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Measurement equivalence of a safety climate measure among Hispanic and White Non-Hispanic construction workers

Konstantin P. Cigularov [a,1], Paige G. Lancaster [b,1], Peter Y. Chen [c,*], Janie Gittleman [d], Elizabeth Haile [e]

[a] Department of Psychology, Old Dominion University, United States
[b] Department of Psychology, Colorado State University, United States
[c] International Graduate School of Business, City West Campus, University of South Australia, Adelaide, SA 5000, Australia
[d] Occupational Safety, Health & Environmental Compliance, Defense Intelligence Agency, United States
[e] Environmental Health Bureau, Prevention & Health Promotion Administration, Maryland Department of Health & Mental Hygiene, United States

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ABSTRACT

Research continues to expose ethnic disparities in safety and health outcomes, making comparative studies of work-related factors that may explain these disparities increasingly important. Such studies raise issues about the cross-ethnic validity of the measures used to assess the factors of interest, such as safety climate. The current study is the first to examine the measurement equivalence of a multidimensional safety climate scale. A multi-group confirmatory factor analytic approach was used to assess the equivalence of the measure across White English-speaking, Hispanic English-speaking, and Hispanic Spanish-speaking construction workers. Results indicated that the same pattern of factors and equivalent factor loadings adequately represented the safety climate items across groups. However, other differences in item parameters were identified, including non-equivalence of some error variances and intercepts. This study highlights the importance of establishing measurement equivalence before proceeding with mean comparisons among groups. Future research should continue to investigate why differences in safety-related perceptions across ethnicities might exist.

1. Introduction

Ethnic disparities in safety and health outcomes have received increased attention around the world in recent years (Ahonen et al., 2007; International Labour Organisation, ILO, 2004; National Research Council, 2003). ILO has shown disproportionally high accident rates among migrant workers in Europe. European Foundation for the Improvement of Living and Working Conditions (2007) further revealed that migrant workers with a non-western background tended to experience poor health conditions and be exposed to hazards at work, in addition to high work accident rates. This challenge is particularly noticeable in the US construction industry; given that there has been a dramatic surge of Hispanic workers in the US increasing from 705,000 in 1990 to about 3 million in 2007 (The Center for Construction Research and Training, CPWR, 2009).

There is strong research evidence indicating that Hispanic construction workers are more likely to suffer fatal and non-fatal injuries at work than any other ethnic group across all ages (Anderson et al., 2000; Dong et al., 2009; Dong and Platner, 2004; Fabrega and Starkey, 2001; Loch and Richardson, 2004; Platner and Dong, 2001). Explanations for the above disparities among Hispanic workers in the US, as well as migrant workers in Europe have included cultural factors (Faucett et al., 2001), insufficient education, training, and skills (Brunette, 2005), language barriers (Acosta-Leon et al., 2006; Magaña and Hovey, 2003), as well as limited understanding of on-the-job safety requirements and little or no work experience under government occupational safety and health regulations (Brunette, 2005; ILO, 2004). Considering the above and the fact that Hispanics currently comprise the largest ethnic minority group in the construction industry (Platner and Dong, 2001), there is a significant need for comparative studies aiming to understand the work-related factors that may explain disparities on occupational safety and health issues (Brunette, 2004). Such studies, however, raise issues about the cross-ethnic validity of the measures used to assess the factors of interest (Jorgensen et al., 2007).

1.1. Safety climate

Safety climate is one such factor, which has been viewed as an important antecedent to occupational safety and health in the construction industry (Mohamed, 2002) and thus has received significant attention in construction safety research (e.g., Goldenhar

* Corresponding author.
E-mail address: peter.chen@unisa.edu.au (P.Y. Chen).
[1] These authors contributed equally to this paper.

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et al., 2003; Gillen et al., 2002, 1997; Fang et al., 2006; Siu et al., 2004). Safety climate is a multidimensional construct, as suggested from both qualitative (e.g., Flin et al., 2000; Guldenmund, 2000) and quantitative research (e.g., Christian et al., 2009), defined as workers' perceptions of the organizational and management practices, policies, and procedures related to safety, as well as the relative priority of safety over schedules and production (Snyder et al., 2008; Zohar, 2003).

Since the first conceptualization of safety climate by Zohar in 1980, the topic of its measurement has been a prominent one, focusing on issues, such as levels of measurement, multidimensionality, and predictive validity (Neal and Griffin, 2006; Zohar, 2003). This interest is not surprising considering that safety climate has demonstrated its usefulness for both research and practice as evidenced by its consistent positive effects on perceived injury risk, safety behaviors, work-related injuries and pain, and the reporting of injury incidents in various industries and countries (Cigularov et al., 2008; Christian et al., 2009; Clarke, 2006; Huang et al., 2007; Nahrgang et al., 2011).

What is surprising, however, is that despite the widespread use of safety climate measures in the construction industry (e.g., Dedobbeleer and Beland, 1991; Gillen et al., 2002) and the increased interest in understanding occupational health disparities between Hispanic and non-Hispanic construction workers (National Research Council, 2003), there is no systematic research examining the cross-ethnic validity of safety climate measures. So, how do we know that a measure which is used to assess the safety climate perceptions of construction workers is interpreted in the same way by Hispanic and non-Hispanic construction workers?

1.2. Measurement equivalence

The current study is the first to address the cross-ethnic validity of safety climate measures by examining the measurement equivalence (ME) of a safety climate measure with a sufficiently large sample size. Demonstrating ME ensures that "the items have the same meaning for participants in different populations, or that they are interpreted in the same way and related to the constructs being measured equally well" (Cheung, 2008, p. 593). Only when such equivalence is established, researchers can proceed with examining mean group differences, having confidence that if the group differences found are due to actual differences in safety climate perceptions and are not an artifact of measurement error (Vandenberg and Lance, 2000; van de Vijver and Leung, 2000). Otherwise, when researchers erroneously assume ME across the compared groups, their mean comparisons may result in misleading conclusions, i.e., "comparing apples and oranges" (Hoyle and Smith, 1994, p. 433).

In this study, we were specifically interested in examining the ME of a multidimensional safety climate measure by comparing responses of three groups of construction workers working on the same job site: (a) White Non-Hispanic, who completed the measure in English, (b) Hispanic, who completed the measure in English, and (c) Hispanic, who completed the measure in Spanish.

This study directly addresses the pressing need for reliable and valid safety-related measures for use among Hispanic construction workers (Jorgensen et al., 2007), which also has important implications for migrant workers in general. Below, we discuss the role of ethnicity and language in the ME of safety climate scores of Hispanic and White Non-Hispanic construction workers.

1.3. The role of ethnicity and language in safety climate perceptions

Ethnicity and language are considered two essential indicators of culture (Kagitçibaşi and Berry, 1989; Lenartowicz and Roth, 2001; Peterson and Smith, 1997), which may affect the ME of a psychological measure (Robert et al., 2006). Individuals, who are members of the same ethnic group or share the same language, are likely to have similar general values (Hofstede, 2001; Inglehart and Baker, 2000). These values, in turn, can influence how individuals define and evaluate their work-related experiences (Riordan and Vandenberg, 1994). Thus, when workers with different values respond to an organizational survey, they may interpret and respond to the survey items differently. For example, a concept such as "safety" could have a different meaning for Hispanic construction workers, who may have a different frame of reference for complying or interpreting safety practices, compared to their non-Hispanic counterparts.

The meaning of safety may be understood through a different frame of reference by Hispanic workers due to different expectations and standards related to workplace safety, which may influence the interpretation of survey items. For example, evidence suggests that Hispanic immigrant workers consider pain, injuries, and illness as a normal and inevitable part of work (Faucett et al., 2001). In their study, Faucett et al. found that Hispanic immigrant workers were more inclined to describe their musculoskeletal symptoms as "bothersome discomforts" rather than "pain," because the workers reasoned that they were still able to work and were not suffering from illness. Such a subtle difference in the terms used could have a great impact on an individual's response to the safety survey items.

Second, many Hispanic immigrant workers arriving in the United States come from poor work environments where they have been routinely exposed to physical dangers without access to personal protective equipment, and it is unlikely that they have had health and safety training (Brunette, 2004). Thus, Hispanic immigrant workers may be accustomed to a work situation where hazards are expected, and there are few expectations about management taking responsibility for safety. Hispanic Spanish-speaking employees, who are more likely to be immigrants, may use a different reference point to respond to items regarding the extent to which safety is a priority to their managers or supervisors. If they have low expectations for the role of these individuals in creating a safe work environment, then Hispanic employees may respond to items pertaining to management commitment to safety differently than their non-Hispanic counterparts. In other words, Hispanic employees may be more lenient in rating the safety commitment of their management or supervisors. Should mean differences among ethnic groups (i.e., white English-speaking employees, Hispanic employees who speak English, and Hispanic employees who speak Spanish in the present study) be found, one might incorrectly interpret such differences without evidence of measurement equivalence.

In particular, there may be reason to expect differences between English-speaking employees and Spanish-speaking employees, as the Spanish-speaking employees are likely to be more recent immigrants. Hispanic immigrant workers in construction often lack education and language skills (Gilkey et al., 2002; Magaña and Hovey, 2003). The key risk associated with this language barrier is great difficulty or even an inability to comprehend safety warnings or safety-related information that is communicated in English (Brunette, 2004). A lack of information may leave these workers with inaccurate knowledge about proper safety practices, which may explain why foreign-born Hispanic workers experienced the vast majority (80%) of fatal falls from 2003 to 2006. Complicating the matter is the fact that immigrant workers who do not speak English will naturally gravitate toward others who speak their first language, which inhibits integration with English-speaking colleagues and improvement in English skills (Trajkovski and Loosemore, 2006). In their study of non-English-speaking employees on Australian construction sites, Trajkovski and Loosemore found that nearly half reported misunderstanding work-related

instructions because of their limited English skills, and many also reported avoiding safety training because of its English-only format. Based on this evidence of cultural and linguistic differences, it is possible that Hispanic construction workers, particularly those workers who do not speak or do not feel comfortable speaking English and were not born in the United States, may not have the same understanding of what is expected of employees in terms of safety practices on the job site. If some workers are not very knowledgeable of appropriate safety practices, then this may have an effect on their responses to survey items which ask them to indicate the extent to which proper safety practices are followed at their job site.

Additionally, there may be differences in perceptions of Hispanic and non-Hispanic workers due to varying beliefs regarding the status of managers versus employees. Power inequality is greater in some cultures as compared to others, and Hofstede's (2001) notion of power distance refers to the extent to which less powerful members of an institution accept and expect power to be distributed unequally. Latin American countries tend to score higher on power distance as compared to the United States such that there is a greater divide between individuals who hold power and individuals who do not. In contrast to other countries, the United States is a relatively lower power distance country, and there are fewer barriers for lower status individuals to challenge higher status individuals (Hofstede, 2001). One implication of a high power distance culture for the workplace is that managers will be perceived as figures that deserve power and respect and employees are unlikely to disagree with or question managers. For example, Hispanic workers may be hesitant to disagree with a statement about management's commitment to safety, because they would not want to be perceived as questioning management's behavior. There may be a reluctance to be perceived as criticizing one's supervisor, or there may be a lower expectation for the supervisor's role in safety activities. Anecdotal evidence from a safety training program indicated that Hispanic workers are reluctant to challenge authority or identify problems on job sites (Nash, 2004). They might agree to do unsafe jobs, continue on a job when there is a problem, and avoid pointing out risks, because there is a cultural avoidance of saying "No". On a related note, Hispanic workers may experience an additional motivation for avoiding confrontations with supervisors that is due to fear related to their immigration status or pressure to remain employed (Brunette, 2004). Thus, one might find differences in safety climate item responses that are due to these differences in the frame of reference, and are not actually due to true differences in safety climate perceptions.

A final factor which may influence safety climate responses across cultures and ethnicities is the concept of machismo (i.e., a strong sense of masculine pride), which appears to be a factor in Hispanic employees' understanding of safety. There may be a tendency to ignore safety issues or fail to bring them up with a supervisor because it indicates someone is less masculine (Thompson and Siddiqi, 2007). In their review of organizations that have been successful at improving safety among their Hispanic workforce, Thompson and Siddiqi noted that Hispanic employees should be educated that it is not only appropriate but expected that they raise safety concerns with their supervisors. This notion of machismo may also lead to reluctance to admit that the pace of work is too much to handle. Other employees might be more willing to admit that their workload is too high, because they would attribute fault to the organization. However, employees who are influenced by machismo may be less inclined to agree that the workload is too much for them.

This is consistent with research indicating that culture plays an important role in occupational safety and health (Burke et al., 2008), and specifically how organizational safety climate is created and perceived (Peckitt et al., 2004; Rochlin and von Meier, 1994). The impact of cultural differences on safety climate perceptions in the construction industry has also been documented (Peckitt et al., 2004), with some of this research showing cultural differences in occupational safety and health management practices between construction workers and managers from the US and Mexico (Drysdale, 1995; Meshkati, 1999). As noted by Thompson and Siddiqi (2007), it would be impossible to separate safety issues from cultural issues. As a result, it is possible that measures assessing safety climate are not interpreted the same way by Hispanic Spanish-speaking workers, Hispanic English-speaking workers, and White Non-Hispanic workers. This issue has important implications because it affects the interpretation of results from cultural comparison studies. For example, researchers in one study reported being surprised by their finding that employees who did not speak English reported more positive perceptions of safety compared to those employees that spoke English (Parker et al., 2007). These significant mean differences were unexpected and difficult to explain. Unless measurement equivalence of the scale is demonstrated first, then it is possible that a true difference in perceptions exists, but it is also possible that the workers were using a different frame of reference when responding to the survey and the measures are not actually equivalent.

Measurement equivalence studies are critical for determining whether members of different cultures interpret a measure in a conceptually similar way. Unknowingly, a measure can mean one thing to one group and something completely different to another group. Conducting tests of observed mean differences involves assumptions of measurement equivalence whether researchers are aware of it or choose to acknowledge it. If these assumptions are not tested, any substantive interpretations of results are threatened and any conclusions have no evidentiary basis (Vandenberg and Lance, 2000). Before researchers can make comparisons between cultural or linguistic groups, it is imperative to empirically establish the equivalence of the measures. The current study will investigate the measurement equivalence of a multi-dimensional safety climate measure among three groups of construction workers: (1) White Non-Hispanic workers who completed the survey in English, (2) Hispanic workers who chose to complete the survey in English, and (3) Hispanic workers who chose to complete the survey in Spanish. The results of the tests of equivalence will provide insight into how these populations interpret safety climate in ways which may be similar or different from one another.

2. Method

2.1. Participants

As part of a large safety needs assessment project, a total of 5268 construction workers completed a survey (either an English or Spanish version) during their safety training with a response rate of 87%. To ensure anonymity, information about gender was not collected because there were very few female workers in this sample. In terms of ethnicity, 2341 (44%) of the participants were White Non-Hispanic, 1850 (35%) were Hispanic, 376 (7%) were African–American, 164 (3%) were Native American, 65 (1%) were Asian, 188 (4%) were 'Other,' and 284 (5%) did not report ethnicity. Of the 1850 workers who described themselves as Hispanic, 1318 (71%) chose to complete the English version of the survey and 532 (29%) completed the Spanish version.

For the purposes of this study, we included in the analyses only respondents who identified themselves as White Non-Hispanic and completed the English version of the survey ($n = 2332$), Hispanic, who completed the English version ($n = 1318$), or Hispanic, who completed the Spanish version ($n = 532$) for a total sample of 4182 construction workers. Fourteen different construction

trades were represented in the current sample with carpenters (23.5%), plumbers/pipe fitters (15.6%), electricians (14.7%), and sheet metal workers (10.8%) showing the highest percentages of participation and constituting 64.6% of all trades in this sample. The average age was 40.52 years (*SD* = 11.86) for White Non-Hispanic, 35.99 years (*SD* = 9.58) for Hispanic who completed the English version, and 35 years (*SD* = 8.57) for Hispanic who completed the Spanish version. The average number of years worked in the construction industry was 18.20 years (*SD* = 11.62) for White Non-Hispanic, 12.09 years (*SD* = 8.08) for Hispanic who completed the English version, and 11.14 years (*SD* = 7.42) for Hispanic who completed the Spanish version. The average number of months on the job was 4.81 months (*SD* = 5.51) for White Non-Hispanic, 5.54 months (*SD* = 5.82) for Hispanic who completed the English version, and 7.8 months (*SD* = 7.32) for Hispanic who completed the Spanish version. There were 79.9%, 77.9%, and 82% journeymen (in contrast to apprentices) for the above three groups, respectively. No gender information was asked in the survey, although about 10% of construction workers are females (The Center for Construction Research and Training, 2008).

2.2. Procedure

The surveys were administered during 10-h on-site safety trainings by trainers and training coordinators. First, participants were provided with background information describing the voluntary nature of the survey and that the purpose of the survey was to collect information about safety on the site. There was no individually identifying information collected. Then, participants were provided the surveys and asked to complete them in 10 min. All participants were given the option of completing either an English or Spanish version of the survey. Once completed, the surveys were collected by the trainer/coordinator and put in a sealed self-addressed envelope and sent directly back to the researchers.

2.3. Measures

Based on safety climate surveys available in the literature (e.g., Griffin and Neal, 2000; Huang et al., 2006; Mueller et al., 1999; Zohar and Luria, 2005), as well as Neal and Griffin's (2004) framework of safety climate, a four-dimension safety climate measure (i.e., management commitment to safety, safety practices, supervisor support for safety, and work pressure) was developed to meet the specific needs of the partnering organization by a team of occupational safety and health experts including researchers from CPWR, The Center for Construction Research and Training and the National Institute for Occupational Safety and Health. An initial English version with 25 items was first pilot tested among 120 construction workers. After item analyzing the initial items, 19 items were retained. A bi-lingual staff member of CPWR translated the finalized scales from English to Spanish, and the Spanish version was pilot tested with bi-lingual trainers at CPWR to ensure its accuracy and readability. Reliability and validity evidence of the four-dimensional safety climate measure were demonstrated and reported by Gittleman et al. (2010).

The response scale for all survey items was a 6-point Likert scale with response categories ranging from 1 = "strongly disagree" to 6 = "strongly agree". Table 1 displays the means, standard deviations, ranges, Cronbach's alphas, and intercorrelations among the four dimensions for each sample. Each dimension of the scale is described below, and English and Spanish items of each dimension are displayed in Table 2.

2.3.1. Management commitment to safety

This 7-item scale is considered one of the most important dimensions of safety climate (Flin et al., 2000; Seo et al., 2004; Zohar, 1980, 2003), which refers to the extent to which top management identifies safety as a priority and core value of the organization and manages safety issues effectively. Management commitment to safety has been associated with more safety behaviors (Mohamed, 2002; Pousette et al., 2008), higher safety levels (Jaselskis et al., 1996), and workers' willingness to co-operate to improve safety performance (Langford et al., 2000). An example item is "The General Contractor thinks that job site safety is more important than job schedules and deadlines".

2.3.2. Safety practices

This 4-item scale assesses the extent to which safety-related training, toolbox talks, and site-specific information, as well as personal protective equipment are perceived to be adequate and available. Safety practices play an important role in workplace safety (Cohen, 1977; Coyle et al., 1995; Williamson et al., 1997; Zohar,

Table 1
Descriptive statistics, Cronbach's alphas, correlations between dimensions, and observed mean differences for three construction worker samples.

Scale	Observed mean	SD	Observed range	Possible range	1	2	3	4
White Non-Hispanic English[1]								
1. Management commitment	29.36[b,c]	7.31	7–42	7–42	(.91)			
2. Safety practices	19.62[b]	3.24	4–24	4–24	.37*	(.73)		
3. Supervisor support	29.31	5.58	6–36	6–36	.39*	.58*	(.92)	
4. Work pressure	4.69[b,c]	2.40	2–12	2–12	−.21*	−.26*	−.32*	(.70)
Hispanic English[2]								
1. Management commitment	31.96[a,c]	6.96	7–42	7–42	(.92)			
2. Safety practices	19.20[a]	3.70	4–24	4–24	.47*	(.79)		
3. Supervisor support	29.40	5.47	6–36	6–36	.54*	.63*	(.90)	
4. Work pressure	5.01[a,c]	2.74	2–12	2–12	−.01	−.18*	−.21*	(.75)
Hispanic Spanish[3]								
1. Management commitment	33.65[a,b]	6.29	9–42	7–42	(.84)			
2. Safety practices	19.55	4.30	4–24	4–24	.63*	(.82)		
3. Supervisor support	29.49	6.24	6–36	6–36	.68*	.71*	(.90)	
4. Work pressure	5.48[a,b]	2.94	2–12	2–12	−.22*	−.23*	−.30*	(.69)

Note: Cronbach's alphas are presented in parentheses along the diagonal.
[1] *N* = 2043–2070.
[2] *N* = 1068–1151.
[3] *N* = 497–517.
[a] Indicates a group that is significantly different from White Non-Hispanic.
[b] Indicates a group that is significantly different from Hispanic English.
[c] Indicates a group that is significantly different from Hispanic Spanish.
* $p < .01$.

Table 2
Construction safety climate scale items (English and Spanish versions).

Item number	Item	Dimension
Q1	Safety is visible on this job – for example, I have seen safety personnel or site supervisors or site management doing daily safety checks *La seguridad es evidente en este trabajo – por ejemplo yo he visto al personal de seguridad haciendo chequeos diarios*	Management commitment to safety
Q2	The General Contractor thinks that job site safety is more important than job schedules and deadlines *El Contratista General cree que la seguridad en el lugar de trabajo es mas importante que los horarios de trabajo o las fechas limites para terminar la obra*	
Q3	[The General Contractor] safety personnel step into stop unsafe operations *El personal de seguridad de [ ] interviene para parar (detener) operaciones (maniobras) inseguras*	
Q4	[The General Contractor] thinks that safety is more important than productivity *[ ] cree que la seguridad es más importante que la productividad*	
Q5	The [The General Contractor] safety staff follows up when there is a problem – it gets fixed right away and stays that way *Cuando hay algún problema, el personal de seguridad de [ ] le da seguimiento. El problema se corrige de inmediato y así se queda*	
Q6	[The General Contractor] likes to get safety reports/feedback from workers like me *A [ ] le gusta recibir reportes de seguridad que vienen de trabajadores como yo*	
Q7	[The General Contractor] cares for my safety on this job *[ ] se preocupa por mi seguridad en este trabajo*	
Q8	My foreman has the safety knowledge needed for the hazards we face on this job *Mi supervisor tiene el conocimiento de las medidas de seguridad que se tienen que tomar para protegernos de los peligros que enfrentamos en este trabajo*	Supervisor support for safety
Q9	My foreman makes sure we follow site safety rules and procedures very closely *Mi supervisor se asegura de que sigamos las normas y procedimientos de seguridad del sitio debidamente*	
Q10	My foreman wants us to inform him/her of any safety problems so they can get them fixed or reported to others *Mi supervisor quiere que le informemos de cualquier problema de seguridad que se presente en la obra para repararlo o reportarlo a sus superiores*	
Q11	If my foreman is unsure of a safety question, he or she always calls in a safety specialist *Cuando mi supervisor no está seguro de alguna medida de seguridad, el o ella siempre consulta con un especialista en seguridad*	
Q12	My foreman thinks that safety is more important than productivity *Mi supervisor cree que la seguridad es más importante que la productividad*	
Q13	My foreman stops work if working conditions are unsafe, even if we have a deadline *Mi supervisor para (detiene) las operaciones en la obra cuando las condiciones de trabajo son inseguras, aunque tengamos fecha limite para terminar el trabajo*	
Q14	There is always enough personal protective equipment available to allow work to be done safely *Siempre hay suficiente equipo de protección personal en la obra para asegurar que el trabajo se realice de forma segura*	Safety practices
Q15	I have received enough training to do my work safely *Yo he recibido suficiente entrenamiento para poder realizar mi trabajo en forma segura*	
Q16	I always get enough site-specific information about a job to do it safely *Yo siempre recibo suficiente información con respecto al sitio de trabajo para realizar mis tareas en forma segura*	
Q17	Toolbox talks about safety are given regularly. *Nosotros tenemos reuniones de seguridad constantemente*	
Q18	Sometimes I do not report a hazard because there is not time to stop work or the work task is of too short a duration, so I work around the hazard *Algunas veces no reporto condiciones de peligro porque no hay tiempo de parar el trabajo*	Work pressure
Q19	Sometimes I ignore a safety rule or policy in order to carry out an assignment to meet the schedule *Algunas veces yo no obedezco reglas y procedimientos para poder terminar el proyecto a tiempo*	

Note: Brackets indicate the name of the organization was used in the item.

1980). An example item is "Toolbox talks about safety are given regularly".

2.3.3. Supervisor support for safety

While top management is mostly concerned with establishing safety policies and procedures, first-line supervisors are the ones responsible for implementing these policies and procedures through their actions (Zohar, 2003). There is strong evidence of the association of effective supervisory support with increased safety behaviors and fewer accidents and injuries (Christian et al., 2009; Zohar, 2000). Six items were used to measure supervisor support for safety focusing on the extent to which foremen place a high priority on safety, are competent about safety, respond effectively to safety concerns, and encourage subordinates to comply with safety rules and procedures. An example item is "My foreman makes sure we follow site safety rules and procedures very closely".

2.3.4. Work pressure

Two items indicating the extent to which workload is perceived to exceed construction workers' capacity to perform their tasks safely were used to assess work pressure, which has been consistently related to safety behaviors and accidents/injuries (Christian et al., 2009). These items were "Sometimes I don't report a hazard because there isn't time to stop work or the work task is of too short a duration, so I work around the hazard" and "Sometimes I ignore a safety rule or policy in order to carry out an assignment to meet the schedule".

3. Statistical analyses

Multi-group confirmatory factor analysis (MGCFA) was utilized to assess measurement equivalence. This approach consists of a series of tests where equalities are placed on various item parameters with increasing constraints at each step in the process. The first step commonly consists of testing whether the confirmatory factor analysis (CFA) model assumes a common form across groups. Subsequent analyses test if there is equivalence in the regression slopes which link the latent variable to the manifest indicators (i.e., equivalence of the factor loadings; metric invariance), the regression intercepts which link that latent variable to the manifest indicators, the unique variances of the items, and

Table 3
Series of measurement equivalence tests.

Model number	Model type	Model constraints	Model interpretation
1	Configural invariance	Same factor structure	Factor model holds in each sample
2	Metric invariance	Equal factor loadings	Indicators relate to the latent factor in the same way
3	Error covariance invariance	Equal error covariance between items Q2 and Q4	Error covariance between these items is the same across groups
4	Uniqueness invariance	Equal uniquenesses/error variances	Indicators are measured with the same error
5	Scalar invariance	Equal intercepts	Indicators have the same intercepts (means) across groups
6	Latent means model	Introduce latent means	Differences in latent means
7	Factor variance invariance	Equal factor variances	Equal variances in the latent factors across groups
8	Factor covariance invariance	Equal factor covariances	Equal covariances among latent factors across groups
9	Latent means equal	Equal latent means	Latent means are equal across groups

the variances and covariances of the latent variables (Vandenberg and Lance, 2000). At each step, the question of interest is the extent to which the additional constraints reduce the fit of the model. If the model fit does not become significantly worse, then one can conclude that the additional invariance restriction is appropriate and can be retained.

Specifically, at the first step, a four-factor measurement model was hypothesized and evaluated in each of the three samples (i.e., White Non-Hispanic who completed an English survey, Hispanic who completed an English survey, and Hispanic who completed a Spanish survey) via the multi-group confirmatory factor analytic approach. To examine model fit, the two most often cited goodness-of-fit indices were used, as recommended in the literature (Byrne, 2006; Meade et al., 2008; Vandenberg and Lance, 2000): comparative fit index (CFI) and root mean square error of approximation (RMSEA). The CFI is considered an incremental fit index that compares the model of interest with a null or independence model (Bentler, 1990), with CFI values of .90–.95 indicating acceptable fit and values above .95 indicating good fit (Hu and Bentler, 1999). RMSEA is considered an absolute fit index that estimates lack of model fit and compensates for model complexity, with values of .05 or lower as indicating a well-fitting model, .05–.08 indicating a moderate fit, and .10 or greater indicating poor fit (Browne and Cudeck, 1993). Additionally, traditional chi-square statistics are reported. However, due to the large samples in this study and the sensitivity of the chi-square likelihood ratio test to sample size, chi-square test results were not used in interpreting model fit.

Then, following recommendations from Vandenberg and Lance (2000) and Ployhart and Oswald (2004), a series of models depicted in Table 3 were compared. This analysis begins with tests of configural invariance (i.e., equal number and pattern of factors), metric invariance (i.e., equal factor loadings), and uniqueness invariance (i.e., equal error variances). Next, a test of scalar invariance (i.e., equal indicator intercepts) is conducted and then latent mean differences are introduced into the model. Finally, tests of structural invariance (i.e., equal factor variances and covariances) are conducted and the equality of latent means is assessed. For the purposes of this study, Cheung and Rensvold's (2002) ΔCFI critical value of .01 was used as criterion for adequate measurement equivalence. In other words, if the ΔCFI value was observed to be greater than .01, this would indicate that the more-constrained model exhibits significantly worse fit compared to the less-constrained model and implies that the additional equivalence constraints are not appropriate to include.

4. Results

4.1. Identification of outliers and multivariate normality

Analyses were conducted with SPSS 19 and Mplus 6.0. Cases determined to be outliers in terms of multivariate normality based on Mardia's coefficient values were deleted from the analysis. This included two cases from the White English-speaking group, three cases from the Hispanic English-speaking group, and two cases from the Hispanic Spanish-speaking group. Following closer examination of management commitment items Q2 and Q4, an error covariance was included due to the similarity in item content. Such correlated errors have been modeled in CFA research because they tend to represent nonrandom measurement error (Byrne et al., 1989). Item Q2 was "The General Contractor thinks that job site safety is more important than job schedules and deadlines" and item Q4 was "[The General Contractor] thinks that safety is more important than productivity". The brackets indicate the actual company name that was used in the survey item. Due to non-normality of the data and missing data, it was determined that the Mplus MLR estimator would be most appropriate for the series of multi-group CFA analyses as this provides maximum likelihood parameter estimates with standard errors and a chi-square test statistic that are robust to non-normality (Muthén and Muthén, 2010).

4.2. Examination of factor structure

Within-group tests of the four-factor measurement model were conducted. Table 4 displays model fit statistics supporting the four-factor model with the best fit. The hypothesized four-factor model was compared with a single-factor model, representing a higher order safety climate factor (Hahn and Murphy, 2008), and the four-factor model provided a substantially better fit to the data for each of the three samples ($\Delta\chi^2 = 4735.087$, 1850.942, 344.591, $p < .001$ for White English-speaking, Hispanic English-speaking, and Hispanic Spanish-speaking individuals, respectively). This four-factor model was also compared to a two-factor model which combined the management commitment and safety practices dimensions into an organizational factor and combined the supervisor support and work pressure dimensions into a group factor, following Neal and Griffin's (2004) safety climate framework. Again, the four-factor model provided a significantly better fit to the data ($\Delta\chi^2 = 1645.249$, 983.598, 210.263, $p < .001$, for White English-speaking, Hispanic English-speaking, and Hispanic Spanish-speaking individuals, respectively). The four-factor model also resulted in substantial improvements compared to the single-factor model and two-factor model in both the CFI (.953–.961 compared to .634–.844 and .829–.888) and RMSEA (.040–.046 compared to .077–.126 and .066–.083) in each of the three groups and was retained for the multiple-groups analysis.

4.3. Examination of measurement equivalence

We began with tests of measurement equivalence across the three groups. Table 5 displays results from the series of increasingly restrictive tests of measurement equivalence. A configural

Table 4
Tests of within-group measurement model fit of the construction safety climate scale.

Sample	Model	χ^2	*df*	CFI	RMSEA	90% CI of RMSEA
White English-speaking (n = 2253)	1-Factor	5579.990	151	0.634	0.126	0.123–0.129
	2-Factor	2490.152	150	0.842	0.083	0.080–0.086
	4-Factor	844.903	145	0.953	0.046	0.043–0.049
Hispanic English-speaking (n = 1253)	1-Factor	2285.485	151	0.712	0.106	0.102–0.011
	2-Factor	1418.141	150	0.829	0.082	0.078–0.086
	4-Factor	434.543	145	0.961	0.04	0.036–0.044
Hispanic Spanish-speaking (n = 528)	1-Factor	624.838	151	0.844	0.077	0.071–0.083
	2-Factor	490.510	150	0.888	0.066	0.059–0.072
	4-Factor	280.247	145	0.955	0.042	0.035–0.049

Note: Statistics are based on Mplus MLR estimator. CFI = comparative fit index; RMSEA = root mean square error of approximation; CI = confidence interval.

Table 5
Tests of measurement invariance for the four-factor model of the construction safety climate scale across three samples.

Model	χ^2	*df*	CFI	Compare	ΔCFI	RMSEA	90% CI for RMSEA
M1: configural invariance	1554.448	435	0.955	–	–	0.044	.041–.046
M2: metric invariance	1666.190	465	0.952	M1	−.003	0.044	.042–.046
M3: error covariance invariance	1663.773	467	0.952	M2	0	0.041	.041–.046
M4: uniqueness invariance	2081.559	505	0.937	M3	−0.015	0.048	.046–.050
M4.1: partial uniqueness invariance, Q6 free for H-S	2005.385	504	0.940	M3	−0.012	0.047	.045–.049
M4.2: partial uniqueness invariance, Q6 and Q19 free for H-S	1944.735	503	0.943	M3	−0.009	0.046	.044–.048
M5: scalar invariance	2457.608	541	0.924	M4.2	−0.019	0.051	.049–.053
M5.1: partial scalar invariance, Q23 free for H-S	2417.318	540	0.925	M4.2	−0.018	0.051	.049–.053
M5.2: partial scalar invariance, Q23 free for H-S, Q26 free for W-E	2383.413	539	0.927	M4.2	−0.016	0.050	.048–.053
M5.3: partial scalar invariance, Q23 free for H-S; Q26 and Q33 free for W-E	2344.133	538	0.928	M4.2	−0.015	0.050	.048–.052
M5.4: partial scalar invariance, Q23 free for H-S; Q26, Q33, and Q4 free for W-E	2310.486	537	0.929	M4.2	−0.014	0.050	.047–.052
M5.5: partial scalar invariance, Q23 free for H-S; Q26, Q33, Q4, and Q2 free for W-E	2279.045	536	0.931	M4.2	−0.012	0.049	.047–.051
M5.6: partial scalar invariance, Q23 and Q10 free for H-S; Q26, Q33, Q4, and Q2 free for W-E	2253.921	535	0.932	M4.2	−0.011	0.049	.047–.051
M5.7: partial Scalar Invariance, Q23, Q10, and Q3 free for H-S; Q26, Q33, Q4, and Q2 free for W-E	2223.368	534	0.933	M4.2	−0.010	0.049	.046–.051
M6: latent means differ	2081.970	526	0.938	-	–	0.047	.045–.049
M7: factor variance invariance	2194.402	534	0.934	M6	−0.004	0.048	.046–.050
M8: factor covariance invariance	2289.213	546	0.931	M7	−0.003	0.049	.047–.051
M9: equality of latent means	2417.823	554	0.926	M8	−0.005	0.050	.048–.052

Notes: N = 4036. Statistics are based on Mplus MLR estimator. CFI = comparative fit index; RMSEA = root mean square error of approximation; CI = confidence interval; H-S = Hispanic Spanish-speaking group; W-E = White English-speaking group.

equivalence test of an equal number of factors and pattern of factor loadings indicated a good fit (CFI = .955, RMSEA = .044). Next, an additional constraint of equal factor loadings was imposed in the test of metric invariance. If this constraint does not substantially reduce model fit, then metric invariance can be supported. The results indicated there was not a substantial reduction in model fit (ΔCFI = −.003), indicating that the constraint may be retained since the strength of relationships between the latent factors and the corresponding items are equivalent across groups. Then, we tested whether the error covariance between the two management commitment items was equivalent across groups and results indicated support for this equality constraint (ΔCFI = .000).

The next test of uniqueness invariance indicated that error variances were not equivalent across groups (ΔCFI = −.015; see model 4 in Table 5). In order to test for partial uniqueness invariance, modification indices, parameter estimates, and item content were examined in order to determine where lack of equivalence may exist across groups (Ployhart and Oswald, 2004). Items with slightly more complex wording, large modification index values, and relatively greater differences in parameter estimates among groups might explain the lack of full invariance of uniquenesses or error variances. This process suggested that there were two items in the Hispanic Spanish-speaking group which had error variances that may not be equivalent to the other two groups. One of these items was in the management commitment dimension (Q5: The [General Contractor] safety staff follows up when there is a problem – it gets fixed right away and stays that way). The other item was in the supervisor support dimension (Q13: My foreman stops work if working conditions are unsafe, even if we have a deadline). A model with partial uniqueness invariance (i.e., without constraining these two error variances for the Hispanic Spanish-speaking group) resulted in model fit that was not significantly different from the metric invariance model (ΔCFI = −.009; see model 4.2 in Table 5). These two error variances were allowed to vary in subsequent analyses.

Then, scalar invariance was assessed by constraining intercepts to be equal across groups. This provided a significantly worse fit to the data (ΔCFI = −.019; see model 5 in Table 5), which suggests, as accepted practice (Schmitt and Kuljanin, 2008), to explore partial scalar invariance. In order to test for partial scalar invariance, intercept constraints were released one at a time from either the White English-speaking group or the Hispanic Spanish-speaking group (see models 5.1–5.7 in Table 5). Similar to the test of partial uniqueness invariance discussed above, these decisions were based on examination of modification indices, parameter estimates, and

item content. The process of freeing intercepts for a particular group continued until a partial intercept invariance model was found that was not significantly different from the uniqueness model (ΔCFI = −.010; see model 5.7 in Table 5). For the White English-speaking group, two management commitment items (Q2: The General Contractor thinks that job site safety is more important than job schedules and deadlines, and Q4: [The General Contractor] thinks that safety is more important than productivity) and two safety practices items (Q15: I have received enough training to do my work safely and Q17: Toolbox talks about safety are given regularly) were found to have non-equivalent intercepts compared to the Hispanic English-speaking and Hispanic Spanish-speaking groups. For the Hispanic Spanish-speaking group, two management commitment items (Q3: [The General Contractor] safety personnel step into stop unsafe operations and Q7: [The General Contractor] cares for my safety on this job) and one work pressure item (Q18: Sometimes I do not report a hazard because there is not time to stop work or the work task is of too short a duration, so I work around the hazard) were found to have non-equivalent intercepts compared to the White English-speaking and Hispanic English-speaking groups. Generally, for the management commitment items, the Hispanic Spanish-speaking group tended to have higher intercept values while the White English-speaking group tended to have lower intercept values. For the safety practices items, the White English-speaking group tended to have higher intercept values compared to the other two groups, and in the work pressure items, the Hispanic Spanish-speaking group tended to have lower intercept values compared to the other two groups.

Then, we introduced the latent means into the model and allowed these latent means to vary. This would serve as a baseline for subsequent tests of structural invariance and latent mean differences (Ployhart and Oswald, 2004). Next, we analyzed whether the factor variances were invariant and found that there was support for equality of the factor variances (ΔCFI = −.004). This indicates that there are no group differences in the amount of variability in the latent factors. Equality constraints on factor covariances were also supported, indicating a lack of group differences in the covariances between latent factors (ΔCFI = −.003). Finally, we imposed equality constraints on the latent means in order to test whether there are group differences in the latent safety climate factors. Results showed there was not a significant reduction in model fit (ΔCFI = −.005). Substantively, this reveals that there are no differences in the latent factor means under the partial scalar invariance condition.

5. Discussion

Research has continued to demonstrate that Hispanic workers experience workplace injuries and fatalities at a higher rate compared to other ethnic groups (Dong et al., 2009). In identifying workplace factors that lead to injuries on the job, recent work has highlighted safety climate as a leading indicator of safety performance and injuries (e.g., Christian et al., 2009; Nahrgang et al., 2011). Employers should be encouraged to measure safety climate on their job sites in order to identify and rectify organizational and management issues related to safety prior to the occurrence of safety incidents. However, there has not been any research examining whether different populations of workers interpret and respond to safety climate in an equivalent manner. The purpose of the current study was to address this gap in the literature by investigating the measurement equivalence of safety climate across populations of White English-speaking workers, Hispanic English-speaking workers, and Hispanic Spanish-speaking workers.

5.1. Summary and Interpretation of results

The series of MGCFA models provided evidence that respondents across the three groups utilized the same latent dimensions while responding to the safety climate measure. Results confirmed that the four-factor model of safety climate provided a good fit to the data in each of the three demographic groups. This study also provided evidence that there are equivalent factor loadings across groups, supporting the notion that the items are calibrated equivalently to the true scores in each of the three populations. These results indicated that the Spanish version of the measure reflected the same conceptualization of safety climate dimensions as the English version, and this finding is encouraging for safety climate research.

We also found that the majority of items demonstrated equivalent reliability based on invariance of unique variances in the presence of equivalent factor variances (Vandenberg and Lance, 2000). However, tests of measurement equivalence indicated some differences in the safety climate measures among the three groups which deserve further consideration. Two item uniquenesses were non-equivalent for the Hispanic Spanish-speaking group. One potential explanation is the complex content of those particular items, because both items actually include two clauses. It is possible that the complexity of these statements combined with slight translation issues to introduce a differential amount of error for Spanish-speaking respondents. Results of the scalar invariance test revealed that there were differences found in seven item intercepts. As described by Ployhart and Oswald (2004), interpretation of intercept differences is highly dependent on one's theoretical perspective. In a randomized experiment with a treatment effect for one group, we would have reason to expect a true difference in the latent mean of these groups that would show up in the items. However, in the case of a survey that has been carefully translated to be appropriate for another culture, there is not a theoretical reason to speculate why the groups differ on intercepts. Thus, a logical interpretation pertaining to differences in item intercepts would likely be attributed to item bias, such as a leniency effect (Ployhart and Oswald, 2004). Once partial scalar invariance was allowed, subsequent tests of latent mean invariance indicated that there was support for equality of the latent means. Thus, there were no true differences in safety climate among the three groups after accounting for the non-equivalent item intercepts.

For management commitment, higher item intercepts were observed for the Hispanic Spanish-speaking group while the White English-speaking group had lower intercept values. Values for the Hispanic English-speaking group tended to fall in between these two groups. This appears consistent with literature reporting there may be differences frame of reference or values between workers born in the US and Hispanic immigrant workers (e.g., Brunette, 2004), which would influence expectations for their managers, or that there may be cultural differences between these groups in one's willingness to be perceived as criticizing an authority figure. Both reasons may explain a greater tendency for Spanish-speaking workers to agree with these items. We would expect employees working under the same general contractor and on the same job site to have similar perceptions of the work environment. However, results of the scalar invariance test indicate that these items are not functioning in the same way across groups. Continued work is needed to develop measures with items that function equivalently across workers of different ethnicities. Specifically, further review of the items is critical in order to determine why such differences were identified. Items should be revised and additional data collected from these populations in order to reassess whether safety climate dimensions are equivalent across different ethnic groups in samples other than the one used in this study.

5.2. Limitations

Although our findings suggested that there were no true differences in safety climate among the three groups after accounting for the non-equivalent item intercepts, the results should be interpreted with caution. First, we cannot be certain about the language differences between Hispanic workers who completed the English version and Hispanic workers who completed the Spanish version. Hispanic workers may have completed either version of the survey for a variety of reasons. It is possible that the individuals who completed the English survey chose to do so because they spoke and comprehended English fluently while the individuals who completed the Spanish survey chose to do so because they spoke limited English. If this were true, then the main difference between the White and Hispanic English-survey groups is how they identify their ethnicity, and the main difference from the Hispanic employees in the English-survey or Spanish-survey groups is English language proficiency. However, it is also possible that Hispanic workers completed the survey in English chose to do so for various reasons, such as the pressure of being surrounded by White Non-Hispanic workers. Similarly, it is possible that the Spanish-survey employees were individuals with a high level of English proficiency but who simply preferred to complete the Spanish version. The survey did not ask employees to indicate their reason for choosing one version over the other. Thus, the only information available to the research team is how employees identified their ethnicity and which language version they chose. The three groups were formed based on this information, but this is a limitation of the study.

Second, the three groups differed in average age and industry experience, so it is possible that these factors may account for any non-equivalence of survey items between the groups. White Non-Hispanic workers tended to be older and had worked in the construction industry longer than the other two groups, and Hispanic workers who completed the Spanish version had worked on the job sites significantly longer than the other two groups. The three groups also differed in the type of work they were doing on the job site. White Non-Hispanic employees were more likely to be electricians, plumbers/pipefitters, and sheet metal workers as compared to the other two groups. The Hispanic workers who completed the English survey had smaller percentages of employees in these trades, and the number of Hispanic employees who completed the Spanish survey and were in these trades was close to zero. Hispanic employees who completed the Spanish survey were more likely to be bricklayers, carpenters, painters, and laborers. Smaller percentages of Hispanic employees who completed the English survey were in these trades, and even smaller percentages of White Non-Hispanic employees were doing this type of work. Therefore, another possibility is that the different types of work across the three groups may account for any non-equivalence in their safety climate survey items.

5.3. Implications for research and practice

Findings from this research highlight the fact that researchers need to obtain a better understanding of the cultural factors that may influence safety climate perceptions. Some additional qualitative research may be necessary whereby items and safety climate dimensions are reviewed by individuals from different backgrounds. Such studies could help clarify how these individuals decide how they will respond to an item by considering their thought processes in a more in-depth way. Expanding our knowledge of cultural differences in safety perceptions can ultimately serve to help create better safety-related interventions that are effective for all construction worker populations.

After over 30 years of safety climate studies, it is well-established that safety climate is an important predictor of safety performance on the job (e.g., Christian et al., 2009; Nahrgang et al., 2011). Given that safety climate has been viewed as a leading indicator for safety and health performance, its use for early intervention should be encouraged. Safety climate surveys hold great utility for understanding the status of safety on a job site. If an organization finds that its employees do not perceive that safety is important, then steps can be taken in order to address this issue before serious incidents occur. To prepare for adequate actions to reduce injuries and fatalities in industries that consist of diverse work groups (e.g., immigrants, ethnicities, young or old), future research should continue to pursue cross-group comparisons of factors that may influence occupational safety and health disparities.

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