist, Gustafsson, Muthén, & Nelson, 1994). On the other hand, safety climate theories have stressed the shared nature of safety climate dimensions and, as a natural analytical strategy, aggregation of individual perceptions, as well as multilevel or hierarchical analyses, have been used (e.g. Huang, Chen, DeArmond, Cigularov, & Chen, 2007; Neal & Griffin, 2006; Wallace *et al.*, 2006; Zohar & Luria, 2005). These studies aggregated individual responses to safety climate items that are extremely similar to those employed in the present study. Even the more "personal" dimensions of Workers Role are usually employed in safety climate research as indicators of the construct (Flin et al., 2000), and Worker Environment indicators have contextual referents.

Once aggregation to any upper level has been done, a statistic to summarize the group has to be chosen. According to Zohar's (2003) recommendations, the second level variables were aggregated calculating both the mean for each group (level) and the standard deviation of the variable at each group (strength). Therefore, a sequence of exploratory models, as proposed by Hox (2002) and Snijders and Bosker (1999), has been used. The sequence starts with the simplest possible model and subsequent models add various types of parameters step by step. Specifically, the sequence of models tested was:

- Model 1. Null model. No predictor at any level of analyses
- Model 2. Random coefficients models with individual (level one) predictors
- Model 3. Multilevel model with level one predictors and second level mean (level) predictors
- Model 4. Multilevel model 3 adding cross-level interactions
- Model 5. Multilevel model with level one predictors and second level standard deviations (strength) predictors
- Model 6. Multilevel model 5 adding cross-level interactions
- Model 7. Multilevel model only with statistically significant effects in models 2 to 6

With the use of multi-level regression model potential multicollinearity between the independent variables used in each model needs to be considered. Multicollinearity measures were calculated in the models using Variance Inflation Factor (VIF) measures and no multicollinearity problems were present in the data.

Results

Confirmation of factor structure

A confirmatory factor analysis including the items in section two of the questionnaire found a two factor orthogonal solution, comprising of Active Safety Behavior (ASB) and Risk Taking (RT). Model fit was adequate: CFI = 0.94; AGFI = 0.94; RMSEA = 0.06; SRMR = 0.05, with factor loadings ranging from a minimum of 0.3 to a maximum of 0.82.

A CFA was also estimated to test for the a priori 9-factor solution of section three in the survey. Overall fit for the nine factor oblique solution was adequate: CFI = 0.905; AGFI = 0.88; RMSEA = 0.045; SRMR = 0.058, with factor loadings ranging from a minimum of 0.44 to a maximum of 0.87. Analyses to establish discriminant validity were also performed. Firstly, a one-factor CFA was tested. This one-factor model resulted in a poor model fit (CFI = 0.728; AGFI = 0.616; RMSEA = 0.082;

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SRMR = 0.085), thus providing evidence for the distinctiveness nature of the factors. Secondly, correlations among factors were all tested against the value of 1 and all comparisons were statistically significant ($p < .01$). Table 1 shows the factor means and standard deviations, mean factor loadings and standard deviations, Pearson's correlations, and Composite Reliability Indexes and Cronbach's alphas (in the diagonal) for the resultant variables, together with the two safe behavior variables from section two of the questionnaire. Involvement was the only variable that did not reach the usually employed cut-off criteria of .7 for reliability (Composite Reliability Index = .68, α = .66), which must be born in mind when interpreting the results.

Intraclass correlation coefficients

ICC's were estimated for every observed variable under study. ICC estimates and their statistical significance are shown in table 2. ICCs were all statistically significant, with percentages of variance that can be attributed to work group ranging from 3% to 37%. Clearly most of the ICCs were moderately sized with the exception of Active Safety Behavior, Risk Taking, Involvement and, especially, Personal Responsibility. Given the values for the ICCs, there is a need to model the group level variability, as noted, among others by Barcikowski (1981) who found inflation of the Type I error rates even for ICCs much lower than those in the study. Moreover, Muthén (1997) states that typically, coefficient values in survey data tend to range from 0.0 to 0.5, and that when values of .1 or larger are combined with group sizes exceeding 15 the multilevel structure of the data should be modeled.

Since a portion of the variance can be attributed to work groups, the mean, standard deviation, and bivariate correlations at the group level are shown in table 3 for all core constructs.

Multilevel models

Given that two levels (individual and group) of analysis exist, that both are of theoretical interest, and that the amount of variance at the group level is not negligible, multilevel regression models were estimated in order to predict relevant safety outcomes. The sequence of seven multilevel models (see above) proposed by Hox (2002) and Snijders and Bosker (1999) was estimated four times, one for each of the outcomes considered: Worker Involvement, Personal Responsibility, Active Safety Behavior and Risk Taking. Fit results for the sequence of model are shown in table 4. In general, the inclusion of level one and two predictors improved the null models, because the Akaike Information Criterion (AIC), which is often used as a measure of model accuracy, was considerably lower when level one and two predictors were added in sequence. Also a general result is that lowest AIC was associated to model 7 for each of the outcome variables. The fixed effects of model 7 for each outcome variable are therefore shown in table 5.

The largest effects on *Involvement* at the individual level were the positive associations with Communication and Management Commitment, but there also were other three significant effects of Team Leader Actions,

Table 1. *Means, standard deviations, Pearson's correlations, and reliabilities for the variables at the individual level*

	ASB	RT	MC	TLA	PS	COM	SR	WRP	WR	INV	PR
Active Safety Behavior (ASB)	.82/.78										
Risk Taking (RT)	.061*	.79/.76									
Management Commitment (MC)	–.092**	–.410**	.89/.91								
Team Leader Actions (TLA)	.015	–.336**	.774**	.89/.90							
Priority of Safety (PS)	–.062*	–.439**	.813**	.713**	.75/.76						
Safety Communication (SC)	–.004	–.333**	.821**	.804**	.746**	.87/.87					
Safety Rules (SR)	.054	–.502**	.402**	.279**	.411**	.307**	.77/.78				
Workplace Risk Perception (WRP)	–.239**	–.288**	.522**	.387**	.386**	.389**	.301**	.75/.71			
Work Resources (WR)	–.181**	–.409**	.601**	.483**	.506**	.478**	.542**	.556**	.69/.73		
Involvement (INV)	.102**	–.295**	.608**	.596**	.632**	.641**	.271**	.185**	.270**	.68/.66	
Personal Responsibility (PR)	.266**	–.311**	.265**	.272**	.396**	.318**	.314**	–.057	.040	.484**	.78/.71
Factor mean	2.77	1.74	3.36	3.15	3.37	3.44	3.17	2.90	2.75	3.56	4.01
Factor standard deviation	.63	.72	.83	.87	.78	.82	.72	.91	.90	.67	.58
Factor mean loading	.61	.67	.75	.79	.63	.77	.62	.67	.65	.59	.58
Factor loading standard deviation	.13	.11	.08	.05	.16	.08	.02	.15	.10	.12	.05

Note. *= $p < .05$¸ **= $p < .01$, Composite Reliability Indexes and Cronbach's alphas are both presented in this order in the diagonal

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Table 2. *Intraclass Correlation Coefficients (ICC) and their statistical significance for the observed variables under study*

Latent variable	Observed variable	*ICC*	*p*
Safe Behavior (SB)	Active Safety Behavior (ASB)	.096	.001
	Risk Taking (Compliance, RT)	.132	< .001
Safety climate (SC)	Management Commitment (MC)	.275	< .001
	Team Leader Actions (TLA)	.181	< .001
	Priority of Safety (PS)	.194	< .001
	Communication (COM)	.215	< .001
Work Environment (WE)	Safety Rules (SR)	.155	< .001
	Workplace Risk Perception (WRP)	.318	< .001
	Work Resources (WR)	.370	< .001
Workers Role (WoR)	Involvement (INV)	.140	< .001
	Personal Responsibility (PR)	.030	.01

Table 3. *Means, standard deviations, Pearson's correlations, for the variables at the group level*

	Mean	*SD*	ASB	RT	MC	TLA	PS	COM	SR	WRP	WR	INV
Active Safety Behavior (ASB)	2.80	.34										
Risk Taking (RT)	1.70	.38	−.407**									
Management Commitment (MC)	3.47	.53	−.087	−.614**								
Team Leader Actions (TLA)	3.29	.49	−.336**	−.560**	.644**							
Priority of Safety (PS)	3.43	.47	−.314**	−.667**	.855**	.719**						
Safety Communication (SC)	3.54	.47	−.231*	−.532**	.846**	.749**	.790**					
Safety Rules (SR)	3.23	.37	−.457**	−.764**	.673**	.551**	.671**	.603**				
Workplace Risk Perception (WRP)	3.00	.61	−.491**	−.501**	.737**	.352**	.544**	.542**	.532**			
Work Resources (WR)	2.87	.66	.026	−.676**	.851**	.532**	.739**	.736**	.708**	.680**		
Involvement (INV)	3.58	.32	.362**	−.346**	.477**	.558**	.553**	.551**	.353**	.284*	.249*	
Personal Responsibility (PR)	4.03	.29	.354**	−.192	−.013	.277*	.194	.088	.274*	−.121	−.230*	.466**

Note. *= $p < .05$; **= $p < .01$

Table 4. *Fit indices for the sequence of multilevel models estimated to predict the four outcomes: Involvement, Personal Responsibility, Active Safety Behavior and Risk Taking*

		Involvement			*Personal Responsibility*			*Active Safety Behavior*			*Risk Taking*		
	MODEL	χ^2	Par.	AIC	χ^2	Par.	AIC	χ^2	Par.	AIC	χ^2	Par.	AIC
1	Null model -no predictor-	2251.95	3	2255.95	2034.15	3	2038.15	2223.18	3	2227.18	2512.61	3	2516.61
2	RCM –individual level predictors	1393.04	17	1411.04	1592.47	15	1606.47	2052.37	17	2066.37	2083.05	16	2095.05
3	ML model with mean group level predictors	1411.65	21	1423.65	1598.69	21	1610.69	2064.10	26	2078.10	2094.46	25	2106.46
4	Model 3 plus mean cross-level interactions	1420.82	27	1430.82	1574.40	25	1580.40	2079.94	34	2091.94	2089.93	34	2101.93
5	ML model with SD group level predictors	1393.53	20	1403.53	1576.17	21	1588.17	2048.40	25	2060.40	2082.16	25	2094.16
6	Model 5 plus SD cross-level interactions	1397.86	27	1407.86	1567.83	27	1577.83	2055.87	34	2067.07	2088.84	34	2100.84
7	ML model only with significant effects	1376.34	15	1384.34	1548.09	19	1558.09	2038.69	12	2004.69	2043.14	12	2051.14

Table 5. *Fixed effects for the best-fitting multilevel models predicting each outcome: Involvement, Personal Responsibility, Active Safety Behavior and Risk Taking*

		Involvement			*Personal Responsibility*			*Active Safe Behavior*			*Risk Taking*		
	Predictors	*b*	SE	*p*	*b*	SE	*p*	*b*	SE	*p*	*b*	SE	*p*
Level 1 (individual) predictors	Management Commitment (MC)	.159**	.037	<.001	−.073	.042	.082						
	Team Leader Actions (TLA)	.081**	.027	.004	−.002	.028	.942	.136**	.034	<.001			
	Priority of Safety (PS)	.155**	.034	<.001	.325**	.035	<.001	−.437**	.145	.003	−.173**	.029	<.001
	Communication (COM)	.224**	.032	<.001	.523**	.117	<.001	.057	.039	.141			
	Safety Rules (SR)	.118**	.020	<.001	.218**	.023	<.001	.137**	.029	<.001	−.131**	.043	.003
	Workplace Risk Perception (WRP)				.089**	.019	<.001	.119**	.023	<.001			
	Work Resources (WR)				−.400**	.102	<.001	−.119**	.028	<.001	−.108**	.027	<.001
	Personal Responsibility (PR)							.241**	.035	<.001	−.212**	.038	<.001
Level 2 (group) predictors	Management Commitment MEAN	−.178	.101	.083									
	Priority of Safety MEAN	.123	.124	.327									
	Safety Rules MEAN										−.118	.075	.119
	Work Resources MEAN				−.133**	.043	.003						
	Management Commitment SD										.171	.125	.177
	Priority of Safety SD							.136	.156	.384			
	Communication SD				.195	.114	.091						
	Safety Rules SD	−.245*	.112	.030									
	Work Resources SD				.299*	.117	.013						
Cross−level interactions	MC x MC MEAN	.239**	.063	<.001									
	PS x PS MEAN	−.213**	.080	.008									
	SR x SR MEAN										.486**	.089	<.001
	WR x WR MEAN				.194**	.039	<.001						
	PS x PS SD							.306	.188	.108			
	COM x COM SD				−.492**	.146	.001						
	WR x WR SD				.307*	.130	.022						

Priority of Safety and Safety Rules. Among the second level predictors only Safety Rules strength (standard deviation) had a statistically significant and negative impact on involvement at the group level, indicating that involvement is higher when safety rules are perceived to be homogeneous within the group. Two of the cross-level interactions were statistically significant: the interaction between Management Commitment and Management Commitment level (group mean), and the negative interaction between Priority of Safety and Priority of Safety level (group mean). Overall, the amount of variance in Involvement explained by model 7 was 0.84 at group level and 0.51 at the individual level.

Table 5 also shows the fixed effects of individual and group predictors on *Personal Responsibility.* There were large and positive effects of Priority of Safety, Communication and Safety Rules on Personal Responsibility at the individual level, while the effect of Work Resources was negative, indicating that better work

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resources diminished the responsibility of workers in safety. Work Resources level (mean) also had a negative impact on Personal Responsibility at group level, but Work Resources strength (standard deviation) had a positive effect. These two group level effects point out that groups with higher and more homogeneous work resources had lower means of personal responsibility. Finally, three cross level interactions were statistically significant. First, higher levels of Work Resources at the group level make the relationship between Work Resources and Personal Responsibility stronger at the individual level. Second, higher homogeneity (strength) of Work Resources at the group level makes the relation between Work Resources and Personal Responsibility decrease. Third, as the strength of safety Communication at the group level increases the positive relationship between Communication and Personal Responsibility increases. The amount of variance explained by model 7 was 0.49 at group level and 0.38 at the individual level.

A multilevel regression model to explain *Active Safety Behavior* was estimated and the fixed effects are presented in table 5. In this particular case, only predictors at the individual level were statistically significant. Team Leader Actions, Safety Rules and Personal Responsibility promoted active safe behavior by the workers. In the same vein, Workers Perception of Risk exacerbates the need for active safe behavior. However, high Priority of Safety and the existence of more Work Resources were negatively associated to active safe behavior. Overall, the percentage of variance explained by the predictors at the group level was 38.27% and 18.2% at the individual level.

Finally, table 5 shows the fixed effects of the multilevel regression model estimated to predict *Risk Taking*. At the individual level, there were four statistically significant and negative effects on risk taking: as Priority of Safety, Safety Rules, Work Resources and Personal Responsibility increased, the workers decreased their levels of Risk Taking. Additionally, there was a cross-level interaction between Safety Rules and Safety Rules level (mean). The interaction showed that the effect of Safety Rules and Risk Taking at the individual level is stronger when Safety Rules are higher in the group the worker belongs to. The amount of variance of risk taking explained by the multilevel model was 0.76 at the group level and 0.39 at the individual level.

Discussion

Most recent theoretical positions offer a picture of safety climate as a multidimensional (Flin et al., 2000) and multilevel construct that may have direct, indirect and moderator effects on safety outcomes (Neal & Griffin, 2006; Zohar, 2000; 2003). Accordingly, the methodology to understand those links should take into account such complexities. This research simultaneously accounts for these complexities. The multilevel analysis showed clear empirical evidence for the shared nature of most variables under study. In particular Safety Climate and Work Environment variables exhibited moderate to high intraclass correlations. The larger ICCs were associated with dimensions clearly connected with operational definitions of safety climate, such as Management Commitment, Communication, Priority of Safety, or Risk Perception, giving some empirical support to the shared nature of safety climate (Zohar, 1980; 2000; 2003). ICC values found in this study were quite similar to those found in previous research by Wallace et al. (2006), with ICC's ranging from 0.14 to 0.21, or Zohar and Luria (2005), with values of 0.17 and 0.22. These findings are also in line with previous findings (Cheyne et al., 2005). In this case there would appear to be support for the application of multilevel analyses to explain such a phenomenon.

The main aim of this study was to examine a multilevel explanation of employee involvement and safe behaviors. The hypotheses set out earlier have been partially supported by the results. Overall *H1a* is supported although there is no consistent picture emerging from the multilevel analysis, with different variables important in the explanation of each outcome. At an overall level the results are broadly consistent with previous research at the individual level (Cheyne et al., 1998) and Zohar's (2003) proposal that climate will influence behaviors. In this research the variables relating to Involvement and Personal Responsibility were examined as the first stage of the broad climate-individual expectation-behavior model proposed by Zohar (2003). Again at the individual level, Involvement seems to be influenced by mostly Safety Climate variables similar to the link found by Fernández-Muñiz et al. (2007). Issues of Personal Responsibility, on the other hand seem to be related most to appraisals of available Work Resources, suggesting the better the resource environment is, the less individual responsibility is needed.

In terms of individual behavioral outcomes, Active Safety Behavior was influenced positively by supervisors, rules and responsibility; Neal and Griffin (2006) also suggest that safety climate can influence participative behaviors to a degree. Here, Active Safety Behavior would appear to go hand in hand with positive views of the organization's approach to safety (in the supervision and rules in place) and an appreciation of the worker's own personal responsibility for safety. It could be argued here that employees saw voluntary participative behavior to be more closely associated with their immediate work environment (their supervisors, the rules or their job) than more distal influences

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(such as managers commitment and wider communication). This distinction may be consistent with the finding that Active Safety Behavior was related negatively to Priority of Safety and Work Resources. This may reflect a need to raise levels of active participation when safety is not perceived to be high on the organization's (as opposed to the immediate work group's) agenda and available resources are perceived to be limited, especially given the voluntary nature of the participative behavior being assessed in this variable. In other words, employees may compensate for poor resources and a low priority by increasing voluntary safety related behaviors.

Risk Taking behavior is influenced by mostly Work Environment variables and the priority accorded to safety; the higher the priority and the better the environment the less need there is for individuals to take risks. There is, however, no direct association between Risk Taking and the perception of risk in the workplace, suggesting that such non-compliant behavior is not solely dependent on the level of risk in the environment. If this is the case, then the organization may find that any attempts, for example, to modify safety behavior would be fruitful if all workgroups were included, not just those in 'riskier' environments. In overall terms this would suggest that enterprise wide interventions are likely to be successful in improving safety performance in this organization.

Hypothesis *H1b* is also supported as percentage of variance explained for at the group level is larger than at the individual level, although there are less direct significant relationships. At the group level, only the shared nature of Safety Rules seemed to have an influence on Involvement; groups with more homogeneous views of Safety Rules included members who got more involved. The strength of appraisals of Work Resources at group level indicates that those in groups with weaker collective appraisals of their Work Resources perceive a greater need for Individual Responsibility, suggesting the subjective norm relating to resources encourages group members to compensate by taking more responsibility.

Hypotheses *H2a* and *H2b* have only been partially supported. Cross-level interactions for Involvement would suggest that the group means (or level) of two climate variables interacted with individual perceptions, suggesting that strength of climate was not important in moderating individual involvement in safety issues. Two cross-level interactions also suggest that both the level and strength of evaluations of Work Resources moderate the relationship between individual perceptions of the environment and taking responsibility, these are discussed below. A link between appraisals of the work environment and personal responsibility was proposed by Cheyne et al. (1998); in that case the relationship suggested the more hazards in the environment the more responsibility was valued.

Overall these results might suggest that the group level of analysis is not as revealing as the individual level, however one strength of this study is that it allows cross-level interactions to be included, in order to examine the interdependence of individual and group (Zohar & Luria, 2005). In this case the cross-level analysis reveals a complex picture. In terms of level (or group mean) of climate, the effects in most cases showed that higher group levels were associated with stronger relationships between individual evaluations and the dependent variable. The converse is true of group levels of Priority of Safety, where greater individual Involvement in safety issues is associated with higher evaluations of the priority accorded to safety, but only in groups with a lower overall evaluation of the Priority of safety. In other words, this finding may indicate a lower individual need for involvement in groups where members perceive that safety is taken seriously by the organization.

There are only two significant interactions involving the strength of group climate, both with effects on the levels of Personal Responsibility for safety taken by individuals; higher strength of evaluations in the group of Work Resources was associated with a decrease in the relationship between individual evaluations of Work Resources and Personal Responsibility. This result suggests that if the individual perceives there to be better levels of Work Resources (for example, time and equipment available), they are less likely to agree that safety is their Personal Responsibility, and this is enhanced by a lack of agreement about Work Resources at the group level. In other words the social norm within the work group in relation to resources available will moderate the relationship between individual appraisals of those resources and their views of their own responsibility for safety; those in groups with stronger climate may be less likely to avoid their personal responsibility in assuring safety when there are adequate Work Resources.

Finally, in groups with stronger collective evaluations of Communication, the relationship between individual evaluations of Communication and Personal Responsibility increases, suggesting that a better collective view of safety communication reinforces the individual's association between Communication and Personal Responsibility; the collective perception of communication about safety issues as valuable might encourage more responsibility on the part of the group members. Practically, organizations may find that it is not only the amount of communication that is important, but also how work groups perceive this information and whether they find it useful and practical. Not surprisingly this would endorse the value of two-way

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communication and feedback between the organization and its employees.

Although a complete test of Zohar's (2003) multilevel model of safety is beyond the scope of this paper, the models tested in this research have been theoretically driven by this and other prevalent theoretical models of safety climate. Despite the potential power of social norms and group influence, the results here do not provide conclusive evidence of their moderation on outcomes. Although there is some evidence of group influence on individual evaluations of their own responsibility for safety, the group strength of the safety climate dimensions (Management Commitment, Team Leader Action, Priority of Safety and Communication) did not seem to have a large influence on individual outcomes. The cross-sectional nature of the survey, together with the incidental (applied) sampling procedure, and the low response rate is somewhat of a limitation of the study. Important issues related to the analytical strategies employed still remain: the multilevel models became extremely complex and quite unstable in terms of estimation as the number of variables involved and parameters estimated grows. These statistical models were, in part, of an exploratory nature, and therefore cross-validation of findings, although complicated, is highly desirable. Also a limitation is that the diversity of the positions could have affected the results obtained considering, for example, differences in the number, type and gravity of the risks presented in each occupational context. A statistical control of risks has been performed in the present study with the variable Risk perception. However, this is not an "objective" measure of risk. Such an objective measure was not available, but its inclusion could provide a better control, and therefore a better understanding of the results.

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