La Medicina del Lavoro

Med Lav 2015; *106*, 6: 447-459

Griffin and Neal's safety model: Determinants and components of individual safety performance in the Italian context

S. Toderi, A. Gaggia, M.G. Mariani, G. Mancini*, M. Broccoli**

Department of Psychology, University of Bologna, Bologna, Italy
* AUSL of Romagna, Occupational Health and Safety Unit - Ravenna, Ravenna, Italy
** AUSL of Romagna,Occupational Health and Safety Unit - Ravenna, Bagnacavallo (Ravenna), Italy

Key words
Safety motivation; safety participation; validation study

Parole chiave
Motivazione alla sicurezza; partecipazione alla sicurezza; studio di validazione

Summary
Introduction: *Griffin and Neal's model is a useful model to understand workers' different safety behaviour (compliance and participation) starting from their mastery of safety procedures (safety knowledge) and the motivation to put them in place (safety motivation). Although the theoretical model has proven to be adequate and is widely used in research, two problems arise: 1) there is no Italian validation of the four scales measuring the key constructs of the model; 2) the hypothesis regarding the differential impact of the determinants on the components of safety performance produced mixed evidence.* **Objectives:** *The study had a twofold objective: 1) validate an Italian version of the four scales, primarily assessing their construct validity; 2) verify the relationships between the constructs according to the assumptions made within the theoretical model.* **Methods:** *The psychometric properties of the scales as well as the relationships between the constructs were investigated in a sample of 277 workers in the construction and logistics sectors, using questionnaires. The analyses were based on the use of structural equation modelling technique.* **Results:** *Results confirmed the validity and reliability of the Italian scales, showing indices that were both satisfactory and aligned with those from previous studies. The relationships between the constructs were substantially consistent with the safety model.* **Conclusions:** *The study provided a valid version of the scales measuring determinants and components of individual safe performance. Such scales can be appropriately used in the Italian context for the development of theoretical as well as practical contributions on work safety. The results suggest that interventions to increase overall safe performance should address both knowledge and motivation for safety.*

Riassunto
«Il modello sulla sicurezza di Griffin e Neal: determinanti e componenti della prestazione di sicurezza individuale nel contesto italiano». **Introduzione:** *Il modello di Griffin e Neal costituisce una proposta utile per comprendere i diversi comportamenti di sicurezza dei lavoratori (compliance e partecipazione) a partire dalla padronanza che i lavoratori hanno a proposito delle procedure di sicurezza (conoscenza della sicurezza) e dalla motiva-*

Pervenuto il 3.7.2015 - Revisione pervenuta il 10.9.2015 - Accettato il 22.9.2015
Corrispondenza: Stefano Toderi, viale Berti Pichat 5, 40127 Bologna, Italy - Tel. +39 051 2091388
E-mail: stefano.toderi@unibo.it

zione a metterle in atto (motivazione alla sicurezza). Sebbene il modello teorico abbia dato prova di adeguatezza e sia ampiamente utilizzato nella ricerca, si rilevano due criticità: 1) non esiste una validazione italiana delle quattro scale di misura dei costrutti chiave del modello; 2) le ipotesi circa l'impatto differenziale delle determinanti sulle componenti della prestazione sicura hanno ricevuto evidenze di tipo misto. **Obiettivi:** *Lo studio si propone un duplice obiettivo: 1) validare una versione italiana delle quattro scale di misura valutandone la validità di costrutto; 2) verificare le relazioni esistenti tra i costrutti in accordo con le ipotesi avanzate dal modello teorico.* **Metodi:** *Le caratteristiche psicometriche delle scale e le relazioni tra i costrutti sono state indagate in un campione di 277 lavoratori dell'edilizia e del settore logistico mediante l'utilizzo di questionari. Le analisi si sono basate sull'impiego dei modelli di equazioni strutturali.* **Risultati:** *I risultati hanno confermato la validità e l'affidabilità delle scale italiane mostrando indici soddisfacenti in linea con quelli di studi precedenti. Le relazioni tra i costrutti risultano sostanzialmente in linea con il modello di sicurezza.* **Conclusioni:** *Lo studio ha fornito una versione valida delle scale di misura delle determinanti e delle componenti della prestazione sicura. Tali scale possono essere opportunamente utilizzate nel contesto italiano per lo sviluppo di contributi teorici e pratici sulla sicurezza lavorativa. Infine, i risultati suggeriscono che gli interventi volti a incrementare la prestazione sicura dovrebbero considerare sia la conoscenza che la motivazione alla sicurezza.*

Introduction

Over the past three decades, research in occupational safety has gained increasing weight and importance. A fundamental aim of the studies in this area is to make predictions about safety aspects and indicators (e.g., the probability of accidents and injuries) in order to provide useful information to improve and raise the levels of safety within organizational contexts. According to this objective, contributions have attempted to identify both the factors that affect safety and the way in which this influence is determined (26, 35). Recognition of the importance of social and organizational factors in influencing safety performance led to a number of studies being undertaken in the fields of safety culture and safety climate, both internationally (13, 16, 19, 28, 38) and nationally (6, 9, 12). In particular, it is widely recognized that the safety climate represents a reliable predictor of behaviour and organizational outcomes related to safety (11, 14, 17, 39), although a clear consensus on its constituent dimensions has yet to be reached (40). The construct of safety climate is based on perceptions that employees of a company share about the policies, procedures and business practices relating to safety and, more generally, about the value, importance and priorities that safety assumes within the specific organizational context (4). These perceptions, to which we refer when we speak about safety climate, seem to be related to employees' motivations to perform their duties safely, that affect concrete safety behaviour and, ultimately, the occurrence of accidents and injuries. There have been several theoretical proposals to understand the factors implied in the relationship between safety climate and workers' behaviour – see also the contributions by Siu et al. (34) and Wu et al. (36). One of the first models developed to address this problem was by Griffin and Neal (17, 30). The solution they found is based on the integration of two major research lines: on the one hand the theories of psychological climate (23) and the theories of individual performance (8) on the other. This integration is ensured, within the theoretical framework, by the mediational role played by safety knowledge and safety motivation. The introduction of these two variables, that can explain the practice of safety behaviour by workers, is the main element of originality in Griffin and Neal's model. The present study covers the key constructs and relationships proposed within this model as we believe that a valid and consistent framework is needed both to advance knowledge on safety behaviour dynamics and to make reliable forecasts of safety performance. In response to this need, our general purpose was to evaluate the adequacy of such framework in the Italian context, providing suitable measurement scales based on those originally proposed by Neal et al. (29).

Griffin and Neal's model: key concepts and theoretical bases

The authors of the model argued that safety climate should be kept conceptually distinct from perceptions regarding knowledge, motivation and behaviour affecting work safety (17). According to the theories of performance (3, 8), a differentiation between components and determinants of performance was proposed: the components of performance describe the actual behaviour that individuals manifest at work. Two components were recognized: one related to the task (compliance) and another related to the context (participation). Compliance behaviour refers to the essential activities that have to be carried out in order to maintain safety of the work environment (e.g., compliance with safety protocols/procedures and proper use of personal protective equipment). Safety participation behaviour, however, refers to actions, mostly voluntary, that do not directly contribute to the safety of the work environment but are important in developing attention and social value to safety within the organizational context (e.g., participation in safety initiatives on a voluntary basis, to provide help to colleagues in activities regarding safety, attendance at safety meetings, etc.). Safety knowledge and safety motivation represent the determinants of performance and are meant to differentially affect task and context related behaviour. The first is defined as the degree of mastery that workers have of rules and procedures necessary to carry out their duties safely (e.g., emergency procedures). The second reflects the will of the worker to make an effort to put safety behaviour into effect, as well as the value associated with this behaviour (31). In summary, Griffin and Neal's model is based on the integration between the theories of job performance and theories of psychological climate and it is characterized by two innovative key aspects (17): a) the distinction between two components of safety performance related to the task and the environment; b) the inclusion of safety knowledge and safety motivation concepts, which have a direct and differential influence on the components of performance. These aspects form an original framework within which to identify the determinants of safety behaviour and understand the way they exercise their impact on different aspects of performance. Such understanding is important from both a theoretical and a practical point of view.

Determinants and components of safety performance: measurements and evidence

The model of Griffin and Neal has been widely used in applied research dealing with problems of work safety, in different countries and within different organizational contexts. Over the last ten years, in the scientific literature on safety more than ninety studies can be counted referring directly to the hypotheses proposed by this model (4). Some of these studies used the scales proposed by the authors (29, 31) for measuring the determinants and the components of safety performance. Other studies, for example Larsson et al. (26) and Vinodkumar and Bhasi (35), tested the model's structural assumptions by using different measurement scales. The studies that used the scales developed by Griffin and Neal offer different opinions on the measurement model's reliability and validity. In the original study by Neal et al. (29) scales that measure the constructs of knowledge, motivation, compliance and participation were presented. Each measurement scale includes four items and provides a five-point Likert-type response scale. The scales have good psychometric properties; in particular, the measurements appear to be stable, showing excellent indices of internal consistency (with Cronbach's alphas ranging from a minimum of 0.84 to a maximum of 0.95) in studies conducted in different geographical and organizational contexts (25, 29). Even the factor weights of individual items confirm the validity of the measurement model (coefficients are high ranging from a minimum of 0.77 to a maximum of 0.96) (25). Lastly, variation ranges of Construct Reliability indices (0.89 to 0.97) and AVE (0.68 to 0.88) provide evidence in support of the convergent validity of the four constructs (knowledge, motivation, compliance, participation), each of which is specified by four empirical indicators (25).

A "reduced" version of the measurements related to motivation, compliance and participation, which includes three items for each scale, was proposed in a longitudinal study by Neal and Griffin (31). The authors did not suggest any substantial motivation for the use of a smaller number of items, which retain the same reflective properties in respect of relating constructs (i.e., content domain was not changed, but simply lightened the measurement model). The reliability indices of the three item scales are based on a lower number of empirical tests – in particular, there is little information on the scale measuring safety knowledge, which was only tested by Braunger et al. (4) – and generally appear less consistent. Cronbach's alphas related to motivation, compliance and participation scales still showed satisfactory values (ranging from a minimum of 0.85 to a maximum of 0.93) (31). In addition, reliability indices of the scales measuring the two components of safety performance were corroborated by two recent studies (20, 37). However, the replication study conducted by Braunger et al. (4) reported significantly more attenuated indices, especially in relation to the scale of compliance (α=0.57) and the scale of participation (α=0.62).

In addition to the evidence on the adequacy of measurement scales, the literature provides confirmation on the general validity of the theoretical model suggested by Griffin and Neal. With regard to assumptions about relationships between the determinants and the components of safe performance, indications can be drawn from three studies (4, 25, 29). These studies, although conducted in heterogeneous geographical and organizational contexts, empirically tested the same theoretical hypotheses by using both the measurement scales proposed by the authors of the model (29, 31) and the same strategy for data analysis (structural equation modelling, path analysis), therefore allowing a comparison of results. Neal et al. (29), in line with the assumptions of their model, tested the predictive ability of both the two determinants (knowledge and motivation) with respect to the components of safe performance (compliance and participation). Although all relationships were significant, no evidence was found supporting the hypothesis of differential impact (i.e., a greater positive impact) of motivation on the participation component. In other words, the positive impact of motivation on safety participation (R^2=0.29) was lower than the impact exerted on the component of compliance (R^2=0.57). Such discrepancy was reported also by Braunger et al. (4), whose study came to very similar results: all hypothesized paths between determinants and components were significant and positive, with the impact of motivation on participation (R^2=0.38) lower than the impact exerted on the component of compliance (R^2=0.71). Unlike the two studies above, Kwon and Kim (25) actually found confirmation of the hypothesis of a greater positive impact by motivation on the participation component; this study, however, revealed a critical result pertaining to the relationship between knowledge and participation, which was not significant.

Current study

Faced with a growing interest in the hypotheses implied in Griffin and Neal's model in the Italian context – see the recent contributions by Corso (12) and Brondino et al. (6) – to the best of our knowledge a systematic validation study of scales used for the measurement of determinants and components of safety performance has not yet been made. The availability of valid and reliable tools is an obvious advantage for the development of innovative research hypotheses in the context of occupational safety that are applicable to the Italian context. From an application point of view, the scales can be usefully employed as indicators for the analysis and monitoring of organizational safety performances, as well as for intervention assessment (e.g., training interventions) aiming at improving performance relating to workers' safety. In addition, an empirical test of the model in the Italian context could help to strengthen its validation regarding the hypothesized relationships between the various aspects, allowing a more reliable comparison with the results obtained in international studies. In fact, the original assumptions on the differential impact that determinants (knowledge and motivation) might have on the components of safety performance (compliance and participation) have produced mixed evidence (10). Particularly critical is the hypothesis according to which the impact of motivation on participation is stronger than the impact the motivation has on safety compliance (4, 29). Based on these considerations, the present study had a two-fold objective:

1. To validate the scales as proposed by Neal et al. (29) for the measurement of determinants and components of individual performance of safety.
2. To verify, in line with the assumptions ensuing from Griffin and Neal's model, the relationships between the determinants and components of individual performance safety.

As regards the validation process, the construct validity of scales was explored according to Grimm and Widaman's (18) evaluation framework. This framework distinguishes between internal and external aspects of construct validity. To test internal validity (which is concerned with relationships between the items making up the single scale), analyses primarily focussed on the dimension of items and the reliability scales. With respect to external validity (focussed on relationships between constructs), analyses regarded the convergent and discriminant validity of scales. In addition, assessment of the relationships between the determinants and components of safety performance allowed us to evaluate the nomothetic span of scales (which concerns the network of relationships of a scale score with other variables) according to the basic hypotheses of Griffin and Neal's model presented above. The data analysis strategy is discussed extensively in the "methods" section.

Methods

Participants

The sample consisted of 277 workers in the construction industry (56.3%) and logistics sector (43.7%). The majority of respondents (53%) reported a job tenure in the current organisation of more than 10 years. Migrant workers accounted for 12.1% of participants.

Measures and procedure

As the first step, original items developed by Neal et al. (29) were translated into Italian (see Appendix A for both the original English items and their Italian version). Following the recommendations present in literature (5) the translation process consisted of four successive phases: i) the authors translated the scales independently; ii) translations were compared and a consensus version was agreed upon; iii) this version was translated back into English by a native speaker ignoring the original scales; iv) the back-translated version and the original source were matched and linguistic discrepancies were analysed, and no substantial differences were found. The Italian version of the four scales (i.e., safety knowledge, safety motivation, safety compliance, safety participation) was included in a self-report questionnaire that also comprised the demographic items reported above. The questionnaire was administered in pencil-and-paper format. Respondents were recruited on the occasion of safety courses, which are mandatory according to current legislation. Respondents participated on a voluntary basis after being informed about the aims of the study; questionnaires were completed before the courses started. All items pertaining to the safety constructs (16 in total) were rated on a 5-point (Likert-type) agreement scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

Data analysis

Dimensional analysis

Multiple confirmatory factor analyses were performed in LISREL 8.8 (24) to evaluate the dimensional aspects of the translated items. In order to test whether the four safety constructs were distinct from each other, three competitive (measurement) models were performed:

- aggregating items into a single overall safety construct (1-factor model);
- aggregating items into two constructs measuring safety determinants (items 1 to 8) and safety performance (items 9 to 16) as a whole (2-factors model);
- aggregating items into four distinct safety variables, according to the confirmative hypothesis (4-factors model).

Robust maximum likelihood was used as the estimation procedure (21; 33). The models' degree of good fit was examined by using a mix of absolute and comparative indices; as suggested in the literature (22), the following threshold values were adopted: CFI $\geq$ 0.95, NNFI $\geq$ 0.95, RMSEA $\leq$ 0.06, SMRM $\leq$ 0.08. In addition, AIC and CAIC indices were examined to allow comparison between the models: lower values indicated a better fit with the data.

Reliability analysis

Based on the results of CFA, a reliability and validity analysis of the 4-factors model was conducted. The reliability study focused on the scales' internal consistency, namely the extent to which the items of a scale are measuring the same construct. The Composite Reliability index (hereafter CR) was calculated for this purpose. CR estimates are based on proportions of variance (lambda parameters) and take account of each item's error. Thus, they finally provide a less biased estimate of reliability than Cronbach's alpha (32). CR values greater than 0.70 are recommended (2).

Validity analysis

Validity analysis focused on the scales' convergent and discriminant validity. Convergent validity reflects the extent to which two measures of the same concept are correlated. in practice, according to Anderson and Gerbing (1), it was studied through standardised lambda parameters, which represent the regression coefficients relating each observed variable with the latent one. Significant coefficients greater than 0.50 signify a strong condition of convergent validity. For the same purpose, the AVE index was also calculated. The AVE estimate is the average amount of variation that a latent construct is able to explain in the observed variables to which it is theoretically related – more specifically, the amount of variance that is captured by the latent construct in relation to the amount of variance due to its measurement error. The index was proposed by Fornell and Larker (15) as an indicator of convergent validity: when the common variance of a set of items captured by the latent construct is greater than 40%, acceptable convergent validity is considered to exist. Based on AVE indexes, a discriminant validity test was also conducted. To test for discriminant validity, for each construct we compared the square root of its AVE with its highest correlation with other constructs, following the guidelines provided by Fornell and Larcker (15).

Path analysis

To verify the relationships between safety determinants (knowledge and motivation) on the one hand and components of safety performance (compliance and participation) on the other, we tested the structural model depicted in Figure 1 using LISREL. Analysis focused on significance and magnitude of path coefficients – specifically, the standardized gamma parameters, which express the relationship between an exogenous latent concept (the two safety determinants in our study) and an endogenous one (the components of safety performance).

Results

The proposed scales were subjected to a process of evaluation, focusing on the study of their psychometric properties (objective 1). Specifically, dimensional aspects, reliability and validity (convergent and discriminant) of the items were analysed following recommendations in the literature (18; 1). Secondly, relationships between safety determinants and components of safety performance were examined in order to both evaluate the scales' nomothetic span and verify the theoretical assumptions regarding the differential impact of safety motivation and knowledge on performance (objec-

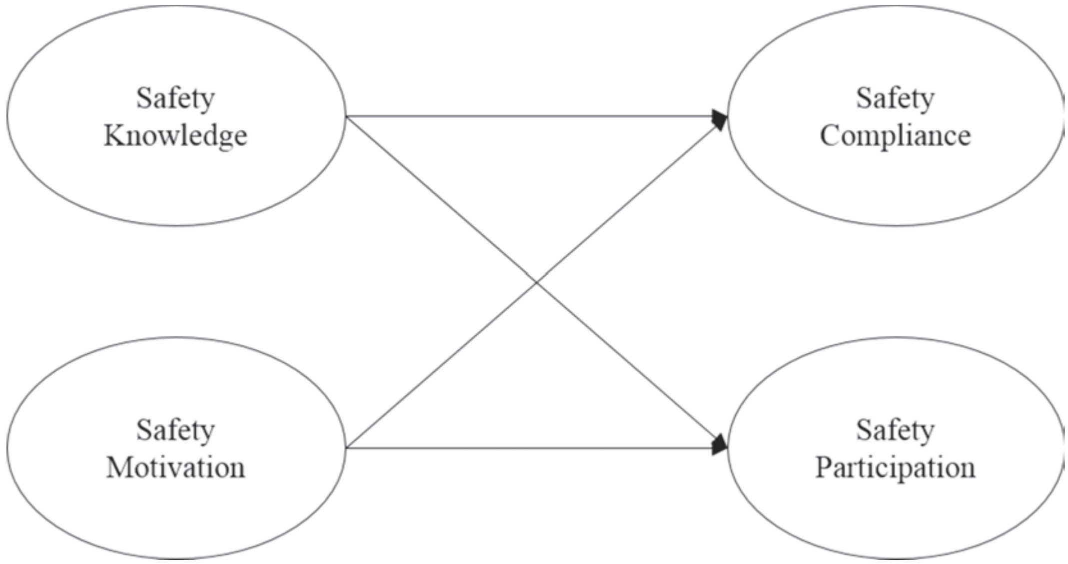

Figure 1 - Conceptual model showing the relationships between determinants and performance components examined in path analysis

tive 2). Table 1 reports the correlation matrix and descriptive statistics for the translated scales.

Objective 1: psychometric properties of the Italian scales (dimensional aspects, reliability, convergent and discriminant validity of items)

With respect to the dimensional aspects test of items, table 2 presents the good fit indices for the three measurement models described above. As can be seen, CFA produced an excellent fit for the 4-factors model, whereas the alternative two models produced a much poorer fit. The poorer fit of these two alternative models suggested that it was better to treat the four constructs separately in our analysis. In addition, the lower AIC and CAIC confirmed the best fit with the data, so that the 4-factor model was preferable.

Table 3 reports LISREL results for the reliability and validity tests of the translated scales. As shown, all parameters were significant ($t \geq 6.41$) and greater than 0.50 (0.51 - 0.87), indicating convergent validity. In addition, AVE coefficients of the two scales (0.62 and 0.63) were aligned and significant being greater than 0.50. All constructs

Table 1 - Correlations (Pearson's *r*) and descriptive statistics of the Italian scales (N=277)

	1	2	3	4
1 Safety Knowledge	-			
2 Safety Motivation	0.49**	-		
3 Safety Compliance	0.45**	0.45**	-	
4 Safety Participation	0.39**	0.35**	0.48**	-
Mean	3.96	4.47	4.08	3.61
Standard Deviation	0.74	0.64	0.72	0.82
Skewness	-0.47	-1.28	-0.49	-0.36
Kurtosis	-0.02	1.22	-0.26	-0.24
# of items	4	4	4	4

Note. ** = correlation is significant at 99% confidence level

showed acceptable values of composite reliability (CR ≥ 0.73) and average variance extracted (AVE ≥ 0.41). To test for discriminant validity, for each construct we compared the square root of its AVE with its highest correlation with other constructs (see correlations in table 1). In all cases, the square root of a construct's AVE was greater than its highest correlation with other constructs, indicating discriminant validity.

Table 2 - Fit indices of three alternative measurement models tested for item dimensional analysis

Models	d.f.	S-Bχ^2	CFI	NNFI	RMSEA	SMRM	AIC	CAIC
1-factor	104	772.3	0.85	0.82	0.15	0.11	836.3	984.2
2-factors	103	561.5	0.89	0.88	0.13	0.09	627.5	780.1
4-factors	98	153.3	0.99	0.98	0.04	0.05	229.3	405.1

Note. d.f.=degrees of freedom; S-Bχ^2=Satorra-Bentler scaled chi-square; CFI=comparative fit index; NNFI=non-normed fit index; RMSEA=root mean square error of approximation; SRMR=standardized root mean square residual; AIC=Akaike information criterion; CAIC=consistent Akaike information criterion

Table 3 - CFA results for the validity and reliability tests of the Italian scales

Construct/*Items*	λ	*t*	CR	AVE
Safety Knowledge			0.86	0.61
Item 1	0.79	(n.a.)		
Item 2	0.84	16.05		
Item 3	0.76	12.59		
Item 4	0.75	12.57		
Safety Motivation			0.84	0.58
Item 5	0.72	(n.a.)		
Item 6	0.73	11.10		
Item 7	0.87	12.17		
Item 8	0.72	8.91		
Safety Compliance			0.86	0.61
Item 9	0.65	(n.a.)		
Item 10	0.77	8.86		
Item 11	0.86	8.85		
Item 12	0.83	8.78		
Safety Participation			0.73	0.41
Item 13	0.51	(n.a.)		
Item 14	0.70	6.41		
Item 15	0.67	6.65		
Item 16	0.67	6.79		

Note. n.a.=not available; t > 2.58 indicates parameter is significant at 99% confidence level; λ=standardized lambda parameters

Objective 2: estimation of the relationships between determinants and components of safety performance

The structural model depicted in Figure 1 was performed using robust maximum likelihood as the estimation procedure. Safety knowledge and safety motivation were not allowed to correlate. The model thus specified resulted in a S-Bχ^2 estimate of 221.22 (N=277; d.f.=100; p=0.00). The principal fit indices were coherent with the cut-off values defined by Hu and Bentler (22), suggesting that the model fitted the data satisfactorily (CFI=0.97; NNFI=0.97; RMSEA=0.06). The parameter estimates for all paths are shown in table 4. As can be seen, all paths were positive and significant. In addition, it is noteworthy to observe that the amounts of total variance explained by the predictors were nearly equal for safety compliance and safety participation. With respect to safety knowledge, this had a stronger relationship with safety participation than with safety compliance. Conversely, safety motivation had a stronger relationship with safety compliance than with safety participation. These results are discussed below.

Table 4 - LISREL results of path analysis (standardized gamma parameters and *t*-values in brackets)

	Safety Compliance	Safety Participation
Safety Knowledge	0.33 (3.96)**	0.39 (3.98)**
Safety Motivation	0.42 (5.59)**	0.29 (3.38)**
R^2	0.28	0.24

Note. **=significant at 99% confidence level

Discussion

In this study, we validated an Italian version of four scales measuring determinants (safety knowledge and motivation) and components (safety compliance and participation) of individual safety performance, as proposed by Neal et al. (29). These constructs represent an important and innovative contribution within the framework of the model developed by the said authors to explain the dynamics of safety behaviour in the workplace. Although this model has been recognised as adequate – and therefore widely used in safety research – currently there is mixed evidence on the specific relationships between determinants on the one hand and components of performance on the other. In response to this ambiguity, the study investigated these relationships together with an examination of the psychometric properties of the Italian version of the scales.

With respect to the study's first objective, the results confirmed the adequacy of the original items by Neal et al. (29), showing satisfactory reliability as well as validity of the Italian scales. However, as regards our second objective, the results did not confirm the original predictions stated by Neal et al. (29). Contrary to what was assumed by the said authors, in our study safety motivation showed a stronger relationship with safety compliance, suggesting that safety motivation is a more important determinant of compliance behaviour than safety participation. Similarly, the results also suggested that safety knowledge is a more important determinant of safety participation than safety compliance. Such results have some theoretical as well as practical implications (especially in suggesting further research directions) that will be discussed.

Firstly, the results relating to validity and reliability of the Italian scales support the adequacy of the original version provided by Neal et al. (29). The indices and estimates found in our study were substantially aligned with those found in previous studies examining the 4-item version of the scales (e.g., (25)). Considering these findings together with the lower validation and consistency of the more recent 3-item version of the scales, the suitability of using this 4-item version can be suggested to properly measure determinants and components of safety performance as conceptualized in Griffin and Neal's model of safety.

Secondly, relationship patterns between determinants and components of safety performance highlighted a known criticism of the differential impact hypothesis. In fact, this result is not surprising and strengthens findings from previous studies. This series of consistent findings raises both theoretical and practical questions. From a theoretical viewpoint, it reproposes the question of whether the constructs of safety knowledge and safety motivation are separable in the way proposed in terms of their specific impact on the components of safety behaviour (4). Consequently, to definitely reject the hypothesis, a possible direction for future research would be to explore the relationships between determinants and components by using measures differently operationalized. This solution appears particularly appropriate for safety motivation measurement: in fact, motivation items assessed the general value that employees placed on workplace health and safety and did not assess the value that individuals place on participation in safety activities within the workplace. A more specific and differentiated operationalization is also likely to help overcome the problem of social desirability influencing responses to the motivation items. Consistent with findings in Neal et al. (29), responses on the motivation scale in this study were close to ceiling values, which restricted the ability of the motivation scale to predict performance outcomes. From a practical point of view, relationship patterns between the safety constructs found in this study suggest that knowledge and motivation can be considered as equally important determinants of safety behaviour. This information can be used in the design of interventions to ensure that both aspects are targeted: for example interventions aimed solely at improving safety motivation (e.g., incentive programmes) could be less effective with respect to interventions that target both knowledge and motivation. An integrated intervention strategy aimed at increasing knowledge as well as motivation for safety have to consider at least three leverages (4): extension of management values and practice in safety issues, improvement of safety training, and development of organizational safety communication. As pointed out by Neal and Griffin (31), changing the work environment may be more difficult and time consuming than punishing or retraining the individual; however, in the long term, such change might be more effective. Indeed, interventions should develop an intrinsic motivation where safety is interesting and satisfying in itself and not only a way to achieve an external goal (extrinsic motivation) (27); moreover interventions should adopt more engaging training methods, that require trainees' active participation so that workers demonstrate greater knowledge acquisition, and achieve reductions in accidents, illnesses, and injuries (7). Finally, our results renew the call for the development of measurement systems to evaluate the efficacy of safety management practices (29). Incorporating measurements of knowledge, motivation, compliance, and participation in safety monitoring systems could provide a more accurate assessment of the effects and functioning of safety practices.

Lastly, the scores reported in our study offer useful preliminary information on the scales' calibration relating to the occupational sectors considered here (construction and logistics), which can be considered representative of safety-critical contexts. Further applications of the measurements will permit better calibration and comparisons between different sectors.

Obviously, our findings need to be discussed in the light of the limitations shared by most studies relying upon self-report questionnaires. The common method bias cannot be excluded, given that all measurements were based on self-reported tools. Moreover, the cross-sectional design of the study hindered the determination of sequential relationships connecting safety determinants and safety performance. Another limitation was the use of a mixed convenience sample. We were unable to gather information about the workers' role in their organizations (whether they were safety representatives or "simply" workers), the reasons for their presence at the safety courses (whether they were "volunteers" or "sent" to represent the whole organization), and the number of individuals from the same organization (i.e. how many organizations and workers per organization were tested). In addition, because of the classroom setting, informants could be more susceptible to social desirability, thus showing more motivation and commitment to safety. These aspects raise concerns on the sample's representativeness[1]; hence, any attempt to generalize the research findings must be made with caution. However, the means of the scales found in our study were aligned with those observed in other studies (4, 29), regarding both absolute values and the general pattern (in all the studies Safety Participation had the lowest score and the other variables were substantially aligned). This supports the possibility that our results are independent from the sample potential biases.

Taking into account the limitations described above, this research has enabled the development of a valid Italian version of the four scales proposed by Neal et al. (29), allowing measurement of workers' knowledge, motivation, compliance and participation related to safety. This represents an important practical contribution, as we believe that the availability of a validated instrument can promote the development of safety research as well as innovative solutions in guiding and monitoring safety interventions.

No potential conflict of interest relevant to this article was reported

References

1. Anderson JC, Gerbing DW: Structural equation modelling in practice: a review and recommend two-step approach. Psychol Bull 1988; *103*: 411-423.
2. Bagozzi RP, Yi Y: Specification, evaluation, and interpretation of structural equation models. J Acad Market Sci 2012; *40*: 8-34
3. Borman WC, Motowidlo SJ: Expanding the criterion domain to include elements of contextual performance. In Schmitt N, Borman WC (eds): *Personnel selection in organizations*. San Francisco (CA): Jossey-Bass, 1993: 71-98
4. Braunger P, Frank H, Korunka C, et al: Validating a safety climate model in metal processing industries: a replication study. Int J Occup Saf Ergon 2013; *19*: 143-155
5. Brislin RW: Back-translation for cross-cultural research. J Cross Cult Psychol 1970; *1*: 185-216
6. Brondino M, Silva SA, Pasini M: Multilevel approach to organizational and group safety climate and safety performance: co-workers as the missing link. Saf Sci 2012; *50*: 1847-1856

[1] We thank the anonymous reviewer who brought these aspects to our attention

7. Burke MJ, Sarpy SA, Smith-Crowe K, et al: The relative effectiveness of worker safety and health training methods. Am J Public Health 2006; *96*: 315–324
8. Campbell JP, Gasser MB, Oswald FL: The substantive nature of performance variability. In Murphy KR (ed): *Individual differences and behavior in organizations.* San Francisco (CA): Jossey-Bass, 1996: 258-299
9. Cavazza N, Serpe A: Effects of safety climate on safety norm violations: exploring the mediating role of attitudinal ambivalence toward personal protective equipment. J Safety Res 2009; *40*: 277-283
10. Christian MS, Bradley JC, Wallace JC, Burke MJ: Workplace safety: a meta-analysis of the roles of person and situation factors. J Appl Psychol 2009; *94*: 1103-1127
11. Cooper MD, Philips RA: Exploratory analysis of the safety climate and safety behaviour relationship. J Safety Res 2004; *35*: 497-512
12. Corso LD: Mediation effects of safety climate and safety motivation on the relation between organizational climate and safety performance in the workplace. TPM Test Psychom Methodol Appl Psychol 2008; *15*: 77-90
13. Cox S, Flin R: Safety culture: philosopher's stone or man of straw? Work Stress 1998; *12*: 189-201
14. Dedobbeler N, Beland F: Is risk perception one of the dimensions of safety climate? In Freyer A, Williamson A (eds): *Occupational injury: risk prevention and intervention.* London: Taylor and Francis, 1998: 73-81
15. Fornell C, Larcker DF: Evaluating structural equation models with unobservable variables and measurement error. J Mark Res 1981; *18*: 39-50
16. Glendon AI, Stanton NA: Perspectives on safety culture. Saf Sci 2000; *34*: 193-214
17. Griffin MA, Neal A: Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge and motivation. J Occup Health Psychol 2000; *5*: 347-358
18. Grimm KJ, Widaman KF: Construct validity. In Cooper HE, Camic PM, Long DL, Panter AT, Rindskopf DE, Sher KJ (eds): *APA handbook of research methods in psychology,* Vol 1: Foundations, planning, measures, and psychometrics. Washington DC: American Psychological Association, 2012: 621-642
19. Guldenmund FW: The nature of safety culture: a review of theory and research. Saf Sci 2000; *34*: 215-257
20. Hoffmeister K, Gibbons AM, Johnson SK, Cigularov KP, et al: The differential effects of transformational leadership facets on employee safety. Saf Sci 2014; *62*: 68-78
21. Hu L, Bentler PM, Kano Y: Can test statistics in covariance structure analysis be trusted? Psychol Bull 1992; *112*: 351-362
22. Hu LT, Bentler PM: Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling 1999; *6*: 1-55
23. James L, McIntyre M (eds): *Perceptions of organizational climate.* San Francisco (CA): Jossey-Bass, 1996
24. Jöreskog KG, S rbom D: LISREL 8.8 for Windows [Computer software]. Skokie: Scientific Software International Inc., 2006
25. Kwon OJ, Kim YS: An analysis of safeness of work environment in Korean manufacturing: the "safety climate" perspective. Saf Sci 2013; *53*: 233-239
26. Larsson S, Pousette A, Torner M: Psychological climate and safety in the construction industry-mediated influence on safety behaviour. Saf Sci. 2008; *46*: 405-412
27. Mariani MG, Soldà BL, Curcuruto M: Employee Safety Motivation: perspectives and measures on the basis of the Self-Determination theory. Med Lav 2015; *106*: 333-341
28. Mearns K, Whitaker SM, Flin R: Safety climate, safety management practice and safety performance in offshore environments. Saf Sci 2003; *41*: 641-680
29. Neal A, Griffin MA, Hart PM: The impact of organizational climate on safety climate and individual behavior. Saf Sci 2000; *34*: 99-109
30. Neal A, Griffin MA: Safety climate and safety at work. In Barling J, Frone MR (eds): *The psychology of workplace safety.* Washington DC: American Psychological Association, 2004: 15-34
31. Neal A, Griffin MA: A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group level. J Appl Psychol 2006; *91*: 946-953
32. Peterson RA, Kim Y: On the relation between coefficient alpha and composite reliability. J Appl Psychol 2013; *98*: 194-198
33. Satorra A, Bentler PM: Corrections to test statistics and standard errors in covariance structure analysis. In von Eye A, Clogg CC (eds): *Latent variables analysis: applications for developmental research.* Thousand Oaks: Sage, 1994: 399-419
34. Siu O, Phillips DR, Leung T: Safety climate and safety performance among construction workers in Hong Kong: the role of psychological strains as mediators. Accid Anal Prev 2004; *36*: 359-366
35. Vinodkumar MN, Bhasi M: Safety management practices and safety behaviour: assessing the mediating role of safety knowledge and motivation. Accid Anal Prev 2010; *42*: 2082-2093
36. Wu TC, Chen CH, Li CC: A correlation among safety leadership, safety climate and safety performance. J Loss Prevent Proc 2008; *21*: 307-318

37. Xu Y, Li Y, Ding W, Lu F: Controlled versus automatic processes: which is dominant to safety? The moderating effect of inhibitory control. PLoS One 2014; *9*: e87881
38. Zohar D: Safety climate in industrial organizations: theoretical and applied implications. J Appl Psychol 1980; *65*: 96-102
39. Zohar D: A group-level model of safety climate: testing the effect of group climate on micro accidents in manufacturing jobs. J Appl Psychol 2000; *85*: 587-596
40. Zohar D: Thirty years of safety climate research: reflections and future directions. Accid Anal Prev 2010; *42*: 1517-1522

Appendix

Appendix A. Original items by Neal et al. (29) and their Italian version in square brackets

Label	Content
Item 1	I know how to perform my job in a safe manner [So come compiere il mio lavoro in maniera sicura]
Item 2	I know how to use safety equipment and standard work procedures [So come usare i dispositivi di sicurezza e le procedure standard di sicurezza sul lavoro]
Item 3	I know how to maintain or improve workplace health and safety [So come mantenere o migliorare la sicurezza e la salute sul posto di lavoro]
Item 4	I know how to reduce the risk of accidents and incidents in the workplace [So come ridurre il rischio di infortuni e incidenti sul posto di lavoro]
Item 5	I believe that workplace health and safety is an important issue [Sento che la sicurezza e salute sul posto di lavoro è una problematica importante]
Item 6	I feel that it is worthwhile to put in effort to maintain or improve my personal safety [Sento che vale la pena sforzarsi per mantenere o accrescere la mia sicurezza personale]
Item 7	I feel that it is important to maintain safety at all times [Sento che è importante mantenere la sicurezza in ogni momento]
Item 8	I believe that it is important to reduce the risk of accidents and incidents in the workplace [Sento che è importante ridurre il rischio di infortuni e di incidenti sul posto di lavoro]
Item 9	I carry out my work in a safe manner [Svolgo il mio lavoro in modo sicuro]
Item 10	I use all the necessary safety equipment to do my job [Utilizzo tutto l'equipaggiamento necessario per portare avanti il mio lavoro]
Item 11	I use the correct safety procedures for carrying out my job [Uso le corrette procedure di sicurezza nello svolgimento del mio lavoro]
Item 12	I ensure the highest level of safety when I carry out my job [Garantisco il massimo livello di sicurezza quando svolgo il mio lavoro]
Item 13	I promote the safety program within the organization [Promuovo il programma di sicurezza all'interno dell'organizzazione]

Item 14	I put in extra effort to improve the safety of the workplace [Metto in atto uno sforzo extra per migliorare la sicurezza del posto di lavoro]
Item 15	I help my coworkers when they are working under risky or hazardous conditions [Aiuto i miei colleghi quando stanno lavorando sotto condizioni di rischio o di pericolo]
Item 16	I voluntarily carry out tasks or activities that help to improve workplace safety [Svolgo volontariamente compiti o attività che aiutano a migliorare la sicurezza del posto di lavoro]

Note. Item rating scale anchors: 1=strongly disagree; 2=disagree; 3=neither agree nor disagree; 4=agree; 5=strongly agree.
Nota. Ancoraggi delle scale di valutazione degli item: 1=forte disaccordo; 2=in disaccordo; 3=né d'accordo né in disaccordo; 4=in accordo; 5=forte accordo