

6-27-2014

# A Moderation Effect of Safety Climate Variability on the Relationship Between Safety Climate Level and Safety Behavior and its Boundary Conditions

Jin Lee  
jin.2.lee@uconn.edu

Follow this and additional works at: <http://digitalcommons.uconn.edu/dissertations>

---

## Recommended Citation

Lee, Jin, "A Moderation Effect of Safety Climate Variability on the Relationship Between Safety Climate Level and Safety Behavior and its Boundary Conditions" (2014). *Doctoral Dissertations*. 504.  
<http://digitalcommons.uconn.edu/dissertations/504>

A Moderation Effect of Safety Climate Variability on the Relationship Between  
Safety Climate Level and Safety Behavior and its Boundary Conditions

Jin Lee, Ph.D. 2014

Abstract

This research explored the possibility that the purported relationship between safety climate level and safety behavior differs depending on safety climate variability among workgroup members. An underlying proposition for this moderation effect is that a large variability in safety climate perceptions reflects inadequate human-organization interface design, poor team member coordination, and organizational acceptance of unsafe behaviors. In fact, empirical studies on organizational climate have already shown that climate variability moderates the relationship between organizational climate levels and outcomes. The present study utilized 2,043 electrical utility workers from 183 workgroups to examine the moderation effect of safety climate variability on the safety climate level and safety behavior relationship as well as its potential boundary conditions. The interaction between safety climate variability and level was statistically significant while individual and organizational characteristics such as employee company tenure, workgroup-level company tenure, task independence, and individualistic tasks did not fully explain safety climate variability. In sum, the present study provided evidence that safety climate level and variability jointly play an important role in the promotion of safe behavior among employees, and that safety climate variability is not merely an artifact of individual or organizational conditions. Additionally, it was shown that safety climate scale items with more variability tend to have lower means, and that they were less predictive of safety behavior. These findings are congruent with previous findings regarding an organizational climate level and variability interaction, and emphasize the importance of using a multilevel framework for understanding safety climate.

Additionally, the study findings underscore the need for conjoint management of safety climate level and variability to more effectively promote workplace safety.

A Moderation Effect of Safety Climate Variability on the Relationship Between  
Safety Climate Level and Safety Behavior and its Boundary Conditions

Jin Lee, M.A.

B.A. Yonsei University, 2006

M.A. Yonsei University, 2008

M.A. University of Connecticut, 2013

A Dissertation

Submitted in Partial Fulfillment of the  
Requirements for the Doctor of Philosophy

at the

University of Connecticut

2014

APPROVAL PAGE

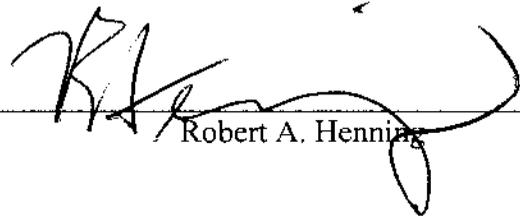
Doctor of Philosophy Dissertation

A Moderation Effect of Safety Climate Variability on the Relationship Between  
Safety Climate Level and Safety Behavior and its Boundary Conditions

Presented by

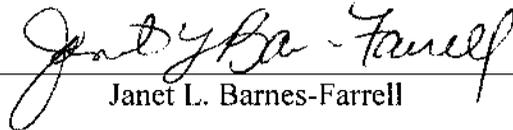
Jin Lee, B.A., M.A.

Major Advisor



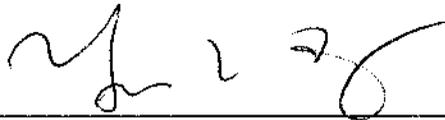
Robert A. Henning

Associate Advisor



Janet L. Barnes-Farrell

Associate Advisor



Yueng-Hsiang (Emily) Huang

University of Connecticut

2014

(Dissertation Completed: May 2014)

## Acknowledgments

I acknowledge that the data used in this study was collected by the Liberty Mutual Research Institute for Safety under the safety climate project LMRIS 09-02.

## Table of Contents

Introduction.....	1
Safety Climate.....	1
Safety Climate Variability.....	3
Safety Climate Variability Measurement.....	6
Organizational Climate Level and Variability Interaction.....	7
Safety Climate Level and Variability Interaction.....	11
Hypothesis 1.....	15
Safety Climate in Utility/Electrical Industry.....	15
Boundary Conditions of the Moderation Effect of Safety Climate Variability on the Safety Climate Level and Safety Behavior Relationship.....	18
Hypothesis 2-1.....	20
Hypothesis 2-2.....	20
Hypothesis 3.....	22
Hypothesis 4.....	24
Item-level Safety Climate Variability and Safety Behavior.....	25
Hypothesis 5.....	27
Method.....	27
Participants.....	27
Measures.....	29
Safety Climate.....	29
Safety Behavior.....	30
Analytical Approaches.....	31
Results.....	34
Safety Climate Variability across Workgroups.....	34

Between Workgroup Variance in Safety Behavior.....	35
HLM Results for Hypothesis 1 .....	37
HLM Results for Hypothesis 2 .....	40
Hypothesis 2-1 .....	40
Hypothesis 2-2 .....	43
HLM Results for Hypothesis 3 .....	45
HLM Results for Hypothesis 4 .....	47
Results for Hypothesis 5 .....	48
Discussion.....	50
Results Summary .....	50
Theoretical Implications .....	53
Practical Implications.....	58
Limitations and Suggestions for Future Study.....	63
Conclusion .....	66
References.....	67
Appendix A. Items of the safety climate scale.....	82
Appendix B. Items of the safety behavior scale .....	83

## Index of Tables

Table 1. Descriptive statistics of the study sample .....	84
Table 2. Workgroup distribution by safety climate level (at workgroup-level) and variability (workgroup n = 183).....	85
Table 3. Hierarchical linear modeling (HLM) models and results for Hypothesis 1.....	86
Table 4. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 1.....	87
Table 5. Hierarchical linear modeling (HLM) models and results for Hypothesis 2-1 .....	88
Table 6. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 2-1 .....	90
Table 7. Hierarchical linear modeling (HLM) models and results for Hypothesis 2-2 .....	91
Table 8. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 2-2 .....	93
Table 9. Hierarchical linear modeling (HLM) models and results for Hypothesis 3.....	94
Table 10. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 3.....	95
Table 11. Hierarchical linear modeling (HLM) models and results for Hypothesis 4.....	96
Table 12. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 4.....	98
Table 13. Results for Hypothesis 5 .....	99

## Index of Figures

Figure 1. Graphical illustration of the study hypotheses .....	100
Figure 2. Safety climate level (at workgroup-level) and variability relationship .....	101
Figure 3. Safety climate level (at psychological-level) and variability relationship across 183 work groups .....	102
Figure 4. Graphical illustration of Hypothesis 1 .....	103
Figure 5. Safety climate level (at psychological-level) and safety behavior relationship for the high and low safety climate variability conditions .....	104
Figure 6. Graphical illustration of Hypotheses 2-1 and 2-2 .....	105
Figure 7. Graphical illustration of Hypothesis 3 .....	106
Figure 8. Graphical illustration of Hypothesis 4 .....	107

## Introduction

### Safety Climate

Safety climate refers to shared perception of workers about their organization's managerial and operational policies, procedures, and practices in the promotion of safety over other competing demands such as productivity (Griffin & Neal, 2000; Zohar, 1980; 2000; 2011; Zohar & Hofmann, 2012). Based on the theoretical framework for organizational climate etiology (Schneider & Reichers, 1983), three approaches of how safety climate can emerge within an organization have been proposed (Huang, Robertson, Jeffries, Garabet, Murphy, & Lee, 2012; Huang, Zohar, Robertson, Garabet, Lee, & Murphy, 2013a). According to the structural approach (Payne & Pugh, 1976), organizational work contexts in terms of safety, such as provisions for proper safety training, maintenance of technology and systems for safety, and empowerment of safety managers are thought to be the origin of employees' attitudes, values, and perceptions concerning safety. The second is the attraction-selection-attrition (Schneider, 1987) approach. Organizations that care about safety are likely to recruit and select applicants whose values and perspectives on safety are congruent with the organizations'. Also, employees who have a high regard for safety are likely to leave when their views on safety don't match with their organizations. The result is an organization comprised of employees with fairly strong and homogeneous safety perceptions. The third approach involves symbolic interaction (Schneider & Reichers, 1983; Zohar, 2010). It refers to employees' sense-making process regarding safety based on the information from the organization's enacted safety practices. By collecting pieces of information and making interpretation of it through social interaction (e.g., verbal communication), employees reach a consensus about the organization's safety-related values and attitudes.

Characteristics of an organization with a higher level of safety climate include steadfast and uncompromising organizational/managerial interest and effort to improve

workers' safety as well as effective and timely interaction between leader and member in regard to safety (Zimolong & Elke, 2006). Also, supervisory behavioral integrity, referring to the consistency between words and deeds of management, is an integral part of safety climate (Zohar, 2011). Safety climate can be promoted with transformational leadership (Bass, 1990; 1998) or high leader-member exchange (Graen & Uhl-Bien, 1995) as such types of leadership involve high-quality communication between leaders and members through which employees' concerns (including safety related issues) are likely to be addressed. Although closely related, leadership is distinct from safety climate. Leadership is more about styles of leader-member relationships that can be typically characterized by being passive or active, and also proactive or transformative (Bass, 1990), while safety climate is more about supervisory or management commitment, particularly directed to employees' safety (Flin, Mearns, O'Connor, & Bryden, 2000; Zohar, 2011).

Recent meta-analytic studies have shown that safety climate predicts safety outcomes such as safety behavior and/or rates of workplace accident/injury (Beus, Payne, Bergman, & Arthur Jr., 2010; Christian, Bradley, Wallace, & Burke, 2009; Clarke, 2006; Nahrgang, Morgeson, & Hofmann, 2011). This is in line with the findings from a large volume of previous and recent safety climate research in numerous industry sectors such as the manufacturing and mining industries (e.g., Griffin & Neal, 2000), health care industry (e.g., Neal, Griffin, & Hart, 2000), trucking industry (e.g., Huang et al., 2013a), electrical/utility industry (e.g., Huang, Zohar, Robertson, Garabet, Murphy, & Lee, 2013b), and construction industry (e.g., Siu, Phillips, & Leung, 2004). Some of these studies adopted a prospective design and showed that safety climate can predict future safety outcomes such as accident/injury rate and injury severity (e.g., Beus et al., 2010; Huang et al., 2013a). Also, Zohar and Polachek (in press) adopted a randomized field experimental approach and showed that an increase in safety climate level was associated with improvement in safety behavior.

Specifically, provision of continuous performance feedback during the 12-week discourse-based safety climate intervention resulted in improved compliance to safety procedures. As such, a close relationship between safety climate level and safety behavior and/or outcomes has been widely supported.

In sum, safety climate is an important indicator of organizational efforts that help workers perform safely as individuals or as teams, and it should be carefully considered in examination of workplace safety and its improvement. Given this, it is critical to examine the mechanisms underlying safety climate such as how it relates to specific safety performance and how the relationship can be enhanced (moderation). The focus of the present study is on the multi-level aspects of safety climate noting that it is based on organizational members' perceptions (Zohar, 2011; Zohar & Luria, 2005). Specifically, interplay between two different aspects of safety climate, level (or quality) and variability, is investigated. Safety climate level, oftentimes represented by mean score both at individual- and/or above-individual-levels, is what safety climate generally refers to in most of extant safety climate research. On the other hand, safety climate variability, frequently represented by dispersion statistics like standard deviation or consensus statistics like  $r_{wg}$ , is a kind of concurrence measure of safety climate perceptions among organizational members, thus it always exists at the above-individual-level. Further conceptual clarification of safety climate variability follows.

### **Safety Climate Variability**

One unique feature of safety climate that serves as the bottom-line of safety climate variability is a sharedness in workers' perceptions (Zohar, 1980; 2000; Zohar & Luria, 2004). Like other types of organizational climate, such as procedural justice, diversity, ethical, and empowerment climate (Schneider, Ehrhart & Macey, 2011), safety climate is based on organizational members' shared perceptions. Operationally, safety climate can be assessed by aggregating perceptions of individual workers to the appropriate unit of analysis (Zohar,

2011). To form an above-individual-level (e.g., work group-, department-, or organization-level) safety climate construct as it is originally conceptualized, within-group agreement in safety climate perceptions is critical (Klein, Conn, Smith, & Sorra, 2001; Kozlowski & Klein, 2000). Lack of within-group agreement in safety climate cannot justify the aggregation of lower-level (e.g., individual) safety climate perception to create a higher-level (e.g., workgroup) safety climate variable because the aggregated score of sum or mean cannot be a good representation of the wide range of group members' perceptions (Bliese, 2000; LeBreton & Senter 2008; Schneider et al., 2011). Moreover, Schneider and Reichers (1983) argued that shared perceptions serve as an institutionalized social norm that affects worker behavior. Specifically, it is expected that workers at an organization with strongly shared safety climate perceptions tend to perform in accordance with the overall organization's safety climate level to conform to the social norms for safety in their work organization. These independent studies suggest the importance of shared safety climate perceptions in terms of statistical justification for the notion of safety climate as an upper-individual-level construct, and the need for an optimal level of agreement in safety climate perceptions of within-group members for the promotion of their safety behavior and outcomes.

In fact, perfectly shared perceptions, in other words perceptions with complete consensus within group or organization members, are unlikely in the real world (Dickson, Resick, & Hanges, 2006) due to numerous organizational and individual factors. Specifically, various organizational aspects such as size, hierarchy (Lindell & Whitney, 1995), leadership quality, role definition and role stress, characteristics of within-workgroup interaction, and job attributes (James & James, 1989; James, James, & Ashe, 1990) influence organizational climate. Considering multidimensional structure of an organization, these kinds of organizational characteristics may substantially vary within an organization (e.g., by hierarchy, sectors, locations) and climate perceptions of workers can subsequently be

heterogeneous. Additionally, individual differences in values and attitudes that might affect climate perception have been well received by the theories of organizational climate development, such as the attraction-selection-attrition process (Schneider, 1987) and organizational socialization (Moreland & Levine, 1990). As organizational climate is an emerging property (Glick, 1988; Ostroff, Kinicki, & Muhammad, 2012) with workers continuously coming in and going out of the workforce, the chance of heterogeneous climate perception among workers always exists. For example, the same level of organizational safety effort in terms of time and budget may be viewed differently among workers depending on how efficiently the effort is carried out by supervisors, duration and quality of employee-supervisor relationship, types of jobs (e.g., handling hazardous materials, heavy lifting, operating complex systems), job characteristics (e.g., job challenge, job autonomy, job importance), role ambiguity/conflict, and so on. Also, safety training programs provided by the organization may not be viewed as equally effective across workers with different value, attitude, experience, knowledge, and skill sets. Feasibility, acceptability, and appropriateness of the training program as well as applicability and sustainability of the training program's impact can vary largely across these properties. Moreover, inconsistent safety practices/policies (e.g., over time, across contexts, by supervisors) or complicated safety messages from management (e.g., of conflicting values, being nonspecific and unclear) might serve as ambiguous cues for organizational safety standards, and subsequently employees may develop incongruent safety climate perceptions. In sum, there can be substantial deviation in workers' safety climate perceptions due to a number of factors inherent in a complex and dynamic organization as they all serve as "discretionary stimuli" for organizational climate (Hackman, 1992).

Lindell and Brandt (2000) referred the variance of climate perceptions as climate consensus while Schneider, Salvaggio, and Subirats (2002) called it climate strength which is

borrowed from literature on organizational culture (Martin, 1992; Trice & Beyer, 1993). In fact, the term climate strength has been widely accepted in numerous organizational climate studies (e.g., Colquitt, Noe, & Jackson, 2002; Dickson et al., 2006; Gonzalez-Roma, Peiro, & Tordera, 2002; Zohar, 2011; Zohar & Luria, 2005) though it is also recognized that the climate strength is about consensus or deviations in organizational members' climate perceptions. In the present study, the term climate variability will be preferred over climate consensus and climate strength for the following two reasons. First, compared to climate consensus or strength, climate variability is conceptually more in line with the dispersion model (Chan, 1998) and the dispersion composition model (Cole, Bedeian, Hirshfeld, & Vogel, 2011) on which the current study is based.

Within these multi-level analytic frameworks, a focal above-individual-level construct is the variance of individual members' perceptions, and this notion is more clearly represented by 'variability' than 'consensus' or 'strength' in terms of direction. Second, the term climate strength may pose difficulty in interpretation of what stronger climate means. In other words, "climate strength" does not explicitly denote that climate is a collective concept, and this term can also be easily confused with climate quality or climate level.

### **Safety Climate Variability Measurement**

The present study operationalized safety climate variability as standard deviation ( $SD_x$ ) of the within-workgroup members' safety climate perceptions.  $SD_x$ , which is the square root of the average of the squared differences from the mean, is a measure of disagreement unlike another potential measure of climate variability, the  $r_{wg}$  index (James, Demaree, & Wolf, 1984) which indicates chance agreement-adjusted inter-rater reliability. The difference between  $SD_x$  and  $r_{wg}$  can be notable when they are used as consensus indicator for a single-group, or when the number of groups or organizations to compare is small (Lindell & Brandt, 2000). However, what these two measures indicate become very similar when the number of

response categories for the target climate perceptions is equal by using the same response scale across groups or organizations because adjustment for chance agreement will be constant (James et al., 1984). In this case,  $r_{wg}$  will be perfectly correlated in the negative direction with the variance statistic, which is equal to the square of  $SD_x$ . Thus, use of  $r_{wg}$  or  $SD_x$  as a climate variability measure would return the same bivariate relationships between the climate variability and climate antecedents or outcomes. Also, a concern when using  $r_{wg}$  as a climate strength measure has been raised as its calculation of chance agreement is based on uniformly distributed (rectangular-shaped) responses that might overlook the possibility that respondents give random ratings only in a particular response range (Bliese, 2000). Additionally,  $r_{wg}$  statistic may have values greater than one, possibly due to an overestimation of the degree of agreement, and these values are difficult to interpret (Zohar & Luria, 2005). For these methodological reasons,  $SD_x$  has been widely accepted as a climate variability measure in numerous studies (e.g., Dickson et al., 2006; Schneider et al., 2002; Sowinski, Fortmann, & Lezotte, 2008; Zohar & Luria, 2005). Furthermore,  $SD_x$  is preferred over  $r_{wg}$  because it is easier to calculate and its meaning is more straightforward to most people. This practicality issue is important from translation and dissemination standpoints. If safety climate variability is shown to play important roles in promotion of workplace safety and health, it needs to be kept track of carefully and taken into account for safety management and intervention. To facilitate the broader consideration of safety climate variability, having a simpler measure of safety climate variability would be more advantageous.

### **Organizational Climate Level and Variability Interaction**

Even before the notion of climate variability or strength was well-formulated, potentially different effects of homogeneous/heterogeneous organizational climate perceptions among organizational members on climate outcome had been suggested. For example, in discussion of the impact of organizational culture/climate on organizational goal

achievement, Kopelman, Brief, and Guzzo (1990) stated the following: “Tasks for which goals are set, rules and procedures formulated, rewards allocated, and support given are ones that signal to employees what is expected of them. Clearly, the message carried by these signals would be more influential in directing effort to the degree the signals are consistent. (...) Without consistency, managers may release opposing forces that cause the organization to vacillate rather than to move forward with unity of effort. And, if such unity can be achieved, the goals of the organization might be advanced further by the resultant organizational syntality (p. 307).” The term “syntality” is a combination of the words “synchronization” and “vitality”.

According to this paragraph, ‘consistent’ climate can signal straightforward directions on organizational goals to members. The ‘consistency’ of climate in this context is directly related to the degree to which the climate perceptions are shared among organizational members and it is conceptually very similar to what climate variability indicates (in the opposite direction). Also, it is suggested that smaller climate variability is more likely to induce desired climate outcomes, hinting the possibility of main and interaction effects of climate variability on climate outcome.

Similarly, Lindell and Brandt (2000) inferred that climate variability (consensus) would moderate the relationship between average climate level (i.e., climate quality) and intended climate outcome such that the relationship would be stronger when climate variability is smaller (stronger climate consensus). In line with Hackman (1992) and Zander, (1994), Lindell and Brandt hypothesized that interpersonal conflict regarding role expectation, subsequent poor coordination among workers, and inefficiency in organizational resource allocation are associated with higher organizational climate variability. However, this inference was not empirically supported. Variability in organizational climate for general performance was assessed among 180 chairs of the local emergency planning committees

across numerous aspects of leadership, teamwork, role expectation, and job characteristics. Only small portion (15%) of them was statistically significantly correlated with climate outcome measures in terms of effort, attendance, job satisfaction, citizenship, and turnover intention. Also, introduction of the climate variability, as well as its interaction term with climate quality, to the regression model in prediction of climate outcomes respectively yielded only .017 and .008 of  $R^2$  increment on average over climate quality. Regardless of these findings, Lindell and Brandt did not rule out the potential impact of climate variability and offered two explanations for the failure to find meaningful main and interaction effects of climate variability on organizational outcomes. First, the effect of climate variability may exist only for the organizations or groups where members and job demands are highly interdependent. This deliberation has an important implication about boundary conditions for a climate variability and quality interaction. It might be organizational structure such as hierarchy (e.g., Blau, 1972) and workgroup size (e.g., Goodma, Ravline, & Schminke, 1987), intra and interpersonal characteristics such as tenure (e.g., Rollag, 2004) and socialization procedures (e.g., Feldman, 1981), types of tasks (e.g., Neuman & Wright, 1999), and so on that determine interdependence of an organizational system. Thus these factors need to be considered in examination of a climate variability and quality interaction. Second, the effect of climate variability as well as climate quality may be so crucial that organizations with high climate variability or low climate quality cannot function and endure, and could not be included in a research study. From this standpoint, Lindell and Brandt called for the application of a longitudinal framework to investigate the dynamics of climate quality/variability and climate outcome relationships.

Schneider et al. (2002) also hypothesized climate variability (i.e., strength) would moderate the climate quality and outcome relationship such that low climate variability would enhance the relationship. They treated climate variability as situational strength

(Mischel, 1976; Ostroff & Bowen, 2000). According to Mischel (1976), perceptual consensus, homogeneous expectations for desired behavior, and consistent pursuit of such behavior are expected from a “strong situation”. On the contrary, behavior would be determined mostly by individual differences in a “weak situation” as it delivers inconsistent and ambiguous cues for expected behavior. By utilizing bank worker ( $n = 2,134$ ) and customer data ( $n_{\text{phase 1}} = 3,100$ ,  $n_{\text{phase 2}} = 1,900$ ) obtained from 118 bank branches, Schneider et al. were able to find significant interaction between climate quality and variability in prediction of customer perceptions of service quality. Specifically, when service climate quality and variability as well as their interaction term were introduced to the hierarchical regression models to predict each of the four different facets of customers’ service quality perception (i.e., efficiency, security, competency, and relationships) that were cross-sectionally measured, the interaction term resulted in .13 - .24 increment of  $R^2$ , and they were all statistically significant ( $p < .01$ ). When climate variability is low, indicating higher consensus among organizational members on service climate (i.e., stronger climate), the effect of service climate quality on customer perceived service quality tended to be stronger, as hypothesized. Similar findings were observed for the prospective dependent variables (i.e., the service quality reports from customers that were obtained three years later the service climate survey implementation).

Empirical support for the moderating effect of climate variability on climate quality – outcome relationship has been offered by several other studies. For example, by utilizing 88 manufacturing teams of 1,747 workers, Colquitt et al. (2002) showed that the relationship between the quality of procedural justice climate and team performance/absenteeism was significantly moderated by climate variability. With the 197 work units of a regional public health service and 932 employees, Gonzalez-Roma et al. (2002) revealed that climate variability can moderate the relationship between the goals orientation and innovation climate, and climate outcomes like work satisfaction and organizational commitment. Additionally,

Sowinski et al. (2008) detected a significant moderation effect of climate variability on the service climate – turnover/profitability relationship based on the sample of 756 workers from 129 automotive service stores. Across all of these studies, smaller climate variability enhanced the climate quality and outcome relationship, which concurs with Schneider et al.'s (2002) findings.

In regard to the deliberation of the role of climate variability and findings described above, Dickson et al.'s (2006) statement as follow may be a good summary: “In organizations with stronger climate (i.e., less variability), consensus among members regarding how the organization operates ultimately enhances the relationship between climate level and outcomes by leading to greater consistency and continuity of member behavior (p. 353).”

Unlike the prevailing view that variability compromises systems behavior stability (Smith, Henning, Wade, & Fisher, 2014), researchers like Harbourne and Stergiou (2009) and Karwowski (2012) deemed that variability can contribute to effective system behavior control, given that it allows multiple degrees of freedom and flexibility to adapt to environmental variations. In fact, the state of perfect consensus in organizational climate may be less than ideal because it is very fragile and susceptible to being negated by even a minor breach of consensus. Nevertheless, the combined processes of improving climate level and alleviating climate variability in order to reduce situational ambiguity in behavioral expectation can be generally effective in promoting target outcomes.

### **Safety Climate Level and Variability Interaction**

Likewise, safety climate variability (safety climate strength) can moderate the relationship between the level of safety climate and safety behavior/outcomes for the following potential reasons. First, from the macroergonomic standpoint, higher safety climate variability may reflect poor human-organization interface design (Hendrick, 1997; Hendrick, 2000; Hendrick & Kleiner, 2002; Robertson, 2001). Given that every worker in an

organization has different experience, skill, knowledge, perceptual and cognitive style, role expectation, preference in interpersonal relationship, etc., organizational safety efforts should be made via adjustable and diverse routes to accommodate different needs for safety across individual workers. If not, organizational safety efforts cannot be efficiently accessed to or accepted by individual workers. For instance, safety training programs or safety policies that are designed and implemented without considering heterogeneous safety climate perceptions across workers, average level of safety climate perception could be enhanced in general but the practical impact of the programs or policies can still be suboptimal due to different levels of employee motivation, participation, commitment, and satisfaction that can be influenced by perceptions of safety climate.

A second way that safety climate variability moderates the safety climate level and safety behavior/outcomes relationship is that higher safety climate variability can negatively affect coordination among workgroup members, which is critical for safety performance in many work contexts. If there is a lack of consensus in safety climate perceptions among workers who work together as a team, safety is likely to be compromised due to miscommunication during interdependent task activities. This mechanism can be understood within the framework of shared mental model (Cannon-Bowers, Salas, & Converse, 1993; Klimoski & Mohamed, 1994; Stout, Cannon-Bowers, & Salas, 1996). Mental models help organizational members to understand organizational goals, functioning, and expected future outcomes (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers 2000; Rouse & Morris, 1986). Thus, individual workers' safety climate perception by and large corresponds to a facet of their mental models for workplace safety (Prussia, Brown, & Willis, 2003) because safety climate is depending on organizational value, attitude, and practice in pursuit of safety. Large variability in safety climate indicates that workers have different mental models about safety, and this can lead to ineffectiveness in team processes such as planning and coordination,

cooperation, and communication (Mathieu et al., 2000). In this regard, Wahr, Prager, Abernathy, Martinez, Salas, Seifert et al. (2013) stated that “teams lacking in shared understanding (e.g., shared mental model) have reduced coordination, which leads to poor performance” (p. 1143).

A third way that the safety climate level and safety behavior/outcomes relationship can be moderated by safety climate variability is that, higher safety climate variability can signal organizational acceptability of safety compromising behavior. Consequently, workers are more likely to act like other workers who behave less safely than act like workers who behave more safely whenever safety climate is ambiguous and large safety climate variability exists within a group or organization. Specifically, when safety climate variability is high, workers are unclear about how to perform safely. Under such uncertainty situation, they begin to look for behavioral reference and would refer to the most available safety-related behavior of their co-workers or supervisors. In fact, perceptions of individuals heavily rely on information that is the most accessible, and the impact of accessible information on one's perception outweighs the credibility (Johnson, 1997) and quality (Choo & Auster, 1993) of perceived information. This suggests that people tend to perceive something based on accessible information although the information is from an unfaithful source and poor in quality (Rice & Shook, 1990). The accessible information may serve as a perceptual and psychological anchor, and this process is analogous to application of availability heuristics under uncertainty (Tversky & Kahneman, 1973; 1974). In observation of the wide variety of organizational behavior from being highly attentive to being indifferent to safety, workers are likely to take shortcuts, and cutting corners with safety. This is because it generally requires more effort to perform safely, and people tend to behave in a way to preserve as many resources as possible (Fiske & Taylor; 1991; Maddux & Snyder, 1997). The theory of limited cognitive capacity supports this idea (Hirst, Spelke, Reaves, Caharack, & Neisser, 1980;

Shiffrin & Schneider, 1977). For example, an asphalt paving worker can be confusing when seeing different levels of safety expectations and efforts of other team members. The worker may be able to observe 'safe' team members who are vigilant to safety policies and keep wearing personal protective equipments (PPE) such as gloves, goggles, and masks. However, if there are other 'unsafe' team members who ignore safety rules, the likelihood is higher for the worker to model after them, because extra physical and cognitive effort required by safety procedures such as enduring higher temperature when wearing PPEs (particularly in summer) and slower work speed due to paying constant attention to safety rules (Murphy, Robertson, & Huang, 2012).

If the role of safety climate variability as a moderator in determining the safety climate level and safety behavior/outcome relationship can be shown to exist, a number of theoretical and practical implications are suggested. First of all, this would again support the dominant view for the impact of any organizational climate variability on the climate level and behavior relationship (e.g., Gonzalez-Roma et al., 2002; Lindell & Brandt, 2000; Schneider et al., 2002). This would also emphasize the importance of adopting a multi-level framework for safety climate research because safety climate variability necessarily exists at the group- or organization-level (Zohar, 1980; 2000; 2001). Antecedents and consequences of the safety climate variability can therefore be examined in future studies to extend prior safety climate research. Extant research on safety climate has focused mostly on safety climate level (quality) than on safety climate variability. Additionally, studies of safety climate interventions would be advised to take into account not only the overall level of safety climate but also safety climate variability to optimize the impact of safety climate in the promotion of safety. Detection of large safety climate variability itself would be meaningful because this informs the possibility of suboptimal consequences of even high levels of safety climate. Moreover, interventions may be able to be designed to reduce the

variability in safety climate perceptions among workers through better or more tailored communication strategies, training, or work system design.

However, unlike other organizational climate domains such as procedural justice climate and service climate, there is currently no empirical study directly showing the moderation effect of safety climate variability on the relationship between the level of safety climate and safety behavior/outcomes (Beus et al., 2010). In one study of Zohar and Luria (2004), moderation effect of safety climate variability on the relationship between safety climate level and safety outcome was examined with 2,024 infantry soldiers in 81 platoons. However, after controlling for the risk level of operational duties, only the main effect of safety climate level in the prediction of behavior-dependent injury rate during the six month period from the questionnaire completion was advocated while the moderation effect of safety climate variability was not supported.

To address this gap in the literature, the primary goal of the present study is to examine whether the safety climate level and safety behavior relationship varies depending on safety climate variability. The following hypothesis is proposed (Figure 1-A provides a graphical illustration of *Hypotheses 1*).

*Hypothesis 1. The safety climate level and safety behavior relationship will be stronger when safety climate variability is smaller (two-way interaction).*

### **Safety Climate in Utility/Electrical Industry**

The present study utilized workers from two large size electrical utilities in United States. According to Bureau of Labor Statistics (BLS, 2012a, b) and National Institute of Occupational Safety and Health (NIOSH, 2013), there are high risks of injuries and fatalities in the electrical utility industry. Specifically, 22 fatal injuries (BLS, 2012a) and 13,000 non-

fatal injuries (BLS, 2012b) were reported in 2012 only. Between 2003 and 2006, fatal injuries totaled 225 which resulted in the cost of \$281,000,000 (NIOSH, 2013). Utility/electrical workers face numerous types of challenges (Kelsh, Lu, Ramachandran, Jesser, Fordyce, & Yager, 2004). For example, they are frequently exposed to hazardous (e.g., contact with high-voltage electricity and working at elevated/underground stations) and unpredictable work environments (e.g., emergency work in harsh weather conditions), and physically demanding tasks (e.g., pole climbing and use of heavy equipment). Also, some utility/electrical workers' jobs involve extensive travel and driving. According to Kelsh et al.'s (2004) investigation on approximately 530,000 electric utility employees from 12 companies, the 10 most frequent injuries between 1995 and 2002 are sprain/strain (36.7%), cut/laceration/puncture (17.8%), contusion/bruise (9.9%), other injury, not elsewhere classified (7.1%), fracture/dislocation (6.3%), burn from heat/thermal contact (1.6%), electric shock/electrocution (1.4%), inflammation of joints (1.4%), hernia/rupture (.5%), and burn from other than heat/thermal contact (.5%). Reflecting the complex nature of the utility/electrical industry, many different job types are present such as meter readers, line workers, and electricians. Depending on the characteristics of the primary job and contingent working environment, workers are exposed to different types and frequencies of hazards. As a result, workers with different jobs experience different types and rates of injury. For example, between 1995 and 2002, the top five injury rate job classifications were meter readers, welders, line workers, drivers, and mechanics (Kelsh et al., 2004). For these job categories, injury rates per 100 employees ranged from 3.88 to 9.63. Some types of common injury were specific to particular job categories (e.g., animal/insect bite for meter readers and scratch/abrasion for welders) while others were more general (e.g., sprain/strain).

A large portion of electrical utility employees work without in-person supervision (Barsness, Diekmann, & Seidel, 2005; Kurland & Bailey, 1999). This type of worker is also

more likely to experience greater safety risks in the face of hazardous situations such as inclement weather conditions and equipment failure (Health and Safety Executive, 2009). Unlike non-remote working conditions, remote workers have to handle these safety issues mostly on their own with only limited access to timely assistance from supervisors or co-workers. Thus, safety climate may partly compensate for possibly weaker impact of supervisory safety support for this remote worker population who are at higher risk of injury or fatality (Huang et al., 2013a; Huang, et al., 2013b). Although remote workers may not interact with their supervisors or co-workers as much as traditional in-house workers, managerial practice and supervisory care for employee safety could help these remote workers to develop a general sense of safety expectation. Specifically, if the remote workers' safety concerns are carefully considered by their supervisors, if their safety behavior such as proper use and maintenance of safety equipment is consistently encouraged, and if supervisors do not pressure them to sacrifice any safety procedures even when they fall behind the work schedule, the remote workers are more likely to perceive greater sense of safety support from their management. In this way, a good safety climate can emerge even for remote workers. Previous studies provide consistent findings that dimensions of safety climate for lone/remote workers are closely related to management's commitment to safety (Huang et al., 2012; Huang et al., 2013a; Huang et al., 2013b) in support of this inference. Furthermore, Stout et al. (1996) pointed out that a shared mental model will be more important when particular work contexts (e.g., overwhelming workload, time pressure, independent tasks) restrict communication among organizational members. Under such conditions of the reduced communication opportunity, team members are not able to engage in the discussion on their next moves and they have to turn to pre-existing knowledge regarding task demands and their potential impact on team and teammates (Mathieu et al., 2000). Hence, the role of safety climate in promotion of safety behavior becomes remarkably

important for remote-working utility/electrical workers as it can serve as a mental model of workplace safety (Prussia et al., 2003).

Given this, examination of the possible mechanisms of safety climate level and safety climate variability in the prediction of safety behavior would provide practical implications for achieving safer working environment in the utility/electrical industry.

### **Boundary Conditions of the Moderation Effect of Safety Climate Variability on the Safety Climate Level and Safety Behavior Relationship**

The hypothesized moderation effect of safety climate variability on the safety climate level and safety behavior relationship may be present in particular situations only, or it may be less marked in particular conditions because numerous organizational and individual factors that are known to be systematically associated with safety climate level and variability. Understanding under which conditions safety climate variability particularly enhances or impairs the safety climate level and safety behavior relationship is therefore important. A more sophisticated understanding of the mechanisms of how safety climate level and safety climate variability work jointly to promote safety behavior is then worth examining. Also, if certain conditions are identified under which the moderation effect of safety climate variability is weaker, safety climate interventions aimed at improving safety climate level and addressing safety climate perception gaps among group members could then be implemented.

Moreover, a potentially unique moderation effect of safety climate variability beyond other organizational and individual factors needs to be examined to rule out the possibility that the safety climate variability is merely an artifact or surrogate of organizational and individual factors. If the moderation effect of safety climate variability on the safety climate level and safety behavior relationship diminishes as other organizational or individual factors are introduced to the moderation equation, this would provide evidence that safety climate variability is of less importance than the organizational and individual contexts.

Beus, Bergman, and Payne (2010) showed that worksite mean tenure was significantly and negatively associated with safety climate variability. According to the authors, this could be due to socialization processes and attraction-selection-attrition procedures. In other words, with more chances to observe organizational safety efforts and interact with others, organizational members are more likely to develop assimilated safety climate perceptions which in turn lead to smaller safety climate variability. Also, as an organization goes through a series of processes of recruiting, selecting, and retaining members whose safety values and attitudes are congruent with those of the organization, within-organization members' safety climate perceptions would become more similar. Thus, it can be inferred that the relationship between safety climate level and safety behavior would be stronger as tenure increases because it would be benefited by decreased safety climate variability. This suggests a potential mediation effect of safety climate variability between the tenure and safety behavior relationship. However, temporal precedence of tenure over safety climate variability has not been established yet. Also, without precluding the possibility of an interaction between tenure and safety climate variability, the mediating effect of safety climate variability cannot be examined properly (MacKinnon, Fairchild, & Fritz, 2007). More importantly, in order to examine the unique moderating effect of safety climate variability, tenure needs to be viewed as a competing moderator. Thus, tenure can be modeled as an additional moderator of the safety climate level and safety behavior relationship besides safety climate variability. If safety climate variability is simply an artifact of workers' tenure, the tenure itself will directly moderate the relationship between safety climate level and safety behavior while safety climate variability would no longer moderate the safety climate and safety behavior relationship.

Although Beus et al. (2010) focused only on the tenure at the worksite-level, individual workers' worksite tenure could also interact with safety climate variability such

that the impact of safety climate variability on safety behavior would be stronger for workers with shorter tenure. Workers who are relatively new to the organization or workgroup are yet to develop their own mental model for safety and are more likely to rely on small pieces of information they have and others' safety related perception/behavior as means of reducing uncertainty. Hence, they are more susceptible to safety climate variability than individuals with longer tenure who are more likely to have already established their own conception of safety climate.

#### *Hypothesis 2-1*

- *The moderating effect of safety climate variability on the safety climate level – safety behavior relationship varies in relation to workers' tenure such that it is stronger for workers with longer company tenure (three-way interaction).*
- *The safety climate level and safety behavior relationship will be stronger when workers' company tenure is greater (two-way interaction).*

#### *Hypothesis 2-2*

- *The moderating effect of safety climate variability on the safety climate level – safety behavior relationship varies in relation to work-groups' tenure such that it is stronger for workgroups with longer company tenure (three-way interaction).*
- *The safety climate level and safety behavior relationship will be stronger when work-groups' company tenure is greater (two-way interaction).*

Although Hypotheses 2-1 and 2-2 posit an augmenting effect of both workgroup- and individual employee-level company tenure on the safety climate level and safety behavior relationship, these hypotheses are exploratory. Specifically, the possibility that tenure

attenuates the safety climate level and safety behavior relationship was not dismissed because workers with longer tenure may hold a well-established personalized mental model for safety performance which can be independent of safety climate. Again, the major goal of Hypotheses 2-1 and 2-2 was to test the unique moderating effect of safety climate variability over workgroup- and individual employee-level company tenure on the safety climate level and safety behavior relationship.

Additionally, various task characteristics can be associated with reduced safety climate variability (i.e., greater safety climate consensus) considering that particular task types may involve more active and frequent interaction with other team members and supervisors. At the same time, if safety climate variability is simply the result of task characteristics, the task characteristics themselves will directly moderate the relationship between safety climate level and safety behavior, while safety climate variability will no longer moderate the safety climate and safety behavior relationship.

Specifically, required job values are known to differ across job types. O\*NET online (2013) specifies independence as one of the major work values for electrical power-line installers and repairers, suggesting that this type of worker needs proper responsibility and autonomy to make work-related decisions independently. Workers who perform independent tasks tend to have less social influence factors to keep them in check as far as observing, learning, and internalizing safety procedures even though their tasks are not always individualistic due to the nature of the tasks. For example, line workers perform highly specialized installation or repairing jobs in an isolated location such as overhead power line while their team members are on the ground supporting this work or working elsewhere at a distance on different tasks. Also, for many independent professions workers have higher decision latitude and their safety is directly affected by their own decisions. Given this, it is

essential for the independent task workers to have a solid and unambiguous mental model of workplace safety in order to perform safely. As such, a well-established safety mental model is more likely when variability in safety climate is small. Exposure to low safety climate variability would be more important for the workers with independent tasks, like electrical power-line installers and repair workers, than electrical maintenance and repair workers for whom independence is relatively less important. Accordingly, the following hypotheses can be drawn:

### *Hypothesis 3*

- *The moderating effect of safety climate variability on the safety climate level – safety behavior relationship varies depending on task characteristics, such that it is stronger for electrical power-line installers & repair workers than electrical maintenance & repair workers (three-way interaction).*
- *The safety climate level and safety behavior relationship will be stronger for electrical power-line installers & repair workers than electrical maintenance & repair workers (two-way interaction).*

Even though Hypothesis 3 postulates the enhancing impact of being independent task workers on the safety climate level and safety behavior relationship, this hypothesis was exploratory and the opposite possibility was not precluded. Workers with more independent jobs may be more reliant on a set of personal skill/knowhow or technology instead of safety climate perception. Moreover, if safety climate variability is a simple representation of the job categories determined by task independence, the moderation effect of safety climate on the relationship between safety climate level and safety behavior would diminish once the job categories are introduced in the original moderation equation.

Some job types of the electrical utilities such as trouble shooters and meter readers are individualistic while other types of jobs such as line, substation, and ground workers are crew. It does not mean that the trouble shooters and meter readers don't belong to any particular teams. For instance, there can be a group of trouble shooters or meter readers who are supervised by the same supervisor(s) and they may interact one another before they are dispatched to the task locations and in some specific occasions such as training and pre-job briefing sessions. However, those workers are more frequently exposed to remote or lone-working situations than other workers with less individualistic tasks. This suggests that workers with particular types of jobs would have fewer opportunities for work-related and social interaction in regard to safety, which may result in less homogenous safety climate perceptions. Also, unlike the non-individualistic or team-based task workers for whom collaboration and coordination among workers are of more importance, individualistic task workers are less likely to be influenced by their workgroup or organization's safety values and attitudes. Instead, their own unique safety climate perceptions are likely to unfold because it is difficult to expect timely feedback or assistance from colleagues or supervisors during their individualistic task performance. Hence, the moderation effect of safety climate variability on the safety climate level and safety behavior relationship may differ across the team-based versus individualistic job categories. A mediating effect of safety climate variability between individualistic task and safety behavior relationship can be posited as well. However, given that temporal precedence of holding an individualistic task over safety climate variability is not yet clearly established, and any potential interaction between individualistic task and safety climate variability in relation to safety behavior, Hypothesis 4 addresses only with the moderating effect of individualistic task and safety climate variability for the link between safety climate level and safety behavior. Also, like Hypotheses 2 and 3,

Hypothesis 4 aims to test the unique moderating effect of safety climate variability as well as its boundary condition, therefore “individualistic task” was introduced as an additional moderator of the safety climate level and safety behavior relationship. Accordingly, the following hypotheses can be drawn:

*Hypothesis 4*

- *The moderating effect of safety climate variability on the safety climate level – safety behavior relationship varies depending on task characteristics, such that it is stronger for team-based task workers than individualistic task workers (three-way interaction).*
- *The safety climate level and safety behavior relationship will be stronger for team-based task workers than individualistic task workers (two-way interaction).*

Hypothesis 4 assumes the attenuating effect of being individualistic task workers on the safety climate level and safety behavior relationship. This hypothesis was exploratory like Hypotheses 2 and 3. Thus, the possibility that individualistic task workers have a stronger safety climate level and safety behavior relationship than team-based workers was not ruled out. This can occur if individualistic task workers who lack instant safety feedback or support from management and colleagues tend to strongly rely on safety climate perception because it is more available for them.

Figure 1-B is the graphical illustration of *Hypotheses 2 to 4*. As the diagram suggests, the primary goal of these hypotheses were to identify the boundary conditions of the moderation effect of safety climate variability on the safety climate level and safety behavior relationship. At the same time, the uniqueness of the moderation effect of safety climate variability was challenged by additionally introducing interaction variables like tenure, task

independence, and individualistic task characteristics that are possibly related to safety climate variability. If the moderation effect of safety climate variability is shown to exist even after controlling for the factors that may moderate the safety climate level and safety behavior relationship, this supports the proposition that not only safety climate level but also its variability need to be considered to promote workplace safety.

### **Item-level Safety Climate Variability and Safety Behavior**

*Hypotheses 1 through 4* are essentially based on the premise that safety climate variability would moderate the relationship between the level of safety climate and safety behavior. In other words, it is assumed that a high level of safety climate is a major protective factor for workplace safety while an increase in safety climate variability reflects organizational contexts, where the impact of safety climate level on safety performance would be diminished. On the other hand, safety climate variability itself might be indicative of safety hazards not reflected in safety climate level alone. For example, a lack of consensus in safety climate perceptions may pose risks of uncoordinated and disintegrated safety performance of individuals, hampering joint optimization of processes for safety (Hendrick & Kleiner, 2002; Kleiner, 2006). These risks may in turn lead to increases in near misses, accidents, and injuries. Therefore, if particular items of a safety climate scale show more variability, this may reflect that organizational situations or conditions represented by those items are of greater concern because these may be serving as ambiguous cues to team members that consistent safety behavior is not necessary. This proposition could be tested by looking at the main effect of safety climate variability in prediction of safety behavior. However, the present study takes a different approach for two reasons. First, when interaction between two factors (i.e., safety climate level and variability) is being considered, the main effect of either of the two factors per se is oftentimes less meaningful because it should be understood in conjunction with the interaction term (i.e., a product of both the safety climate

level and variability). For instance, if there exists a significant interaction, the main effect of one factor on the dependent variable can be substantially different, even opposite in direction, across different levels of the other factor. Hence, simple observation of main effect can be misleading (e.g., Cox, 1984; de González & Cox, 2007). Second, safety climate variability can be assessed in different ways. Specifically, in examination of the interaction between safety climate level and variability (i.e., *Hypotheses 1 to 4*), within-workgroup safety climate variability is calculated based on the composite score of the safety climate scale. In this context, variability of the safety climate scale composite score is more conservative than variability of individual items of the scale because large variability of the items with extreme ratings will be offset by small variability of other items which are more frequent. This logic can explain how multiple-item measurement is more reliable than single-item measurement. However, item-level variability can inform for which specific safety climate facets (items) workers' perceptions converge or diverge more than others. Variability may be smaller or greater not only within particular workgroups but also consistently across all workgroups. More specifically, some items may have smaller or greater variability in groups with high to low within-workgroup safety climate variability (i.e., universal variability) while others may report varying levels of variability (i.e., workgroup-specific variability). To this end, the mean of within-workgroup safety climate variability across different workgroups needs to be examined, but which will not be of major interest in the examination of the safety climate level and variability interaction. If a certain item's within-group safety climate variability is small across all workgroups, it can be due to the specific aspect of safety climate the item represents is so clear that there is relatively little chance of incongruent perception among workers. In this case, the item can serve as a conforming cue for safe (i.e., low variability with high item mean score, indicating congruently high safety climate) or unsafe behavior (i.e., low variability with low item mean score, indicating congruently low safety climate).

On the contrary, if an item's within-group safety climate variability is large across the workgroups, this suggests that the item is more susceptible to unsynchronized perception among workgroup members possibly due to inconsistent organizational safety procedures and practices. Thus, this item may serve as an equivocal cue for variation in safety behavior.

Based on this line of reasoning, the following hypothesis can be drawn:

*Hypothesis 5: Safety climate scale items with less variability will be more predictive of safety behavior than scale items with more variability.*

If the safety climate scale items with greater variability are more weakly associated with safety behavior than other safety climate scale items with less variability, this would again support the importance of using safety climate variability as well as safety climate level when monitoring workplace conditions. Also, safety climate scale items that are identified as having greater variability across team members can be carefully evaluated to address the potential risks of large safety climate variability, potentially suggesting the need for more focused efforts for safety that are specific to the high variability items when planning workplace interventions.

## **Method**

### **Participants**

For this study, part of the safety climate research project data was used which was collected by the Liberty Mutual Research Institute for Safety (LMRIS) for the development and validation of a utility/electrical industry-specific safety climate scale (Huang et al., 2013b). From two large-sized electrical utilities in the United States, 1,560 (Company 1) and 861 (Company 2), questionnaires were originally obtained with response rates of 46% and 74%, respectively. More specific information about the data collection procedures can be

found at Huang et al. (2013b). As the primary focus of the present study is safety climate variability which is present at workgroup-level, and the moderation effect of safety climate variability on safety climate level and safety behavior relationship, this needs to be examined within a multi-level analysis framework (Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). Only the workgroups with three or more members were retained. In the final data analysis, 2,049 participants (i.e., 1,428 from Company 1 + 621 from Company 2) nested within 183 workgroups were used. In this particular data set, workgroup was defined by platforms and departments (task/job types) of the workers. Workers within the same workgroup work in the same geographic locations, perform a number of related tasks together, and are managed by the same supervisor(s). The number of workgroups ( $n = 183$ ) was appropriate for accurate parameter estimation in multi-level modeling as it is greater than 50 (Maas & Hox, 2005). The size of the workgroup ranged from 3 to 45 with the mean of 11.20 (S.D. = 9.73).

Demographic information such as gender and age could not be obtained due to confidentiality reasons. Most of the utility/electrical workers reported that their company tenure was 16 years or more (55.8%). Meanwhile, 9.3%, 14.0%, 19.0%, and 2.0% of the workers respectively fell in the company tenure categories of 11-15 years, 6-10 years, 1-5 years, and less than 1 year. The composition of the types of task/job was different across the two electrical utilities. Specifically, in Company 1, there were electric line workers (65.9%), substation workers (8.2%), electric metering workers (3.1%), and meter readers (22.9%). In Company 2, there were overhead trouble shooters (5.0%), overhead line workers (63.7%), substation workers (14.4%), and underground workers (16.9%). Among these job types, electric line workers, overhead trouble shooters, and overhead line workers were categorized as independent task workers based on O\*NET online (2013). Also, electric metering workers and meter readers were categorized as individualistic task workers as they work alone in most

cases. This information is summarized in Table 1.

## Measures

**Safety Climate.** 19-item group-level subscale of the electric/utility industry-specific safety climate scale (Huang et al., 2013b) was utilized to assess safety climate in the electrical utilities. Three factors of the scale are supervisory care, participation encouragement, and safety straight talk. The safety climate scale is calibrated on 5-point Likert scale (1: strongly disagree, 5: strongly agree), and example items include “My supervisor discusses ways to improve performance after non-routine or unusual job tasks (supervisor care factor)”, “My supervisor makes sure I use all the safety equipment for the job (PPE, rubber on lines) (participation encouragement factor)”, and “My supervisor takes the time to check on me, especially when I’m stressed or tired (safety straight talk factor)”. The scale’s psychometric properties such as construct validity and criterion-related validity are well established. More information can be found in Huang et al. (2013b). Internal consistency of the scale items was satisfactory with Cronbach’s  $\alpha = .93$ .

Safety climate level at psychological-level (level 1) was calculated by averaging the ratings on the 19 items while safety climate level at workgroup-level (level 2) was the mean of the within-workgroup members’ *psychological-level safety climate level*. The aggregation of the psychological-level safety climate to create the workgroup safety climate was supported by the result of ANOVA analysis ( $F[182, 1862] = 3.77, p < .01$ ) as well as the within-workgroup agreement and reliability statistics like  $r_{wgj}$  of .96 and intra-class correlation coefficients ICC(1) of .20 and ICC(2) of .73 (Bartko, 1976; James et al., 1984; James, Damaree, & Wolf, 1993; Bliese, 2000).  $r_{wgj}$  is an index of within-group members’ inter-rater agreement (James et al., 1993). A median of  $r_{wgj}$  greater than .70 is conventionally regarded as an evidence of acceptable within-group agreement (Bliese, 2013). ICC(1) means to what extent individuals within the same group agree in their perceptions of their group

characteristic (Ostroff & Schmitt, 1993). Although there are no definitive guidelines, ICC(1) over .10 indicating medium effect size is widely considered as acceptable (Murphy and Myors, 1998). ICC(2) examines whether the groups can be reliably differentiated in terms of the aggregated group-level score and it is the reliability measure for the aggregated group-level score (Bartko, 1976; Ostroff & Schmitt, 1993). Conventionally, the criterion for acceptable ICC(2) is over .70 (LeBreton & Senter, 2008; Ostroff & Schmitt, 1993).

Safety climate variability was measured by calculating the standard deviation of the within-workgroup members' safety climate scores as described in the *Safety Climate Variability Measurement* section, above. As shown in Table 1-A, the range of safety climate variability across 183 workgroups was .11 to 1.19 with a mean of .57 (S.D. = .17).

**Safety Behavior.** Employee safety behavior was measured with an 11-item scale adapted from Huang, Roetting, McDevitt, Melton, and Smith (2005). The items were behaviorally anchored and based on 5-point Likert scale (1: strongly disagree, 5: strongly agree). Example items include "I always report back to my supervisor with any safety concerns" and "I never throw or toss hand tools to a co-worker on a ladder or in a raised bucket". Cronbach's  $\alpha$  statistics of the 11 items was .67 which is below .70 criteria of acceptable internal consistency (Nunnally & Bernstein, 1994). This could be due to the design of the scale in which a broad higher-order construct of workplace safety is measured by a series of heterogeneous safety behavior categories, represented by individual items of the scale (Clark & Watson, 1995; Tavakol & Dennick, 2011). In other words, even though the behavior categories altogether are related to workplace safety, inter-correlations among the specific safety behavior categories may be relatively small. As the scale items have good content validity, and considering that prior studies have utilized psychological scales with

suboptimal ( $< .70$ ) Cronbach's  $\alpha$  values<sup>1</sup>, unless they are unacceptably low ( $< .50$ ; George & Mallery, 2003; Kline, 2000), the safety behavior measure was viewed as acceptable in the present study. Mean and standard deviation of safety behavior were respectively 3.67 and .50 for all study participants.

### **Analytical Approaches**

Prior to testing the hypotheses, it is important to examine the overall distribution of the 183 workgroups in terms of safety climate level and variability. If safety climate variability is high or low only in the workgroups with a particular level of safety climate, otherwise stated if safety climate variability is substantially specific to safety climate level, there can be little implication to study the interaction between safety climate level and variability. Specifically, if low safety climate variability is observed mostly in the workgroups with very low or high safety climate level, this suggests the possibility that ceiling and/or floor effects underestimate the safety climate variability in these particular workgroups. Also, if workgroups have low safety climate variability only when they have high safety climate level, it would be difficult to generalize the potential implications of the interaction between safety climate level and variability to unobserved and less likely situations such as 'high safety climate variability – high safety climate level' and 'low safety climate variability – low safety climate level' conditions. Thus, the relationship between safety climate level (at the workgroup-level) and variability was examined. More specifically, a quadratic relationship was tested by a polynomial regression approach.

To test *Hypotheses 1* through *4*, hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) was used to analyze psychological- and workgroup-level variables and

---

<sup>1</sup> For example, 14-item based obsessive compulsive drinking scale's Cronbach's  $\alpha$  was .67 in the study of Teunissen, Spijkerman, Schoenmakers, Vohs, and Engels (2012) while 5-item based level of task challenge measure had Cronbach's  $\alpha$  values ranging from .54 to .71 in the study of King, Botsford, Hebl, Kazama, Dawson, and Perkins (2012).

interactions among the study variables (e.g., safety climate variability interacts with psychological- and workgroup-level safety climate level in prediction of safety behavior). An open source package ‘lme4’ version 1.0-6 (Bates, Maechler, Bolker, & Walker, 2013; Bates & Sarkar, 2007) was utilized in R version 3.0.1 for this analysis. The psychological-level safety climate variable was grand-mean centered to reduce potential problems of multicollinearity (Cronbach, 1987; Hoffman & Gavin, 1998; Kreft, De Leeuw, & Aiken, 1995). In fact, group-mean centering is generally preferred to grand-mean centering in examination of cross-level or within-level interaction within a multilevel modeling framework (Enders & Tofighi, 2007; Hoffman & Gavin, 1998; Preacher, Zyphur, & Zhang, 2010). This is to properly distinguish the between- and within-group effects and to minimize the possibility of spurious cross-level interaction effect due to a potential interaction between the group (upper)-level moderator variable and the between-group variance of the individual (lower)-level predictor. However, Bliese (2002) noted that spurious cross-level interaction is uncommon and grand-mean centered variables can be utilized to examine cross-level interaction as long as the possibility of spurious cross-level interaction is ruled out first by running an additional model based on group-mean centered variables. More importantly, Aguinis, Gottfredson, and Culpepper (2013) emphasized the theoretical and interpretive implications in making a centering decision. Specifically, they stated: “Using group-mean centering suggests that testing interactions needs to reflect theoretical processes addressing deviations from a group average such as in frog pond/social comparison effects in studies of teams. However, not all theories specifically refer to deviations from group averages or have reached that level of sophistication (p. 1512)”. If group-mean centered psychological-level safety climate is used for the present study’s hierarchical linear modeling, the coefficient of the psychological-level safety climate would indicate the estimated change in safety behavior when one’s safety climate perception is one unit greater than the overall workgroup members’ mean safety

climate perceptions. This means that the coefficient is strictly workgroup-specific. However, many previous studies regarding the impact of psychological-level safety climate on safety behavior/outcomes (e.g., Beus et al., 2010; Christian et al., 2009; Clark, 2006; Zohar, 2000; Zohar & Luria, 2005) have focused not on the relative standing of one's safety climate perception within one's group, but on the general level of safety climate perceptions of individual workers. Hence, to address raw differences between psychological-level safety climate entities rather than differences relative to a workgroup mean, the present study utilized the grand-mean centered psychological-level safety climate. Given that, the coefficient of the psychological-level safety climate indicates the estimated change in safety behavior by a one unit increase in individual worker's safety climate perception in this study. Safety climate variability, which is a continuous numeric workgroup-level variable, was not centered as it was constant within each workgroup, where use of grand-mean centered or raw metric variable would only affect the intercept (Enders & Tofighi, 2007).

Initially, a model with every possible fixed (i.e., level 1 and level 2 predictors and their interaction terms) and random (i.e., random intercept and slope) effect was examined. Then, a fixed effect term with non-significant and smallest standard error adjusted coefficient (along with its corresponding random effect term, if available) was omitted to create a more parsimonious alternative model. If the initial model and the alternative model were not significantly different in terms of goodness of fit, the alternative model was preferred because it is more parsimonious. For the model comparison, model fit indexes such as Akaike information criterion (AIC), Bayesian information criterion (BIC), and deviance statistics were utilized. A model with smaller AIC and/or BIC is preferred and the deviance is equal to inverse of twice the log-likelihood while it asymptotically follows the  $\chi^2$  distribution. Thus, a  $\chi^2$  difference test can be applied in this model comparison. This procedure of model trimming and comparison was repeated until the most parsimonious model was identified without

significantly losing explanatory power. However, as long as an interaction term was retained in the model, main effects were retained regardless of their statistical significance according to the suggestions of both Nelder (1977) and Cox (1984).

To test *Hypotheses 5*, overall mean safety climate variability across workgroups was calculated for every safety climate scale item. Also, mean of variance below and also above the workgroup mean were calculated for the individual safety climate items. The reason why variance is utilized instead of standard deviation in this context is as follows. If standard deviation is computed specifically with item ratings above or below the workgroup mean, the degree to which these ratings deviate from overall workgroup mean cannot be properly represented because the reference will be shifted from workgroup mean to the average of the item ratings that are above or below workgroup mean. Therefore, the square of [item rating – workgroup item mean] was averaged across workgroups only when the item rating was smaller than workgroup item mean in order to get the mean of item variance below workgroup mean. Likewise, the square of [item rating – workgroup item mean] was averaged across workgroup only when the item rating is greater than workgroup item mean to get the mean of item variance above the workgroup mean. Lastly, individual item's correlation with safety behavior was then computed to get rank order correlations (Spearman's  $\rho$ ) with the three item-level variability indicators (i.e., overall mean safety climate variability as well as the means of item variance both above and below the workgroup mean).

## **Results**

### **Safety Climate Variability across Workgroups**

The relationship between safety climate level (at workgroup-level) and variability was examined based on the polynomial regression equation as follows. In the equation, SC indicates safety climate.

$$\text{SC variability} = \beta_0 + \beta_1 \times (\text{SC level}) + \beta_2 \times (\text{SC level})^2 + e \quad (1)$$

Instead of a curved quadratic relationship, a simple linear relationship between safety climate level and variability was detected with  $\beta_0 = .58$  (S.E. = .02,  $p < .01$ ),  $\beta_1 = -.11$  (S.E. = .04,  $p < .01$ ), and  $\beta_2 = -.05$  (S.E. = .06,  $p = .38$ ). This indicates the low likelihood of safety climate variability systematically getting closer to relatively greater or smaller values as safety climate level approaches to its both ends. The predictors accounted for 4.3% of the variance of safety climate variability (i.e.,  $R^2 = .043$ ). The correlation between safety climate variability and level was .20 ( $p < .01$ ) indicating small effect size (Cohen, 1988). No particular sign of a ceiling or floor effect was detected with this simple linear trend between safety climate level and variability. A scatter plot of safety climate level and variability was presented in Figure 2 and Table 2 shows the workgroup distribution by above- and below-mean safety climate level and variability. Specifically, 23.5% of workgroups ( $n = 43$ ) had above-mean safety climate level and variability while 17.5% of workgroups ( $n = 32$ ) had below-mean safety climate level and variability. In addition, 33.3% of workgroups ( $n = 61$ ) had above-mean safety climate level and below-mean safety climate variability while 25.7% of workgroups ( $n = 47$ ) had below-mean safety climate level and above-mean safety climate variability. These findings together suggest that safety climate variability is not remarkably specific to safety climate level, and variation of safety climate variability was present across the overall continuum of safety climate level.

### **Between Workgroup Variance In Safety Behavior**

An HLM approach attempts to separate within- and between-group variance to address the possibility of inflated type I error (Raudenbush & Bryk, 2002) which is of more concern when between-group variance is higher. In order to investigate the between-

workgroup variance in safety behavior, which is the dependent variable of the present study, a null model like that found below was tested:

$$\begin{aligned} \text{Level 1: } & \text{Safety Behavior}_{ij} = \beta_{0j} + r_{ij} \\ \text{Level 2: } & \beta_{0j} = \gamma_{00} + U_{0j} \end{aligned} \quad (2)$$

In the above equation,  $i$  indicates individual worker while  $j$  indicates workgroup where the individual  $i$  belongs to. Also,  $r_{ij}$  indicates individual worker-level residual while  $U_{0j}$  indicates variance in safety behavior across workgroups.  $\gamma_{00}$  is the grand mean of all workgroups' safety behavior. The percent of variance in safety behavior that is between workgroups can be denoted by the intra class correlation (ICC) which can be computed by the following equation in which  $\sigma^2$  represents the variance of  $r_{ij}$  while  $\tau_{00}$  represents the variance of  $U_{0j}$ :

$$\text{ICC} = \tau_{00} / (\sigma^2 + \tau_{00}) \quad (3)$$

The ICC was .073 suggesting that 7.3% of the variance in safety behavior exists at the workgroup-level. In past research, ICC values have ranged from 0 to .50, with a median of .12 (James, 1982; Ostroff & Schmitt, 1993), and so the observed ICC of .073 might seem not that impressive. However as depicted in Figure 3, safety climate level (at the psychological-level) and safety behavior relationship pattern were considerably different across the workgroups.

Thus, to what extent safety climate variability can explain the different safety climate level and safety behavior relationship patterns is definitely worthwhile to examine, and the appropriateness of the application of HLM framework to the study data is justified.

### HLM Results for Hypothesis 1

Figure 4 illustrates Hypothesis 1, which involves both within-level (i.e., workgroup-level safety climate level and safety climate variability) and cross-level (i.e., *psychological-level safety climate level* and safety climate variability) interactions. Accordingly, an HLM model with all possible predictors of safety behavior, namely workgroup-level safety climate level (G-SC), *psychological-level safety climate level* (P-SC), safety climate variability (SC variability), G-SC  $\times$  SC variability, and P-SC  $\times$  SC variability, was initially tested. The intercept of the model and slope statistic of the level 1 predictor (i.e., P-SC) were allowed to randomly vary across workgroups. This model is represented as *H1 Model 1* in Table 3. Not every predictor had a statistically significant coefficient. Particularly, the  $t$  value ( $=$  coefficient / S.E.  $= .05 / .23 = .21, p = .83$ ) of the coefficient of G-SC  $\times$  SC variability was the smallest, suggesting that there is only minimal interaction effect between workgroup-level safety climate level and safety climate variability. Thus, in the more parsimonious alternative model of *H1 Model 2* (Table 3), the G-SC  $\times$  SC variability term was omitted and this did not yield statistically significant model fit deterioration (i.e.,  $\Delta\chi^2 = .05, \Delta df = 1, p = .83$ ). In fact, AIC decreased from 2649 to 2647 while BIC also decreased from 2705 to 2698, indicating model fit improvement. In the *H1 Model 2*, the coefficient of G-SC had the smallest  $t$  value of  $-.84$  and it was statistically not significant ( $p = .40$ ). This suggests that workgroup-level safety climate level is not a statistically significant predictor of employee safety behavior in presence of other predictors. Hence, the G-SC term was omitted in the more parsimonious alternative model of *H1 Model 3* (Table 3) and the omission did not result in statistically significant model fit worsening (i.e.,  $\Delta\chi^2 = .62, \Delta df = 1, p = .43$ ). Also, model fit improvement in terms of AIC ( $2647 \rightarrow 2646$ ) and BIC ( $2698 \rightarrow 2691$ ) was observed. Although the coefficient of the SC variability in *H1 Model 3* was statistically not significant ( $\gamma_{02} = .13, \text{S.E.} = .08, p = .08$ ), it needed to be kept in the model because the interaction term of P-SC  $\times$  SC

variability was statistically significant ( $\gamma_{11} = -.26$ , S.E. = .11,  $p < .05$ ). As mentioned in the Method section, main effect terms need to be retained in the interaction effect testing model even though they don't have statistically significant coefficients (Cox, 1984; Nelder, 1977). Another main effect term P-SC was retained in the model for the same reason and it had statistically significant coefficient ( $\gamma_{10} = .44$ , S.E. = .07,  $p < .01$ ). Intercept of the model was 3.58 (S.E. = .05,  $p < .01$ ) and no further model simplification was needed. The *H1 Model 3* represented in the following equations suggests that the workers' safety behavior is 3.58 (on a 1 – 5 scale) when their *psychological-level safety climate level* is equal to the overall mean, and one unit increase in *psychological-level safety climate level* is associated with a .44 increase of safety behavior. At the same time, if safety climate variability in one workgroup is one unit higher than another, the impact of *psychological-level safety climate level* in prediction of safety behavior was smaller by  $-.13 (= -.26 [\gamma_{11}] + .13 [\gamma_{02}])$  while the safety climate variability per se does not significantly predict safety behavior.

$$\text{Level 1: } \text{Safety Behavior}_{ij} = \beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$$

$$\begin{aligned} \text{Level 2: } \beta_{0j} = & \gamma_{00} + \gamma_{01} \times (\text{G-SC}_j) + \gamma_{02} \times (\text{SC variability}_j) \\ & + \gamma_{03} \times (\text{G-SC}_j) \times (\text{SC variability}_j) + U_{0j} \end{aligned}$$

$$\text{Level 2: } \beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{SC variability}_j) + U_{1j} \quad (4)$$

$$\begin{aligned} \text{Safety Behavior}_{ij} = & \gamma_{00} + \gamma_{02} \times (\text{P-SC}_{ij}) + \gamma_{10} \times (\text{SC variability}_j) + U_{0j} \\ & + \gamma_{11} \times (\text{P-SC}_{ij}) \times (\text{SC variability}_j) + U_{1j} \times (\text{P-SC}_{ij}) + r_{ij} \end{aligned} \quad (4)'$$

These findings supported Hypothesis 1 of the present study. However, it should be noted that even though safety climate is oftentimes viewed as an upper-individual-level notion, interaction of safety climate variability was shown to occur only with psychological -

level (i.e., individual-level) safety climate level, instead of workgroup-level safety climate level in prediction of workers' safety behavior.

To examine what proportion of between-workgroup variance can be explained by the interaction between safety climate level at psychological-level and safety climate variability, *H1 Model 4*, which didn't include the interaction term (i.e., P-SC  $\times$  SC variability) was tested and the result is shown in Table 3. Exclusion of the interaction term induced a statistically significant model fit deterioration as presented in Table 4 (i.e.,  $\Delta\chi^2 = 6.09$ ,  $\Delta df = 1$ ,  $p < .05$ ). Even though BIC was somewhat improved from 2691 to 2689 due to the lower number of parameters to estimate (c.f., BIC penalizes model complexity), AIC increased from 2646 to 2650. More importantly, the between workgroup-variance of the psychological-level safety climate and safety behavior relationship was greater in *H1 Model 4* (i.e.,  $\text{var}\{\gamma_{11[\text{H1 Model 4}]}\} = \tau_{11[\text{H1 Model 4}]} = .014$ ) than in *H1 Model 3* (i.e.,  $\text{var}\{\gamma_{11[\text{H1 Model 3}]}\} = \tau_{11[\text{H1 Model 3}]} = .012$ ). The proportional reduction based on the following equation (5) was 14.3% ( $= [.014 - .012] \times 100 / .014$ ).

$$[\tau_{11(\text{H1 Model 4})} - \tau_{11(\text{H1 Model 3})}] \times 100 / \tau_{11(\text{H1 Model 4})} \quad (5)$$

In other words, the interaction term explained 14.3% of the between-workgroup variability of the psychological-level safety climate and safety behavior relationship.

Figure 5 depicts the observed moderation effect of safety climate variability. The solid and dotted estimation lines in the figure that were based on the HLM coefficients of *H1 Model 3*, respectively represent the different patterns of relationship between *psychological-level safety climate level* and safety behavior in the high and low safety climate variability conditions. The relationship between *psychological-level safety climate level* and safety behavior was found to be more marked when safety climate variability is smaller.

Finally, when grand-mean centered P-SC in *H1 Model 3* was replaced with group-mean centered (a.k.a., centering within cluster; CWC) variable, P-SC and SC variability interaction term was still statistically significant ( $\gamma_{11} = -.30$ , S.E. = .12,  $p < .05$ ). Moreover, when the group-mean of the P-SC (which is equal to workgroup-level safety climate level, G-SC) and SC variability interaction was additionally controlled for according to Aguinis et al. (2013)'s suggestion, the interaction between P-SC and SC variability was still statistically significant ( $\gamma_{11} = -.28$ , S.E. = .12,  $p < .05$ ). These findings rule out the possibility that the significant P-SC and SC variability interaction is simply due to spurious cross-level interaction effects (Enders & Tofghi, 2007; Hoffman & Gavin, 1998).

In sum, the results jointly supported Hypothesis 1 such that higher safety climate variability tends to attenuate the relationship between *psychological-level safety climate level* and workers' safety behavior. Workgroup-level safety climate level (G-SC) and safety climate variability (SC variability) didn't show a statistically significant interaction. Thus, *H1 Model 3* served as a baseline model for testing Hypotheses 2 through 4.

## **HLM Results for Hypothesis 2**

**Hypothesis 2-1.** Figure 6-A is the graphical representation of Hypothesis 2-1 and Tables 5 and 6 are the summary of the HLM results. At the beginning, the *H2-1 Model 1* was created by additionally including employee's company tenure variable to *H-1 Model 3*, the final model for testing Hypothesis 1. Specifically, the model had level 1 predictors such as P-SC, employee's company tenure (tenure), and their interaction term (P-SC  $\times$  tenure), level 2 predictor SC variability, as well as its interaction terms (with the included level 1 predictors). Like the Hypotheses 1 testing procedure, the intercept of the model and all the level 1 predictors' slope statistics in prediction of safety behavior were allowed to randomly vary across workgroups. Except for the intercept, none of the coefficients were statistically significant. Particularly, the coefficients for the P-SC  $\times$  tenure  $\times$  SC variability ( $\gamma_{31}$ ) reported

the smallest  $t$  values in general (ranged from -.01 to .17 for the four dummy code variables). The PSC  $\times$  tenure  $\times$  SC variability term was deleted in the more parsimonious alternative model *H2-1 Model 2* and the two models were not statistically significantly different in terms of goodness of fit (i.e.,  $\Delta\chi^2 = .80$ ,  $\Delta df = 4$ ,  $p = .93$ ). Instead, other goodness of fit indices indicated improved fit such that AIC decreased from 2666 to 2658 and BIC also decreased from 3091 to 3062 (Table 6). In *H2-1 Model 2*, the coefficient for tenure  $\times$  SC variability ( $\gamma_{21}$ ) generally got the smallest and non-significant  $t$  values in general (ranged from -.05 to -.61 for the four dummy code variables). Hence the coefficient was removed and a more parsimonious alternative model, *H2-1 Model 3*, was created. In terms of goodness of fit, there was no statistically significant difference between *H2-1 Model 2* and *H2-1 Model 3* (i.e.,  $\Delta\chi^2 = 2.82$ ,  $\Delta df = 4$ ,  $p = .89$ ). Moreover, AIC (2658  $\rightarrow$  2653) and BIC (3062  $\rightarrow$  3034) showed improvement (Table 6). Although SC variability did not have the statistically significant coefficient ( $\gamma_{01} = .11$ , S.E. = .08,  $p = .17$ ), it was retained in the model as it showed statistically significant interaction with P-SC ( $\gamma_{11} = -.26$ , S.E. = .10,  $p < .05$ ). Other coefficients for P-SC ( $\gamma_{10}$ ), tenure ( $\gamma_{20}$ ), and P-SC  $\times$  tenure ( $\gamma_{30}$ ) were all statistically significant as presented in Table 5. Therefore, no additional model simplification was needed and *H2-1 Model 3* was the final model for testing Hypothesis 2-1, and this is presented below.

$$\text{Level 1: } \text{Safety Behavior}_{ij} = \beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + \beta_{2j} \times (\text{tenure}_{ij}) + \beta_{3j} \times (\text{P-SC}_{ij}) \times (\text{tenure}_{ij}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{SC variability}_j) + U_{0j}$$

$$\text{Level 2: } \beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{SC variability}_j) + U_{1j}$$

$$\text{Level 2: } \beta_{2j} = \gamma_{20} + \gamma_{21} \times (\text{SC variability}_j) + U_{2j}$$

$$\text{Level 2: } \beta_{3j} = \gamma_{30} + \gamma_{31} \times (\text{SC variability}_j) + U_{3j} \quad (6)$$

$$\text{Safety Behavior}_{ij} = \gamma_{00} + \gamma_{01} \times (\text{SC variability}_j) + U_{0j} + \gamma_{10} \times (\text{P-SC}_{ij})$$

$$\begin{aligned}
& + \gamma_{11} \times (\text{SC variability}_j) \times (\text{P-SC}_{ij}) + U_{1j} \times (\text{P-SC}_{ij}) + \gamma_{20} \times (\text{tenure}_{ij}) + U_{2j} \times (\text{tenure}_{ij}) \\
& + \gamma_{30} \times (\text{P-SC}_{ij}) \times (\text{tenure}_{ij}) + U_{3j} \times (\text{P-SC}_{ij}) \times (\text{tenure}_{ij}) + r_{ij} \quad (6)'
\end{aligned}$$

According to this final model, workers' overall safety behavior was 3.45 (on a 1 – 5 scale) when *psychological-level safety climate level* was equal to overall mean and employee company tenure was less than one year. When employee company tenure was 16 or more years, safety behavior tended to be higher by .18 compared to workers with less than one year of tenure. As *psychological-level safety climate level* increases one unit, .70 of safety behavior increase is expected. Also, *psychological-level safety climate level* showed significant interaction with employee company tenure such that workers with 6 to 10 years of company tenure tended to have reduced impact of *psychological-level safety climate level* and safety behavior relationship by .28, workers with 11 to 15 years of company tenure tended to have reduced impact of *psychological-level safety climate level* and safety behavior relationship by .37, workers with 16 or more years of company tenure tended to have reduced impact of *psychological-level safety climate level* and safety behavior relationship by .28 all compared to workers with less than one year of company tenure. Safety climate variability did not show a statistically significant effect on safety behavior by itself but it did show a statistically significant interaction with *psychological-level safety climate level*. Specifically, one unit increase in safety climate variability induced a decreased impact of *psychological-level safety climate level* on safety behavior by .15 (= -.26 [ $\gamma_{11}$ ] + .11 [ $\gamma_{01}$ ]). In sum, these findings showed that safety climate variability significantly moderated the relationship between *psychological-level safety climate level* and safety behavior, which is in congruent with the result of Hypothesis 1 testing. However, potential interaction between employee company tenure and safety climate variability was not supported, rejecting Hypothesis 2-1. Safety climate variability was shown to have unique effect on safety climate level and safety

behavior relationship even when employee company tenure was controlled for.

**Hypothesis 2-2.** Figure 6-B is the graphical representation of Hypothesis 2-2 and Tables 5 and 6 are the summary of the HLM results. As a first step, *H2-2 Model 1* was created by adding in workgroup's company tenure variable to *H-1 Model 3*, the final model for testing Hypothesis 1. In detail, the model had a level 1 predictor of P-SC, level 2 predictors such as SC variability, workgroup company tenure (tenure), and their interaction term (tenure  $\times$  SC variability) as well as the workgroup company tenure's interaction terms (with P-SC and tenure  $\times$  SC variability). Like the Hypotheses 1 and 2-1 testing procedures, intercept of the model and all the level 1 predictors' slope statistics in prediction of safety behavior were allowed to randomly vary across workgroups. All coefficients of *H2-2 Model 1* were statistically non-significant except for intercept. Particularly, the coefficient for tenure  $\times$  SC variability term ( $\gamma_{03}$ ) reported the smallest  $t$  values ranged from .06 ( $p = .95$ ) to .23 ( $p = .81$ ) across different dummy coded variables, and so this term was not included in the more parsimonious alternative model *H2-2 Model 2*. The two models (i.e., *H2-2 Model 1* and *H2-2 Model 2*) did not showed statistically significant model fit difference as shown in Table 8 (i.e.,  $\Delta\chi^2 = 2.59$ ,  $\Delta df = 3$ ,  $p = .46$ ). In fact, improvement in model fit was observed in terms of AIC (2652  $\rightarrow$  2649) and BIC (2765  $\rightarrow$  2744). None of the coefficients of *H2-2 Model 2* was statistically significant except for intercept and another predictor term with the least coefficient, which was P-SC  $\times$  tenure  $\times$  SC variability ( $\gamma_{13}$ ) was omitted in the more parsimonious alternative model *H2-2 Model 3*. In *H2-2 Model 2*, this term had  $t$  values ranging from .06 ( $p = .95$ ) to .40 ( $p = .69$ ) for different dummy coded variables. No significant model fit deterioration was detected followed by the omission of P-SC  $\times$  tenure  $\times$  SC variability (i.e.,  $\Delta\chi^2 = 2.45$ ,  $\Delta df = 3$ ,  $p = .48$ ) as shown in Table 8. Also, AIC decreased from 2649 to 2645 while BIC decreased from 2744 to 2724, suggesting improved fit. Still, some coefficients of *H2-2 Model 3* ( $\gamma_{01}$ ,  $\gamma_{02}$ , and  $\gamma_{11}$ ) were statistically non-significant. Among

these, the coefficient for tenure term reported the smallest  $t$  values ranging from  $-.05$  ( $p = .96$ ) to  $-1.41$  ( $p = .16$ ) but this term need to be kept in the model because its interaction with P-SC was yet present in the model. Thus, in the following parsimonious alternative model *H2-2 Model 4*, tenure  $\times$  P-SC term which showed the second smallest  $t$  values ranging from  $-.90$  ( $p = .37$ ) to  $-1.69$  ( $p = .09$ ) was omitted and this did not yield statistically significant model fit difference (i.e.,  $\Delta\chi^2 = 4.63$ ,  $\Delta df = 3$ ,  $p = .20$ ). At the same time, AIC ( $2645 \rightarrow 2644$ ) and BIC ( $2724 \rightarrow 2706$ ) showed improvement. In *H2-2 Model 4*, coefficients for workgroup company tenure ( $\gamma_{01}$ ) and SC variability ( $\gamma_{02}$ ) were statistically non-significant. However, SC variability needed to be retained in the model as its interaction with P-SC was statistically significant ( $\gamma_{11} = -.28$ , S.E. =  $.11$ ,  $p < .01$ ). Hence, the workgroup company tenure variable was additionally deleted in the revised alternative model *H2-2 Model 5* to make it even more parsimonious. In fact, this resulted in statistically significant model fit difference (i.e.,  $\Delta\chi^2 = 7.96$ ,  $\Delta df = 3$ ,  $p < .05$ ). While AIC slightly increased from 2644 to 2646, BIC decreased from 2706 to 2691. Given that  $\tau_{11}$  (= between workgroup variance in the slope statistic for P-SC in prediction of worker's safety behavior) for *H2-2 Model 4* and *H2-2 Model 5* were all  $.012$ , it can be inferred that the workgroup company tenure variable did not explain much of between workgroup difference in P-SC and safety behavior relationship. Thus, even though *H2-2 Model 4* (a model with workgroup company tenure variable) reported somewhat better model fit, *H2-2 Model 5* (a model without workgroup company tenure variable) was preferred as workgroup company tenure variable had a non-significant coefficient with minimal explanatory power.

In sum, *H2-2 Model 5* was the final model for Hypothesis 2-2 and it was exactly the same as the final model for Hypothesis 1 (*H1 Model 3*, Table 3). The moderation effect of workgroup's company tenure on the relationship between *psychological-level safety climate level* and safety behavior relationship (Hypothesis 2-2) was not supported, while the

moderation effect of safety climate variability was supported.

### HLM Results for Hypothesis 3

Figure 7 illustrates Hypothesis 3 and HLM results for Hypothesis 3 are presented in Tables 9 and 10. The first HLM model examined was created by incorporating a level 2 predictor, task independence, to the final model for Hypothesis 1 (*H1 Model 3*). Specifically, the model (*H3 Model 1*) had a level 1 predictor P-SC, level 2 predictors of task independence (idpt), SC variability, and their interaction term (idpt  $\times$  SC variability). Also, interactions between the level 1 and 2 variables were specified (i.e., P-SC  $\times$  idpt, P-SC  $\times$  SC variability, & P-SC  $\times$  idpt  $\times$  SC variability). Like the models for Hypotheses 1, 2-1, and Hypothesis 2-2, the intercept of the model as well as the slope statistic for P-SC in prediction of safety behavior were allowed to randomly vary across workgroups. Not every coefficient in *H3 Model 1* was statistically significant, and particularly, the coefficient for idpt  $\times$  SC variability ( $\gamma_{03}$ ) reported as the smallest  $t$  value of -1.12 ( $p = .26$ ). Thus, the idpt  $\times$  SC variability term was removed in the following alternative model *H3 Model 2*. This omission did not yield statistically significant model fit worsening (i.e.,  $\Delta\chi^2 = 1.25$ ,  $\Delta df = 1$ ,  $p = .26$ ) and improvement in AIC (2633  $\rightarrow$  2632) and BIC (2701  $\rightarrow$  2694) observed, as presented in Table 10. In *H3 Model 2*, idpt  $\times$  SC variability  $\times$  P-SC ( $\gamma_{11}$ ) had a statistically non-significant coefficient while all other predictor and interaction terms had significant coefficients (Table 9). Thus, the idpt  $\times$  SC variability  $\times$  P-SC term was omitted in *H3 Model 3* and this model was not significantly different from *H3 Model 2* in terms of goodness of fit (i.e.,  $\Delta\chi^2 = 2.84$ ,  $\Delta df = 1$ ,  $p = .13$ ). AIC slightly increased from 2632 to 2633 but BIC decreased from 2694 to 2689 Table 10). In *H3 Model 3*, all coefficients were statistically significant and there was no need to further simplify the model. Thus this model was the final model for Hypothesis 3 and it was presented below.

$$\text{Level 1: } \text{Safety Behavior}_{ij} = \beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{idpt}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{0j}$$

$$\text{Level 2: } \beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{idpt}_j) + \gamma_{12} \times (\text{SC variability}_j) + \gamma_{13} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{1j} \quad (7)$$

$$\begin{aligned} \text{Safety Behavior}_{ij} = & \gamma_{00} + \gamma_{01} \times (\text{idpt}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{0j} \\ & + \gamma_{10} \times (\text{P-SC}_{ij}) + \gamma_{11} \times (\text{idpt}_j) \times (\text{P-SC}_{ij}) + \gamma_{12} \times (\text{SC variability}_j) \times (\text{P-SC}_{ij}) \\ & + \gamma_{13} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{1j} \times (\text{P-SC}_{ij}) \end{aligned} \quad (7)'$$

Based on *H3 Model 3* and its coefficient estimates, the following interpretation is possible. Safety behavior was 3.63 (on a 1 – 5 scale) when *psychological-level safety climate level* was set equal to the overall mean, one's task/job was not highly independent, and one's workgroup had zero safety climate variability. Compared to workers from non-independent task/job workgroups, workers from highly independent task/job workgroups tended to have a lower level of safety behavior by .11 when other variables were held equal. One unit increase in safety climate variability was associated with .16 of increase in safety behavior when workers were from non-independent task/job workgroups and *psychological-level safety climate level* was equal to the overall mean. Also, one unit increase in *psychological-level safety climate level* was anticipated to result in .47 of increase in safety behavior when workers were from non-independent task/job workgroups, and safety climate variability was zero. The impact of *psychological-level safety climate level* on safety behavior was significantly moderated by task independence such that it decreased by .08 for highly independent task/job workgroups compared to non-independent task/job workgroups. In addition, the impact of *psychological-level safety climate level* on safety behavior was significantly moderated by safety climate variability such that it decreased by .08 (= -.24 [ $\gamma_{12}$ ] + .16 [ $\gamma_{02}$ ]) for every one unit increase in safety climate variability.

These findings failed to support Hypothesis 3, and actually the relationship between safety climate level (psychological-level) and safety behavior was weaker for workgroups with highly independent task/job (i.e., electrical power-line installers & repair workers) than workgroups with non-independent task/job (i.e., electrical maintenance & repair workers), which is the inverse of the relationship predicted by Hypothesis 3. Meanwhile, the moderation effect of safety climate variability was again supported. When safety climate variability was higher, the link between *psychological-level safety climate level* and safety behavior was less marked even when the effect of task independence was controlled for.

#### **HLM Results for Hypothesis 4**

Hypothesis 4 is illustrated in Figure 8, and HLM results for Hypothesis 4 are summarized in Tables 11 and 12. The initial HLM model *H4 Model 1* was created by including a level 2 predictor, individualistic task, to the final model for Hypothesis 1 (*H1 Model 3*). This model consists of a level 1 predictor of P-SC and level 2 predictors such as individualistic task (idvl), SC variability, and their interaction term  $\text{idvl} \times \text{SC variability}$ . Also, interactions between the level 1 and 2 predictors such as  $\text{P-SC} \times \text{idvl}$ ,  $\text{P-SC} \times \text{SC variability}$ , and  $\text{P-SC} \times \text{idvl} \times \text{SC variability}$  were specified in the model. Consistent with the models for Hypotheses H1 through H4, random intercept and slope across workgroups were allowed. In *H4 Model 1*, the coefficient for  $\text{P-SC} \times \text{idvl} \times \text{SC variability}$  ( $\gamma_{13}$ ) had the smallest and statistically non-significant  $t$  value of  $-.08$  ( $p = .94$ ). Hence,  $\text{P-SC} \times \text{idvl} \times \text{SC variability}$  term was excluded in the more parsimonious alternative model *H4 Model 2*. The exclusion did not produce statistically significant model fit deterioration (i.e.,  $\Delta\chi^2 = .01$ ,  $\Delta df = 1$ ,  $p = .93$ ) and AIC decreased from 2652 to 2650 while BIC decreased from 2719 to 2711 (Table 12). Thus, *H4 Model 2* was preferred over *H4 Model 1*. The coefficient of the interaction term of  $\text{idvl} \times \text{p-SC}$  ( $\gamma_{11}$ ) in *H4 Model 2* had the smallest and statistically non-significant  $t$  values that ranged from  $.80$  ( $p = .42$ ) and  $.95$  ( $p = .34$ ). Therefore, the following alternative model *H4 Model 3*

did not include this term but no goodness of fit worsening was observed (i.e.,  $\Delta\chi^2 = .63$ ,  $\Delta df = 1$ ,  $p = .43$ ). AIC (2650  $\rightarrow$  2648) and BIC (2711  $\rightarrow$  2704) were reduced as well (Table 12). The model was additionally trimmed by removing the interaction term  $idvl \times SC$  variability as its coefficient ( $\gamma_{03}$ ) had the smallest and statistically non-significant  $t$  value of .85 ( $p = .40$ ). The *H4 Model 4* which did not have  $idvl \times SC$  variability term showed no model fit worsening compared to *H4 Model 3* (i.e.,  $\Delta\chi^2 = .71$ ,  $\Delta df = 1$ ,  $p = .40$ ). AIC (2648  $\rightarrow$  2647) and BIC (2704  $\rightarrow$  2698) showed improvement (Table 12). Further model simplification was implemented (*H4 Model 5*) by removal of  $idvl$  variable as its coefficient ( $\gamma_{01}$ ) had statistically non-significant and smallest  $t$  value of  $-.96$  ( $p = .34$ ). This did not yield any significant model fit change compared to *H4 Model 4* (i.e.,  $\Delta\chi^2 = .90$ ,  $\Delta df = 1$ ,  $p = .34$ ). Improvement in AIC (2647  $\rightarrow$  2646) and BIC (2698  $\rightarrow$  2691) detected (Table 12). In *H4 Model 5*, SC variability had statistically non-significant coefficient ( $\gamma_{02} = .13$ , S.E. = .08,  $p = .34$ ), however it did not need to be removed from the model as its interaction with P-SC was statistically significant ( $\gamma_{12} = -.26$ , S.E. = .11,  $p < .05$ ). All other coefficients in *H4 Model 5* were statistically significant, so it was the final model for Hypothesis 5. The model is in fact equal to the final models of Hypothesis 1 and Hypothesis 2-2, suggesting that individualistic task was neither a significant predictor of safety behavior by itself nor did it significantly interact with *psychological-level safety climate level* and safety climate variability.

In sum, Hypothesis 4 was not supported. *Psychological-level safety climate level* and safety behavior relationship was not different across workers with more and less individualistic task/job. On the other hand, the moderation effect of safety climate variability was supported again.

### Results for Hypothesis 5

Item-level mean, mean of item-level within-workgroup standard deviation (i.e., safety climate variability) across workgroups, mean of item-level variance below workgroup

mean, and mean of item-level variance above workgroup mean for every 19 items of the utilized safety climate scale were presented in Table 13. It also shows the correlation between safety climate scale item rating and workers' safety behavior for each of the 19 safety climate scale items. Rank order correlation analysis showed that safety climate scale items with higher safety climate variability tended to have weaker correlation between item rating and safety behavior ( $\rho = -.62, p < .01$ ). In other words, safety climate scale items of stronger perceptual consensus within workgroups are more predictive of the workers' general safety behaviors. This finding is in favor of Hypothesis 5. When safety climate variability at the item-level was decomposed into below and above workgroup mean, they did not show statistically significant rank order correlations with the correlation between item rating and safety behavior. Specifically, item rank order by mean of item-level variance below workgroup mean was correlated with item rank order by correlation between the item rating and safety behavior with  $\rho = .32 (p = .19)$ . Item rank order by mean of item-level variance above workgroup mean was correlated with item rank order by correlation between item rating and safety behavior with  $\rho = -.29 (p = .23)$ .

These findings suggest that what was more relevant to safety climate item's safety behavior prediction was overall safety climate variability within workgroups, rather than the direction of safety climate variability (i.e., below or above workgroup mean variability). At the same time, it needs to be considered that the rank of item-level mean was very highly correlated with item rank by correlation between item rating and safety behavior with  $\rho = .91 (p < .01)$ . Also, item-level mean was significantly and negatively correlated with item-level safety climate variability mean ( $r = -.67, p < .01$ ). Put differently, a lack of consensus in safety climate perception was more likely when ratings on the safety climate scale items were smaller while at the same time these items of lower mean and greater within-workgroup variability were less predictive of worker's safety behavior.

## Discussion

In the present study which utilized a sample of electrical utility workers, an HLM approach was adopted to examine how the effect of safety climate level on purported safety behavior differs depending on safety climate variability. Specifically, it was hypothesized that stronger safety climate variability might attenuate the impact of safety climate on safety behavior because a lack of consensus in safety climate perceptions within the workgroup may be indicative of suboptimal safety efforts and practices, defective team member coordination, and organizational tolerance to unsafe behavior. Also, potential boundary conditions for the interaction between safety climate level and variability were investigated in order to probe in which particular contexts this interaction occurs, and to identify any possible confounding effects of individual and organizational factors on safety climate variability. To this end, factors like individual worker's company tenure, the workgroup's company tenure, task independence, and individualistic tasks were considered. Finally, the strength of the safety climate scale items' correlation with safety behavior was compared to each items' safety climate variability across overall workgroups. Items with less variability were assumed to be more closely linked to safety behavior because these items would serve as more straightforward cues for safe occupational behavior.

## Results Summary

The results in general consistently supported the primary interest of the present study, namely the moderation effect of safety climate variability on the relationship between safety climate level and safety behavior. Specifically, the final HLM model for testing Hypothesis 1 included the interaction term of *psychological-level safety climate level* and safety climate variability as it had a statistically significant coefficient and it accounted for 14.3% of the total between-workgroup variability of the *psychological-level safety climate level* and safety

behavior relationship. This relationship tended to become weaker as safety climate variability increased, as originally hypothesized. However, workgroup-level safety climate level did not have a statistically significant interaction with safety climate variability nor did it have any statistically significant main effect on safety behavior. Considered jointly, Hypothesis 1 was supported but the moderating effect of safety climate variability was present for the safety climate level and safety behavior relationship only at the psychological -level (i.e., individual-level).

The final model of Hypothesis 1 served as the baseline model for Hypotheses 2 to 4 which aimed at testing boundary conditions of the interaction between *psychological-level safety climate level* and variability in prediction of safety behavior. Each of the hypothesized boundary condition factors was introduced to the model, and all possible interactions were assumed. In the final model for testing Hypothesis 2-1, employee tenure showed a statistically significant interaction with psychological-level safety climate in prediction of safety behavior, and the effect of *psychological-level safety climate level* on safety behavior tended to be smaller for employees with longer company tenure. However, Hypothesis 2-1 was not supported because employee company tenure lacked a statistically significant interaction with both safety climate variability and with the interaction term of *psychological-level safety climate level* and safety climate variability. This indicated that the moderating effect of safety climate variability on the relationship between *psychological-level safety climate level* and safety behavior did not systematically differ by employee tenure. Even after partialling out the effect of employee company tenure on safety behavior, statistically significant *psychological-level safety climate level* and variability interaction was still detected.

In order to test Hypothesis 2-2, company tenure of overall workgroup members was introduced into to the baseline model for the moderation effect of safety climate variability

(final model for Hypothesis 1). Workgroup company tenure also did not have a statistically significant interaction with safety climate variability or with the interaction term of *psychological-level safety climate level* and safety climate variability, resulting in Hypothesis 2-2 to be rejected. In fact, workgroup company tenure did not interact with *psychological-level safety climate level* either, so the final model for Hypothesis 2-2 ended up being equal to the final model for Hypothesis 1 after a series of model simplifications. Since it turned out that workgroup company tenure had minimal impact on the moderating effect of safety climate variability on the *psychological-level safety climate level* and safety behavior, Hypothesis 2-2 was rejected.

HLM models for testing Hypothesis 3 revealed that electrical utility workers with more independent tasks tended to be less reliant on psychological-level safety climate in pursuit of safety behavior compared to the workers with less independent tasks, as expected. However, the omission of the task independence interaction terms with safety climate variability (i.e., task independence  $\times$  safety climate variability & task independence  $\times$  *psychological-level safety climate level*  $\times$  safety climate variability) from the initial HLM model, in which all possible interactions of task independence were assumed in the final Hypothesis 1 model, did not result in statistically significant model fit worsening. These results suggest that the moderating effect of safety climate variability on the association between *psychological-level safety climate level* and safety behavior was not influenced by the independence of worker's tasks, and so Hypothesis 3 was not supported.

As a result of a sequential model simplification, the final model for Hypothesis 4 was the same as the final model for Hypothesis 1. The results showed that the moderating effect of safety climate variability on the *psychological-level safety climate level* and safety behavior relationship was not statistically significantly different across workers with individualistic and those with less individualistic tasks. Also, individualistic tasks did not

interact with *psychological-level safety climate level* either. Jointly, Hypothesis 4 was not supported but the moderating effect of safety climate variability was shown to be statistically significant across the different HLM models with or without this individualistic task factor and its interaction terms (i.e., individualistic task  $\times$  *psychological-level safety climate level*, individualistic task  $\times$  safety climate variability, & individualistic task  $\times$  *psychological-level safety climate level*  $\times$  safety climate variability).

Finally, safety climate scale items with more within-workgroup variability across entire workgroups tend to have lower means, and they were also less predictive of safety behavior. These findings supported Hypothesis 5 and indicated that the safety climate scale items vary in terms of safety climate variability, and that item-level safety climate variability can serve as an important indicator of safety behavior.

### **Theoretical Implications**

The present study confirmed the proposition regarding an organizational climate level and variability interaction in the safety climate domain. Congruent with the previous organizational climate research (e.g., Colquitt et al., 2002; Dickson et al., 2006; Gonzalez-Roma et al., 2002; Lindell & Brandt, 2000; Schneider et al., 2002), a more marked relationship between safety climate level and safety behavior (i.e., stronger organizational climate and climate outcome relationship) was detected for electrical utility workers within workgroups that had more consistent safety climate perceptions (smaller safety climate variability). This finding is the first of its kind in the safety climate research literature to the author's best knowledge, and it points to the need for extending safety climate theory to incorporate antecedents and outcomes of safety climate variability. Thus far, most safety climate research has been focused on safety climate level; for example, social interaction among organizational members and supervisory practice/leadership as precursors, with safety behavior or injury rate as outcomes (e.g., Mearns, Whitaker, & Flin, 2003; Zohar, 2010;

Zohar, 2011; Zohar & Hoffmann, 2012; Zohar & Tenne-Gazit, 2008). In fact, conventional approaches of safety climate intervention have oftentimes been aimed at improving leader-member communication and/or leadership style in promoting a higher level of safety climate (e.g., Zohar, 2002; Zohar & Polachek, in press; Zohar & Tenne-Gazit, 2008). Findings of the present study call for a balanced emphasis on both dimensions of safety climate: safety climate level and variability. As the study analyses have indicated, safety climate variability can be considerable even when safety climate level is generally high (see Figure 2 and Table 2), and high safety climate level may not always be indicative of safety performance if variability in safety climate perceptions of organizational members is large. Therefore, consideration of safety climate variability can be critical to optimizing the positive impact of safety climate on occupational safety. Also, if some factors have a distinctive influence on both safety climate level and variability can be identified, this would suggest that safety climate level and variability need to be separately managed.

Another important theoretical implication of the present study's findings is the importance of multilevel framework for understanding safety climate. The present study showed that workgroup-level (aggregated) safety climate level was not a significant predictor of safety behavior of electrical utility workers, and that it also did not have a statistically significant interaction with safety climate variability. Although safety climate is an organizational entity according to its original definition (Zohar, 1980; 2000), it was the perceived and internalized psychological-level safety climate instead that impacted electrical utility workers' safety behavior, such as compliance to safety policy and paying attention to potential hazards. The stronger impact of psychological-level safety climate level than workgroup-level safety climate level may be attributed to the consideration of an additional workgroup-level variable, safety climate variability. In fact, workgroup-level safety climate level showed significant correlation with safety climate variability, though the effect size was

not big (i.e.,  $r = -.20, p < .01$ ). Also, a less marked impact of workgroup-level safety climate level may be due to the uniqueness of the present utility/electric worker sample; who are known to frequently work without in-person supervision (Huang et al., 2013b). Meanwhile, the fact that safety climate variability, which is necessarily an above-individual-level concept<sup>2</sup>, significantly moderated the relationship between *psychological-level safety climate level* and safety behavior, indicating that the mechanism of safety climate in promotion of safety cannot be fully understood outside the multilevel organizational research scheme. In other words, even if a safety climate level and safety behavior (or outcome) relationship is supported, not at the above-individual-level but only at the psychological-level, the suggested effect of safety climate variability on this relationship, which involves a cross-level interaction (Aguinis et al., 2013; Cole et al., 2011), necessitates taking a multilevel perspective. Even though satisfactory sharedness is not ensured to create above-individual-level safety climate (e.g., Huang et al., 2013a; Zohar, et al. 2014), safety climate variability always exists at the above-individual-level. Also, when safety climate variability is introduced to a model when testing the safety climate level and safety behavior/outcome relationship, a different result can be obtained compared to when safety climate variability is not considered. Specifically, if safety climate variability has a statistically significant interaction with safety climate level, the main effect term of safety climate level has a different meaning, because it should be interpreted in conjunction with the interaction term (Cox, 1984). Also, some predictors of safety behavior/outcome may no longer be statistically significant after controlling for safety climate variability and its interaction terms. Thus, a multilevel perspective would be absolutely critical to properly investigating safety climate. In

---

<sup>2</sup> When safety climate is repeatedly measured for a person, variability may exist at an individual-level. However, this reflects more about the person's perceptual style (susceptibility). With a premise that safety climate variability essentially involves mutual influence among workgroup or organizational members, safety climate variability can be viewed as an above-individual-level concept.

the present study, measurement of safety climate level and variability was based on safety climate scale but responses on the scale items may be more susceptible to detecting psychological-level safety climate. Alternative approaches like focus group can be adopted in future studies to better capture (e.g., direct observation or obtaining consensus among members through discussion) the cross-level influences from organizations/teams to individuals as well as reciprocal influences among organization/team members with respect to safety climate.

The findings of the present study also indicate a need for more empirical studies regarding the role of safety climate variability in the promotion of occupational safety as well as theoretical breakthroughs. First, how safety climate variability impairs team member coordination when it is large can be further speculated upon. In particular, a theory of representational gaps which was proposed by Cronin and Weingart (2007) based on the shared mental model framework (Cannon-Bowers, et al., 1993; Klimoski & Mohamed, 1994; Stout et al., 1996) seems to be a promising way to explain this phenomenon. According to Cronin and Weingart, different knowledge and values of organizational members create gaps in their problem representations, and this in turn derails team information processing. The results are conflict among workers and coordination errors (i.e., actions that work against others'), and both can lead to poor team performance. This line of reasoning can be applied to safety climate research, and representational gaps would be conceptually equivalent to safety climate variability. Future studies need to investigate the relationship between safety climate variability and the numerous aspects of the quality of team member coordination in terms of safety performance.

In a second line of research examining the presence of notable safety climate variability within a workgroup, it is possible to postulate the process of how relatively poor safety climate perceptions of some workers negatively affect safety climate perceptions

and/or safety behaviors of other workers in the same workgroup. In regard to this, the reciprocal safety culture model of Cooper (2000), which is an extension of the social learning theory of Bandura (1977) to the safety domain, could be a good starting point. It emphasizes the interaction between internal psychological factors and external/contextual factors. Specifically, one's safety behavior is a product of contextual factors like perceptual audit based on safety climate perception, and an objective audit as part of a safety management system, with all of these factors closely interrelated. Given this reciprocal determinism, workers are constantly exposed to safety-related organizational cues by interacting with other workers. Accordingly, their safety climate perception and behavior are being continuously adapted. Workers with perceptions of excellent safety climate may adjust their views on their workplace safety practices by observing other workers with perceptions of poor safety climate and who behave unsafely. Similarly, workers with poor safety climate perceptions may modify their perceptions by observing other workers with perceptions of excellent safety climate who also behave safely. Future studies are required to examine whether these propositions are true, and which (i.e., is good safety climate influenced by poor safety climate or is poor safety climate influenced by good safety climate) is more common and compelling.

Even though the main effect of safety climate variability on electrical utility workers' safety behavior was not supported in the current study, a third line of research could examine direct, indirect, or moderating effects on numerous safety climate outcomes other than safety behavior; for example, job satisfaction, engagement, and turnover rate (Huang, Lee, McFadden, Murphy, Robertson, & Zohar, 2014) as well as productivity. This is because ambiguous organizational attitudes and values on safety, and subsequently large safety climate variability, is known to induce conflict in safety-related occupational decision making and cause coordination errors (Cronin & Weingart, 2007), while any conflict and coordination errors may become stressors for workers and impede smooth and efficient

workflow. Beyond the moderation effect of safety climate variability on the safety climate level and safety behavior/outcome relationship, the potential impact of safety climate variability on other psycho-behavioral outcomes needs to be investigated. Mediation relationships such as *safety climate variability* → *conflict* → *job satisfaction* and *safety climate variability* → *coordination* → *productivity* can be examined. Potential boundary conditions for these hypothetical relationships such as worker personality (e.g., agreeableness), frequency and quality of co-worker interaction, and supervisory quality are also worth examining.

In a fourth line of research, theories of risk perception can be applied in safety climate variability research. In the present study, it was shown that workers tended to behave less safe, even when their safety climate level was high, if there was large safety climate variability in their workgroup. As risk perception is a central precursor of specific safety and health behavior in the paradigm of judgment and decision making (Brewer, Chapman, Gibbons, Gerrad, McCaul, & Weinstein, 2007; Weinstein, 1993), it can be inferred that safety climate variability has something to do with risk perception. One possible scenario is safety climate variability affects the familiarity to risky and unsafe behavior. For instance, although a workgroup's safety climate level may be high in general, if workers' safety climate perceptions vary notably workers are likely to observe safety-compromising behavior of those with relatively low safety climate perception. Continuous observation of the unsafe behavior might numb one's sensitivity to the riskiness of the unsafe behavior because familiar risks are perceived to be less risky (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, Fischhoff, & Lichtenstein, 1986; Slovic, 1987). Future studies need to investigate whether safety climate variability is uniquely linked to increased familiarity to hazardous behavior as well as reduced sensitivity to the riskiness of this hazardous behavior.

### **Practical Implications**

The findings of the present study have a number of practical implications. First of all, safety climate variability needs to be taken into account in the management of organizational safety climate. Most previous studies that aimed at promoting workplace safety by improving safety climate have been focusing on safety climate level only (e.g., Zohar, 2002; Zohar & Luria, 2003; Zohar & Polachek, in press; Zohar & Tenne-Gazit, 2008). However, as it was shown in the current study that a higher safety climate level may not be able to induce the anticipated level of safety behavior if safety climate variability is large, it is clear that safety climate variability needs to be assessed in conjunction with safety climate level in order to get a more realistic estimation of workers' safety behavior. Selection of the proper work unit (e.g., team, group, sector, etc.) is also important in the assessment of safety climate variability because it is meaningful only in particular work contexts in which workers collaborate closely (e.g., teamwork), work nearby each other (e.g., in the same location), and are psychosocially interdependent in terms of job performance (e.g., with a strong supervisor-subordinate relationship). Also, the size of the work unit needs to be considered. If it is too small (e.g., two team members only), it would be more straightforward to focus on the gap(s) in safety climate perception between members of the same work unit than computing safety climate variability. If the size of work unit is too large, safety climate variability may have only a weak impact on individual worker's safety behavior/performance due to the loose interdependence of the large number of work unit members. If a target work unit (organization) has for example 500 workers and safety climate variability is computed with these workers' safety climate perceptions, the safety climate variability may be of little meaning to some workers of the same work unit because they may have virtually no chance to interact with the workers who contributed the most to safety climate variability (i.e., those having extreme safety climate perceptions).

To address large safety climate variability, it is critical to understand what factors

may influence the magnitude of safety climate variability. According to Beus, Jarrett, Bergman, and Payne (2012), employee safety climate perceptions can be influenced by faultlines that are defined as “dividing lines based on the alignment of one or more group member attributes” (Beus et al., 2012, p. 455). This is because faultlines affect the sense-making process (Lau & Murningham, 1998) while organizational climate perceptions emerge from sense-making (Ostroff, Kinicki, & Tamkins, 2003). Examples of faultlines include individual differences such as sex, race, tenure, functional work background, values, and personality as well as organizational differences such as hierarchy, management style, job type, and work environment. Particularly, some faultlines are more closely associated with workers’ safety climate perceptions as they are more relevant to safety. For instance, workers with different levels of knowledge and skill may have different views on the safety of their workplace even though they are doing the same jobs in the same immediate work environment. Workers who are highly skilled and have a wide range of knowledge to handle unexpected emergency situations are more likely to view their work environment as less risky even though it is full of potential hazards. Also, just enough or a less than ideal level of organizational safety practices can be viewed as reasonably safe to them, not because of these safety practices but because their personal resources to handle hazardous situations is limited. Within a workgroup, safety climate perceptions may differ across different types of jobs/tasks. Some jobs/tasks involve more safety and health risks such as overexertion, use of dangerous tools, handling toxic materials, and working in harsh climate conditions. Workers who are more frequently exposed to these sorts of work-related hazards may be less sensitive to these ‘routinized’ hazards, and they may view poor safety climate, which is another hazard factor, as being relatively benign. Moreover, idiosyncratic values and attitudes of workers toward occupational safety can lead to heterogeneous safety climate perceptions within a workgroup. Workers who place stronger emphasis on occupational safety and wellbeing are more likely

to be sensitive to the determinants of organizational safety climate. For example, if safety policies and practices are present but if they are superficial at best, workers who care much about safety would view the safety climate of their organization as not as good as it should be, while workers who don't pay as much attention to safety would perceive that the safety climate of their organization is good enough.

Safety climate variability is not only attributed to different perceptual styles of individual workers, but also to the quality of safety supervision and leadership because safety climate chiefly emerges from managerial and supervisory practice (Zohar, 1980; 2010; 2011). If supervisors communicate only with a particular group of workers regarding safety, inconsistency will exist in safety management across time and situations. The delivered safety message is then unclear, and safety climate variability is likely to be greater among within-workgroup members. In regard to this possibility, Zohar and Luria (2005) showed that a straightforward safety message delivered to all workers and based on a simple script had a statistically significant beneficial impact on safety climate variability.

As discussed so far, there can be numerous reasons for greater safety climate variability. Given this, a macroergonomics perspective (Hendrick & Kleiner, 2002) offers many practical solutions to address safety climate variability. First, a participatory ergonomics approach (Nagamachi, 1995; Robertson, 2000) can be applied to address the contributing factors of safety climate variability. Initially, interdependence of the workgroup members in safety performance and the potential impact of safety climate variability (e.g., coordination error) can be highlighted in assessment efforts. Subsequently, open discussion can be facilitated for the entire workgroup members to help reveal any lack of consensus (variability) in their safety climate perceptions, as well as why some view safety climate as good while others don't. In this step, safety climate scale items that have greater variability than other items can serve as a useful starting point because the present study showed that

these higher-safety climate variability items were indeed indicative of workers' lack of safety behavior. What can then follow is an open discussion regarding the unique safety concerns of individual workers and how they perceive their organization's efforts to address these concerns to be efficient. In this way, workgroup members can develop a shared mental model (Cannon-Bowers, et al., 1993; Klimoski & Mohamed, 1994; Stout et al., 1996) for their workgroup's safety climate, and individual worker's safety climate perceptions can be adjusted to be more representative of the workgroup as a whole. This inference is in line with a view that organizational climate is a social-cognitive construct which arises from an active organizational sense-making process (Drazin, Glynn, & Kazanjian, 1999; Weick, 1995).

Safety climate variability would be reduced once the workgroup members are able to make sense about the interdependence of workgroup members, individual and organizational differences in terms of the ability to perform safely, potential hazards in their own and colleagues' work environment, and how well the workgroup's safety is managed.

A second practical approach can be made to improve the worker-organization interface (Hendrick, 2008; Hendrick & Kleiner, 2001; Hendrick & Kleiner, 2002) to meet the different safety expectations and needs of individual workers and reduce safety climate variability.

Specifically, in a workgroup with large safety climate variability, workers with lower safety climate may be in need of more targeted safety support efforts from their organization. Also, they may be more aware of potential hazards in their work than others as well as the limitations of the existing organizational safety efforts. On the other hand, workers who perceive a higher safety climate might overlook their interdependence to other workers who perceive a lower safety climate, or they may be relatively less sensitive to the risks they may experience. In consideration of these sources of heterogeneous safety climate perceptions, multiple safety training program modules can be developed and promoted for different levels of work experience and types of jobs/tasks, various direct and indirect channels for reporting

safety concerns can be established, and participatory job design to optimize worker-work fit can be initiated. The primary goal of improving the worker-organization interface is to tailor organizational safety efforts to an individual worker's characteristics and his/her work context which includes his/her workgroup. In such way, safety climate level can be advanced while safety climate variability can be systematically managed. More specifically, a training program intervention that includes participatory ergonomics to cope with individual workers' needs can benefit improvement in safety climate and subsequent workplace safety, both which are emergent properties of work system design and process (Murphy, Robertson, & Carayon, 2014; Robertson, 2000; Robertson, Kleiner, & O'Neill, 2002; Robertson & Taylor, 1996).

### **Limitations and Suggestions for Future Study**

Regardless of a number of theoretical and practical implications, the present study has some limitations that need to be addressed in future studies to strengthen the applicability of the study findings. First of all, the present study is based on an electrical utility worker sample only, and this limits the generalizability of the study findings to different industries. For instance, the moderating effect of safety climate variability may be less marked in the transportation industry where drivers work mostly alone and interdependence among workers and supervisors can be relatively low (Huang et al., 2013a; Zohar, Huang, Lee, & Robertson, 2014), whereas the impact of safety climate variability on the safety climate level and safety behavior relationship can be stronger for mining workers as their functional interdependence is essential to maintain a safe work environment (Boal, 2009; Brophy, 1964). Thus, the findings of the present study need to be replicated across multiple industries to ensure their generalizability.

Although an employee's company tenure as well as his/her workgroup's company tenure, task independence, and individualistic task were shown to be independent from the

moderating effect of safety climate variability, these factors could still substantially interact with safety climate variability in prediction of safety behavior in other industries. Moreover, other potential boundary conditions that were not examined in this study can exist, leaving open the possibility of the presence of important boundary conditions for the moderating effect of safety climate variability on the relationship between safety climate level and safety behavior. For instance, tenure with a specific team (i.e., how long workers have been working with their current teams) can possibly moderate the safety climate level and safety behavior relationship by itself or in conjunction with safety climate variability. This is because team members work and interact with one another in more proximity and there is greater chance of mutual influence than company members. The uniqueness of the moderating effect of safety climate variability can be confirmed by examining the effect of potentially confounding variables.

Also, in examination of Hypothesis 5, clarity of the safety climate scale items' wording should have been controlled for. True item-level safety climate variability is distinct from perceptual noise that is caused by vague wording of safety climate scale items. If items can be understood in qualitatively different ways because of their unclear expressions, safety climate variability of these items can be overestimated and the findings of present study on Hypothesis 5 can be defective. Consequently, some caution is required in the interpretation and generalization of the Hypothesis 5 results.

Another limitation of the present study is its cross-sectional study design. The results might have been different if a prospective design was used. As previous research have shown that safety climate can predict future safety outcomes (e.g., Beus et al., 2010; Huang et al., 2013a; Zohar et al., 2014), the moderating effect of safety climate variability on the safety climate level and future safety outcomes needs to be examined in future studies.

Additionally, instead of worker's self-reported safety behavior, objective safety

outcome variables such as injury/accident frequency and severity can be used as dependent variables in examination of the safety climate variability's moderation effect. If similar findings are obtained with these objective safety outcome variables, the practical importance of systematically managing safety climate variability can be further underscored.

### **Conclusion**

The present study utilized a 2,043 electrical utility worker sample to examine the moderation effect of safety climate variability on the safety climate level and safety behavior relationship. As hypothesized, safety climate level was more closely related to safety behavior when safety climate variability is lower. The moderating effect of safety climate variability was supported regardless of employee's company tenure, workgroup's company tenure, task independence, or how individualistic tasks were. Additionally, safety climate scale items with more variability were shown to have lower means while also being less predictive of worker safety behavior. These findings suggest that safety climate variability needs to be considered for the proper management of organizational safety climate. Although the contributing factors of safety climate variability need to be further investigated, the results of this study make it clear that improvements in the work system are required to prevent and address high safety climate variability.

## References

- Aguinis, H., Gottfredson, R. K., & Culpepper, S. A. (2013). Best-practice recommendations for estimating cross-level interaction effects using multilevel modeling. *Journal of Management*, *39*, 1490-1528.
- Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice-Hall.
- Barsness, Z. I., Diekmann, K. A., & Seidel, M. L. (2005). Motivation and opportunity: the role of remote work, demographic dissimilarity and social network centrality in impression management. *Academy of Management Journal* *48*, 401–419.
- Bartko, J. J. (1976). On various intraclass correlation reliability coefficients. *Psycho-logical Bulletin* *83*, 762–765.
- Bass, B. M. (1990). *Bass and Stogdill's handbook of leadership: Theory, research and management applications* (3rd ed.). New York: Free Press.
- Bass, B. M. (1998). *Transformational leadership: Industry, military, and educational impact*. Mahwah, NJ: Erlbaum.
- Bates, D., Maechler, M., Bolker, B., & Walker, S. (2013). lme4: Linear mixed-effects models using Eigen and S4. R package version, 1.0-6. Retrieved from <http://cran.r-project.org/web/packages/lme4/index.html> .
- Bates, D. & Sarkar, D. (2007). lme4: *Linear Mixed-Effects Models Using S4 Classes*. R package version 0.9975-12, Retrieved from <http://CRAN.R-project.org/>.
- Beus, J. M., Bergman, M. E., & Payne, S. C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis and Prevention*, *42*, 1431-1437.
- Beus, J. M., Jarrett, S. M., Bergman, M. E., & Payne, S. C. (2012). Perceptual equivalence of psychological climates within groups: When agreement indices do not agree. *Journal of Occupational and Organizational Psychology*, *85*, 454-471.

- Beus, J. M., Payne, S. C., Bergman, M. E., & Arthur, W., Jr. (2010). Safety Climate and injuries: An examination of theoretical and empirical relationships. *Journal of Applied Psychology, 95*, 713-727.
- Blau, P. M. (1972). Interdependence and hierarchy in organizations. *Social Science Research, 1*, 1-24.
- Bliese, P. D. (2000). Within-group agreement, non-independence, and reliability: Implications for data aggregation and analysis. Klein, Katherine J. (Ed); Kozlowski, Steve W. J. (Ed), (2000). *Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions.*, (pp. 349-381). San Francisco, CA, US: Jossey-Bass.
- Bliese, P. D. (2002). Multilevel random coefficient modeling in organizational research: Examples using SAS and S-PLUS. In F. Drasgow & N. Schmitt (Eds.), *Measuring and analyzing behavior in organizations: Advances in measurement and data analysis*: 401-445. San Francisco: Jossey-Bass.
- Bliese, P. (2013). *Multilevel modeling in R*. Retrieved from [http://cran.r-project.org/doc/contrib/Bliese\\_Multilevel.pdf](http://cran.r-project.org/doc/contrib/Bliese_Multilevel.pdf)
- Boal, W. M. (2009). The effect of unionism on accidents in US coal mining, 1897–1929. *Industrial Relations: A Journal of Economy and Society, 48*, 97-120.
- Brewer, N. T., Chapman, G. B., Gibbons, F. X., Gerrard, M., McCaul, K. D., & Weinstein, N. D. (2007). Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology, 26*, 136-145.
- Brophy, J. (1964). *A Miner's Life: An Autobiography*. J. O. Hall (Ed.). University of Wisconsin Press.
- Bureau of Labor Statistics (2012a). *Fatal occupational injuries by industry and event or exposure, All U.S., 2012*. Retrieved from <http://www.bls.gov/iif/oshwc/cfoi/cftb0268.pdf>

- Bureau of Labor Statistics (2012b). *Incidence rates of nonfatal occupational injuries and illnesses by case type and ownership, selected industries, 2012*. Retrieved from <http://www.bls.gov/news.release/pdf/osh.pdf>
- Cannon-Bowers, J. A., Salas, E., & Converse, S. A. (1993). Shared mental models in expert team decision making. In N. J. Castellan, Jr. (Ed.), *Current issues in individual and group decision making* (pp. 221-246). Hillsdale, NJ: Erlbaum.
- Chan, D. (1998). Functional relations among constructs in the same content domain at different levels of analysis: A typology of composition models. *Journal of Applied Psychology, 83*, 234–246.
- Choo, C. W. & Auster, E. (1993). *Environment scanning: acquisition and use of information by managers*. In: Williams ME, editor. Annual review of information science and technology. Vol. 28. Medford (NJ): Learned Information; pp. 279–314.
- Christian, M. S., Bradley, J. C., Wallace, J. C., & Burke, M. J. (2009). Workplace safety: A meta-analysis of the roles of person and situation factors. *Journal of Applied Psychology, 94*, 1103-1127.
- Clark, L. A. & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment, 7*, 309-319.
- Clarke, S. (2006). The relationship between safety climate and safety performance: a meta-analytic review. *Journal of Occupational Health Psychology, 11*, 315-327.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.
- Cole, M. S., Bedeian, A. G., Hirschfeld, R. R., & Vogel, B. (2011). Dispersion-Composition Models in Multilevel Research A Data-Analytic Framework. *Organizational Research Methods, 14*, 718-734.
- Colquitt, J. A., Noe, R. A., & Jackson, C. L. (2002). Justice in teams: Antecedents and

- consequences of procedural justice climate. *Personnel Psychology*, 55, 83–109.
- Cooper, M. D. (2000). Towards a model of safety culture. *Safety science*, 36, 111-136.
- Cox, D. R. (1984). Interaction. *International Statistical Review*, 52, 1-24.
- de González, A. B. & Cox, D. R. (2007). Interpretation of interaction: A review. *The Annals of Applied Statistics*, 1, 371-385.
- Cronbach, L. J. (1987). Statistical tests for moderator variables: Flaws in analyses recently proposed. *Psychological Bulletin*, 102, 414-417.
- Cronin, M. A. & Weingart, L. R. (2007). Representational gaps, information processing, and conflict in functionally diverse teams. *Academy of Management Review*, 32, 761-773.
- Dickson, M. W., Resick, C. J., & Hanges, P. J. (2006). When organizational climate is unambiguous, it is also strong. *Journal of Applied Psychology*, 91, 351-364.
- Drazin, R., Glynn, M. A., & Kazanjian, R. K. (1999). Multilevel theorizing about creativity in organizations: A sense-making perspective. *Academy of Management Review*, 24, 286–307.
- Enders, C. K. & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: a new look at an old issue. *Psychological Methods*, 12, 121-138.
- Feldman, D. C. (1981). The multiple socialization of organization members. *Academy of Management Review*, 6, 309-318.
- Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Policy sciences*, 9, 127-152.
- Fiske, S. T. & Taylor, S. E. (1991). *Social Cognition* (2nd ed.). New York: McGraw-Hill.
- Flin, R., Mearns, K., O'Connor, P., & Bryden, R. (2000). Measuring safety climate: identifying the common features. *Safety Science*, 34, 177-192.
- George, D. & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and*

- reference*. 11.0 update (4th ed.). Boston: Allyn & Bacon.
- Glick, W. H. (1988). Response: Organizations are not central tendencies: Shadowboxing in the dark, round 2. *Academy of Management Review*, *13*, 133-137.
- Gonzalez-Roma, V., Peiro, J. M., & Tordera, N. (2002). An examination of the antecedents and moderator influences of climate strength. *Journal of Applied Psychology*, *87*, 465-473.
- Goodman, P. S., Ravlin, E., & Schminke, M. (1987). Understanding groups in organizations. In L. L. Cummings & B. M. Staw (Eds.), *Research in organizational behavior* (vol. 9, pp. 121-173). Greenwich, CT: JAI Press.
- Graen, G. B. & Uhl-Bien, M. (1995). Relationship-based approach to leadership: Development of leader-member exchange (LMX) theory of leadership over 25 years: Applying a multi-level multi-domain perspective. *The leadership quarterly*, *6*, 219-247.
- Griffin, M. A. & Neal, A. (2000). Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology*, *5*, 347-358.
- Hackman, J. R. (1992). Group influences on individuals in organizations. In M. D. Dunnette & L. M. Hough (Eds.), *Handbook of Industrial and organizational psychology*, Vol. 3 (2nd ed., pp. 199-267). Palo Alto, CA: Consulting Psychologists Press.
- Harbourne, R. T. & Stergiou, N. (2009). Movement variability and the use of nonlinear tools: principles to guide physical therapist practice. *Physical Therapy*, *89*, 267-282.
- Health and Safety Executive. (2009). Working Alone in Safety: Health and Safety Guidance on the Risks of Lone Working. <http://www.hse.gov.uk/publish/indg73.pdf> (retrieved 09.23.13).

- Hendrick, H.W. (1997). Organizational design and macroergonomics. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (pp. 594-636). New York: Wiley.
- Hendrick, H. W. (2000). The technology of ergonomics. *Theoretical Issues in Ergonomics Science 1*, 22–33
- Hendrick, H. W. (2008). Applying ergonomics to systems: Some documented “lessons learned.” *Applied Ergonomics*, 39, 418-426.
- Hendrick, H. W., & Kleiner, B. M. (2001). *Macroergonomics: An introduction to work system design*. Santa Monica, CA: Human Factors and Ergonomics Society.
- Hendrick, H. W. & Kleiner, B. M. (2002). *Macroergonomics: Theory, methods, and applications*. Mahwah, New Jersey: Lawrence Erlbaum Associates.
- Hirst, W., Spelke, E. S., Reaves, C. C., Caharack, G., & Neisser, U. (1980). Dividing attention without alternation or automaticity. *Journal of Experimental Psychology: General*, 109, 98-117.
- Hofmann, D. A. & Gavin, M. B. (1998). Centering decisions in hierarchical linear models: Implications for research in organizations. *Journal of Management*, 24, 623-641.
- Huang, Y., Lee, J., McFadden, A. C., Murphy, L. A., Robertson, M. M., & Zohar, D. (2014, August). *The impact of safety climate beyond safety outcomes: Job satisfaction, employee engagement and objective turnover rate*. Proceedings of the 11th International Symposium on Human Factors in Organisational Design and Management, Copenhagen, Denmark.
- Huang, Y. H., Robertson, M. M., Jeffries, S., Garabet, A., Murphy, L. A., & Lee, J. (2012). A qualitative approach to exploring a truck company’s true priority of safety from the lone worker’s perspective. *Journal of Ergonomic Study*, 14, 65-78.
- Huang, Y. H., Roetting, M., McDevitt, J. R., Melton, D., & Smith, G. S., (2005). Feedback by technology: attitudes and opinions of truck drivers. *Transportation Research Part F*, 8,

277–297.

Huang, Y. H., Zohar, D., Robertson, M. M., Garabet, A., Lee, J., & Murphy, L. A. (2013a).

Development and validation of safety climate scales for lone workers using truck drivers as exemplar. *Transportation Research Part F: Traffic Psychology and Behavior*, *17*, 5-19.

Huang, Y. H., Zohar, D., Robertson, M. M., Garabet, A., Murphy, L. A. & Lee, J. (2013b).

Development and validation of safety climate scales for remote workers using utility/electric workers as exemplar. *Accident Analysis and Prevention*, *59*, 76-86.

James, L. R. (1982). Aggregation bias in estimates of perceptual agreement. *Journal of Applied Psychology*, *67*, 219–229.

James, L. R., Demaree, R. G., & Wolf, G. (1984). Estimating within-group interrater reliability with and without response bias. *Journal of Applied Psychology*, *69*, 85-98.

James, L. A. & James, L. R. (1989). Integrating work environment perceptions: Exploration into the measurement of meaning. *Journal of Applied Psychology*, *74*, 739-751.

James, L. R., James, L. A., & Ashe, D. K. (1990). The meaning of organizations: The role of cognition and values. In B. Schneider (Ed.), *Organizational climate and culture* (pp. 40-84). San Francisco: Jossey-Bass.

James, L. R., Demaree, R. G., & Wolf, G. (1993). rwg: an assessment of within-group interrater agreement. *Journal of Applied Psychology* *78*, 306–309.

Johnson, J. D. (1997). *Cancer-related information seeking*. Cresskill (NJ): Hampton Press.

Karwowski, W. (2012). A review of human factors challenges of complex adaptive systems discovering and understanding chaos in human performance. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *54*, 983-995.

Kelsh, M. A., Lu, E. T., Ramachandran, K., Jesser, C., Fordyce, T., & Yager, J. W. (2004).

Occupational injury surveillance among electric utility employees. *Journal of*

*Occupational and Environmental Medicine* 46, 974–984.

Klimoski, R. & Mohammed, S. (1994). Team mental model: Construct or metaphor? *Journal of management*, 20, 403-437.

Kline, P. (2000). *The handbook of psychological testing* (2nd ed.). London: Routledge.

King, E. B., Botsford, W., Hebl, M. R., Kazama, S., Dawson, J. F., & Perkins, A. (2012).

Benevolent Sexism at Work Gender Differences in the Distribution of Challenging Developmental Experiences. *Journal of Management*, 38, 1835-1866.

Kleiner, B. (2006). Macroergonomics: Analysis & design of work systems. *Applied Ergonomics*, 37, 81-89.

Kopelman, R. E., Brief, A. P., & Guzzo, R. A. (1990). The role of climate and culture in productivity. B. Schneider (Ed.), *Organizational climate and culture* (pp. 282-313). San Francisco: Jossey-Bass.

Kozlowski, S. W., & Klein, K. J. (2000). A multilevel approach to theory and research in organizations. In K. J. Klein & S. W. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations* (pp. 3–90). San Francisco, CA: Jossey-Bass.

Kreft, I. G. G., De Leeuw, J., & Aiken, L. S. (1995). The effect of different forms of centering in Hierarchical Linear Models. *Multivariate Behavioral Research*, 30, 1-21.

Kurland, N. B. & Bailey, D. E. (1999). When workers are here, there and everywhere: a discussion of the advantages and challenges of telework. *Organizational Dynamics* 28, 53–68.

Lau, D. & Murnighan, J. K. (2005). Interactions within groups and subgroups: Effects of demographic faultlines. *Academy of Management Journal*, 48, 645–659.

LeBreton, J. M. & Senter, J. L. (2008). Answers to 20 questions about interrater reliability and interrater agreement. *Organizational Research Methods*, 11, 815-852.

Lindell, M. K. & Brandt, C. J. (2000). Climate quality and climate consensus as mediators of

- the relationship between organizational antecedents and outcomes. *Journal of Applied Psychology*, 85, 331–348.
- Lindell, M. K. & Whitney, D. J. (1995). Effects of Organizational Environment, Internal Structure, and Team Climate on the Effectiveness of Local Emergency Planning Committees. *Risk Analysis*, 15, 439-447.
- MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology*, 58, 593-614.
- Martin, J. (1992). *Cultures in organizations: Three perspectives*. New York: Oxford University Press.
- Maas, C. J. & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology: European Journal of Research Methods for the Behavioral and Social Sciences*, 1, 86-92.
- Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of applied psychology*, 85, 273-283.
- Mearns, K., Whitaker, S. M., & Flin, R. (2003). Safety climate, safety management practice and safety performance in offshore environments. *Safety Science*, 41, 641-680.
- Mischel, W. (1976). Towards a cognitive social model learning reconceptualization of personality. In N. S. Endler & D. Magnusson (Eds.), *Interactional psychology and personality* (pp. 166–207). New York: Wiley.
- Moreland, R. L. & Levine, J. M. (1990). Newcomers and oldtimers in groups. In P. Paulus (Ed.), *Psychology of group influence* (2nd ed., pp. 143-186). Hillsdale, NJ: Erlbaum.
- Murphy, L. A., Robertson, M. M., & Carayon, P. (2014). The next generation of macroergonomics: Integrating safety climate. *Accident Analysis & Prevention*, 68, 16-24.

- Murphy, L. A., Robertson, M. M., & Huang, Y. H. (2012). The development of a conceptual model regarding the role of social modelling in safety behaviour: an integrated literature review. *Theoretical Issues in Ergonomics Science*, *13*, 286-302.
- Nagamachi, M. (1995). Requisites and practices of participatory ergonomics. *International Journal of Industrial Ergonomics*, *15*, 371-377.
- National Institute for Occupational Safety and Health (2013). *NIOSH Fatal Occupational Injury Cost Fact Sheet: Transportation, Warehousing, and Utilities (NAICS 48, 49, 22)*, Retrieved from <http://www.cdc.gov/niosh/docs/2012-131/>
- Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2011). Safety at work: A Meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. *Journal of Applied Psychology*, *96*, 71-94.
- Neal, A., Griffin, M. A., & Hart, P. M. (2000). The impact of organizational climate on safety climate and individual behavior. *Safety Science*, *34*, 99-109.
- Nelder, J. A. (1977). A reformulation of linear models. *Journal of the Royal Statistical Society. Series A (General)*, 48-77.
- Neuman, G. A. & Wright, J. (1999). Team effectiveness: Beyond skills and cognitive ability. *Journal of Applied Psychology*, *84*, 376-389.
- Nunnally, J. C. & Bernstein, I. H. (1994). *Psychometric theory*. Sydney: McGraw-Hill.
- O\*NET Online. (2013). *Summary Report for: 49-9051.00 - Electrical Power-Line Installers and Repairers*. Retrieved from <http://www.onetonline.org/link/summary/49-9051.00>.
- Ostroff, C. & Bowen, D. E. (2000). Moving HR to a higher level: HR practices and organizational effectiveness. In K. J. Klein & S. W. J. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations* (pp. 211–266). San Francisco: Jossey-Bass.
- Ostroff, C., Kinicki, A.J., & Muhammad, R.S. (2012). Organizational culture and climate. In

- N.W. Schmitt & S. Highhouse (Eds.), *Handbook of psychology, Vol. 12: Industrial and Organizational Psychology* (2nd ed., pp. 643-676). Hoboken, NJ: Wiley.
- Ostroff, C., Kinicki, A. J., & Tamkins, M. M. (2003). Organizational culture and climate. In W. C. Borman, D. R. Ilgen, & R. J. Klimoski (Eds.), *Handbook of psychology: Industrial and organizational psychology* (pp. 565–593). Hoboken, NJ: John Wiley & Sons, Inc.
- Ostroff, C. & Schmitt, N. (1993). Configurations of organizational effectiveness and efficiency. *Academy of Management Journal*, *36*, 1345–1361.
- Payne, R. L. & Pugh, S. S. (1976). Organizational structure and climate. In M. D. Dunnette (Ed.), *Handbook of industrial and organizational psychology* (pp. 1125–1173). Chicago: Rand McNally.
- Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods*, *15*, 209-233.
- Prussia, G. E., Brown, K. A., & Willis, P. G. (2003). Mental models of safety: do managers and employees see eye to eye? *Journal of Safety Research*, *34*, 143-156.
- Raudenbush, S. W. & Bryk, A. S. (2002). *Hierarchical Linear Models* (2nd Edition). Thousand Oaks: Sage Publications.
- Rice, R. E. & Shook, D. E. (1990). Relationships of job categories and organizational levels to use of communication channels, including electronic model: a meta-analysis and extension. *Journal of Management Studies*, *27*, 196–229.
- Robertson, M. M. (2001). Macroergonomics: A work system design perspective. In *Proceedings of the SELF-ACE 2001 Conference—Ergonomics for Changing Work* (Vol. 1, pp. 67-77).
- Robertson, M. M. (2000, July-August). *Using a participatory ergonomics design to develop a human factors training program for aviation maintenance*. In: Proceedings of the

international ergonomics association and the 44th annual human factors and ergonomics society, July 29-August 4, San Diego, CA.

- Robertson, M. M., Kleiner, B. M., & O'Neill, M. J. (2002). Macroergonomic methods: Assessing work system processes. In H. W. Hendrick & B. M. Kleiner (Eds.), *Macroergonomics: Theory, methods, and applications* (pp. 67-96). New Jersey: Lawrence Erlbaum Associates Publishers.
- Robertson, M. M., & Taylor, J. C. (1996). Team training in an aviation maintenance setting: A systematic evaluation. In B. Hayward & A. Lowe (Eds.), *Applied aviation psychology: Achievement, change and challenge* (pp. 373-383). Sydney, Australia: Avebury.
- Rollag, K. (2004). The impact of relative tenure on newcomer socialization dynamics. *Journal of Organizational Behavior, 25*, 853-872.
- Rouse, W. B. & Morris, N. M. (1986). On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin, 100*, 349-363.
- Schneider, B. (1987). The people make the place. *Personnel Psychology, 40*, 437-453.
- Schneider, B., & Reichers, A. E. (1983). On the etiology of climates. *Personnel psychology, 36*, 19-39.
- Schneider, B., Salvaggio, A., & Subirats, M. (2002). Climate strength: A new direction for climate research. *Journal of Applied Psychology, 87*, 220-229.
- Shiffrin, R. M. & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological review, 84*, 127-190.
- Siu, O. L., Phillips, D. R., & Leung, T. W. (2004). Safety climate and safety performance among construction workers in Hong Kong: The role of psychological strains as mediators. *Accident Analysis & Prevention, 36*, 359-366.
- Slovic, P. (1987). *Perception of risk*. *Science, 236*, 280-285.

- Slovic, P., Fischhoff, B., & Liechtenstein, S. (1986). *The psychometric study of risk perceptions*. In: V. T. Covello, J. Menkes, & J. Mumpower (Eds.) Risk evaluation and management. New York, London: Plenum Press, pp. 3-24.
- Smith, T. J., Henning, R. A., Wade, M. G., & Fisher, T. (2014). *Variability in human performance*. Taylor & Francis CRC Press.
- Snijders, T. A. B. & Bosker, R. J. (1999). *Multilevel Analysis. An introduction to basic and advanced multilevel modeling*. Thousand Oaks, CA: Sage.
- Sowinski, D. R., Fortmann, K. A., & Lezotte, D. V. (2008). Climate for service and the moderating effects of climate strength on customer satisfaction, voluntary turnover, and profitability. *European Journal of Work and Organizational Psychology, 17*, 73-88.
- Stout, R. J., Cannon-Bowers, J. A., & Salas, E. (1996). The role of shared mental models in developing team situational awareness: Implications for training. *Training Research Journal, 2*, 85-116.
- Maddux, J. E. & Snyder, C. R. (1997). *Social cognitive psychology: History and current domains*. New York: Plenum.
- Tavakol, M. & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53-55.
- Teunissen, H. A., Spijkerman, R., Schoenmakers, T. M., Vohs, K. D., & Engels, R. C. (2012). The Effect of Self-Control on Attentional Bias for Alcohol Cues in Male Heavy Drinkers<sup>1</sup>. *Journal of Applied Social Psychology, 42*, 776-792.
- Trice, H. M., & Beyer, J. M. (1993). *The cultures of work organizations*. Englewood Cliffs, NJ: Prentice Hall.
- Tucker, S., Chmiel, N., Turner, N., Hershcovis, M. S., & Stride, C. B. (2008). Perceived organizational support for safety and employee safety voice: the mediating role of

- coworker support for safety. *Journal of occupational health psychology*, 13, 319-330.
- Tversky, A. & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive psychology*, 5, 207-232.
- Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185, 1124-1131.
- Wahr, J. A., Prager, R. L., Abernathy, J. H., Martinez, E. A., Salas, E., Seifert, P. C., ... & Nussmeier, N. A. (2013). Patient safety in the cardiac operating room: human factors and teamwork a scientific statement, *American Heart Association. Circulation*, 128, 1139-1169.
- Weinstein, N. D. (1993). Testing four competing theories of health behavior, *Health Psychology*, 12, 324–333.
- Zander, A. F. (1994). *Making groups effective*. San Francisco: Jossey-Bass.
- Zimolong, B. & Elke, G. (2006). Occupational health and safety management. . In G. Salvendy (Ed.), *Handbook of Human Factors and Ergonomics* (pp. 673-707). New York: Wiley.
- Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology* 65, 96-102.
- Zohar, D. (2000). A group-level model of safety climate: Testing the effects of group climate on microaccidents in manufacturing jobs. *Journal of Applied Psychology*, 85, 587-596.
- Zohar, D. (2002). Modifying supervisory practices to improve subunit safety: a leadership-based intervention model. *Journal of Applied psychology*, 87, 156-163.
- Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident Analysis and Prevention*, 42, 1517–1522.
- Zohar, D. (2011). Safety climate: Conceptual and measurement issues. In J.C. Quick & L.E. Tetrick (Eds.), *Handbook of Occupational Health Psychology* (2nd ed., pp.141-164).

Washington, D.C.: American Psychological Association.

Zohar, D. & Hofmann, D. (2012). Organizational culture and climate. In S. Kozlowski (Ed.), *Handbook of industrial and organizational psychology* (Vol. 1, pp. 643–666). New York, NY: Oxford University Press.

Zohar, D., Huang, Y. H., Lee, J., & Robertson, M. M. (2014). A mediation model linking supervisory leadership and work ownership with safety climate as predictors of truck driver safety performance. *Accident Analysis and Prevention*, *62*, 17-25.

Zohar, D. & Luria, G. (2003). The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. *Journal of Safety Research*, *34*, 567-577.

Zohar, D. & Luria, G. (2004). Climate as a social-cognitive construction of supervisory safety practices: scripts as proxy of behavior patterns. *Journal of Applied Psychology*, *89*, 322-333.

Zohar, D. & Luria, G. (2005). A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *Journal of Applied Psychology*, *90*, 616-628.

Zohar, D. & Polachek, T. (In Press). Discourse-Based Intervention for Modifying Supervisory Communication as Leverage for Safety Climate and Performance Improvement: A Randomized Field Study. *Journal of Applied Psychology*.

Zohar, D. & Tenne-Gazit, O. (2008). Transformational leadership and group interaction as climate antecedents: a social network analysis. *Journal of Applied Psychology*, *93*, 744-757.

## Appendix A

Items of the safety climate scale (from Huang, Zohar, Robertson, Garabet, Lee, & Murphy, 2013a)

item #	factor	My supervisor...
1	F1	gives me feedback about the quality of my work
2	F1	frequently talks about safety issues throughout the work week
3	F1	takes the time to listen to my concerns regarding safety
4	F1	discusses ways to improve performance after non-routine or unusual job tasks
5	F1	uses explanations (not just compliance) to get us to act safely
6	F1	gives me positive feedback when I perform safely
7	F2	makes sure I use all the safety equipment for the job (PPE, rubber on lines)
8	F1	checks in with me when I am in unsafe neighborhoods
9	F1	talks about safety but pressures us to complete work on time
10	F3	takes the time to check on me, especially when I'm stressed or tired
11	F1	expects me to answer the phone or radio when he/she calls, even while I'm driving
12	F3	trusts our expertise and lets us use that knowledge in the field
13	F1	expects us to discuss the job in depth during the tailboard (pre-job brief)
14	F2	effectively communicates my concerns to the company
15	F1	lets me rearrange my work schedule so it makes sense to me
16	F1	encourages a discussion among us after any major incident
17	F1	assigns too much work for some employees, resulting in uneven work loads
18	F3	discusses how to improve safety
19	F2	compliments workers who pay special attention to safety

*Notes.* Items # 9, 11, and 17 are reverse worded; F1 = supervisory care; F2 = participation encouragement; F3 = safety straight talk

## Appendix B

Items of the safety behavior scale (from Huang, Zohar, Robertson, Garabet, Lee, & Murphy, 2013a)

item #	
1	Before starting a job I take an overview of the whole situation
2	I always report back to my supervisor with any safety concerns
3	I don't like to report near misses because of the ordeal that will follow (IAs, etc.)
4	When I am uncertain how to proceed, I ask for help
5	I jump to get out of my truck quickly
6	When I am rushed, I skip my pre-trip vehicle inspection
7	I am encouraged to speak with any concerns or suggestions
8	I follow orders without offering my own input
9	I never walk under a ladder or raised bucket at work
10	I never throw or toss hand tools to a co-worker on a ladder or in a raised bucket
11	To avoid conflicts I sign off on the tailboard without raising questions

*Notes.* Items # 3, 5, 6, 8, and 11 are reverse worded

Table 1. Descriptive statistics of the study sample

A. Workgroup size and safety climate variability

	min	max	mean	S.D.
group size	3	45	11.20	9.73
safety climate variability	.11	1.19	.57	.17

*Notes.* S.D. = standard deviation; safety climate variability was measured by the standard deviation of the safety climate ratings of within-workgroup members; correlation between group size and safety climate variability was .11 ( $p = .13$ )

B. Frequency and % of company tenure for employees and workgroups

	< 1 year	1-5 years	6-10 years	11-15 years	>= 16 years
employee company tenure	40 (2.0%)	381 (19.0%)	281 (14.0%)	186 (9.3%)	1,121 (55.8%)
workgroup company tenure	-	6 (3.3%)	35 (19.1%)	90 (49.2%)	52 (28.4%)

C. Frequency and % of job types (characteristics) at Company 1

	Company 1 ( $n_{employees} = 621, n_{groups} = 68$ )
electric lines <sup>a</sup>	409 (65.9%)
substation	51 (8.2%)
electric metering <sup>b</sup>	19 (3.1%)
meter readers <sup>b</sup>	142 (22.9%)

D. Frequency and % of job types (characteristics) at Company 2

	Company 2 ( $n_{employees} = 1,428, n_{groups} = 115$ )
overhead (trouble shooter) <sup>a</sup>	72 (5.0%)
overhead (line worker) <sup>a</sup>	909 (63.7%)
substation	205 (14.4%)
underground	242 (16.9%)

*Notes for tables 1-C and D.* <sup>a</sup> : independent task workers, <sup>b</sup> : individualistic task workers

Table 2. Workgroup distribution by safety climate level (at workgroup-level) and variability (workgroup n = 183)

		Safety climate level	
		< 0 (= mean)	$\geq$ 0 (= mean)
Safety climate variability	$\geq .57$ (= mean)	47 (25.7%)	43 (23.5%)
	< .57 (= mean)	32 (17.5%)	61 (33.3%)

Table 3. Hierarchical linear modeling (HLM) models and results for Hypothesis 1

Model	Parameter estimates (S.E.)								
	$\gamma_{00}$	$\gamma_{01}$	$\gamma_{02}$	$\gamma_{03}$	$\gamma_{10}$	$\gamma_{11}$	$\sigma^2$	$\tau_{00}$	$\tau_{11}$
<i>H1 Model 1(df = 10)</i>									
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$									
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{G-SC}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{G-SC}_j) \times (\text{SC variability}_j) + U_{0j}$	3.58 (.05)**	-.07 (.15) <sup>ns</sup>	.12 (.08) <sup>ns</sup>	.05 (.23) <sup>ns</sup>	.46 (.08)**	<b>-.29</b> (.12)*	.20	.012	.012
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{SC variability}_j) + U_{1j}$									
<i>H1 Model 2(df = 9)</i>									
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$									
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{G-SC}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{G-SC}_j) \times (\text{SC variability}_j) + U_{0j}$	3.58 (.05)**	-.04 (.04) <sup>ns</sup>	.12 (.08) <sup>ns</sup>	-	.45 (.07)**	<b>-.28</b> (.11)*	.20	.012	.012
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{SC variability}_j) + U_{1j}$									
<i>H1 Model 3(df = 8) - Final model</i>									
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$									
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{G-SC}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{G-SC}_j) \times (\text{SC variability}_j) + U_{0j}$	3.58 (.05)**	-	.13 (.08) <sup>ns</sup>	-	.44 (.07)**	<b>-.26</b> (.11)*	.20	.012	.012
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{SC variability}_j) + U_{1j}$									
<i>H1 Model 4(df = 7)</i>									
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$									
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{G-SC}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{G-SC}_j) \times (\text{SC variability}_j) + U_{0j}$	3.57 (.05)**	-	.14 (.08) <sup>ns</sup>	-	.27 (.02)**	-	.20	.012	.014
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{SC variability}_j) + U_{1j}$									

*Notes.* Full information maximum likelihood (FIML) estimation was used; S.E. = standard error; P-SC = psychological-level safety climate; G-SC = group-level safety climate; SC = safety climate;  $\gamma_{00}$  = intercept of the model;  $\gamma_{01}$  = coefficient for G-SC;  $\gamma_{02}$  = coefficient for SC variability;  $\gamma_{03}$  = coefficient for G-SC and SC variability interaction term;  $\gamma_{10}$  = coefficient for P-SC;  $\gamma_{11}$  = coefficient for P-SC and SC variability interaction term;  $r_{ij}$  = residual;  $U_{0j}$  = random intercept (between workgroup variance of  $\beta_{0j}$ );  $U_{1j}$  = random slope (between workgroup variance of  $\beta_{1j}$ );  $\sigma^2 = \text{var}(r_{ij})$ ;  $\tau_{00} = \text{var}(U_{0j})$ ;  $\tau_{11} = \text{var}(U_{1j})$ ; \*\*  $p < .01$ ; \*  $p < .05$ ; <sup>ns</sup> non-significant

Table 4. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 1

	AIC	BIC	Log likelihood	Deviance	REML deviance	Model comparison
H1 Model 1	2649	2705	-1315	2629	2654	-
H1 Model 2	2647	2698	-1315	2629	2653	H1 Model 1 vs. H1 Model 2: $\Delta\chi^2 = .05$ ( $\Delta df = 1, p = .83$ )
H1 Model 3	2646	2691	-1315	2630	2649	H1 Model 2 vs. H1 Model 3: $\Delta\chi^2 = .62$ ( $\Delta df = 1, p = .43$ )
H1 Model 4	2650	2689	-1318	2636	2652	H1 Model 3 vs. H1 Model 4: $\Delta\chi^2 = 6.09$ ( $\Delta df = 1, p < .05$ )

*Notes.* Full information maximum likelihood (FIML) estimation was used; AIC = Akaike information criterion; BIC = Bayesian information criterion; REML = restricted maximum likelihood estimation

Table 5. Hierarchical linear modeling (HLM) models and results for Hypothesis 2-1

Model	Parameter estimates (S.E.)												
	$\gamma_{00}$	$\gamma_{01}$	$\gamma_{10}$	$\gamma_{11}$	$\gamma_{20}$	$\gamma_{21}$	$\gamma_{30}$	$\gamma_{31}$	$\sigma^2$	$\tau_{00}$	$\tau_{11}$	$\tau_{22}$	$\tau_{33}$
<b>H2-1 Model 1 (df = 76)</b>													
Level 1: $Safety\ Behavior_{ij} = \beta_{0j} + \beta_{1j} \times (P-SC_{ij})$ + $\beta_{2j} \times (tenure_{ij}) + \beta_{3j} \times (P-SC_{ij}) \times (tenure_{ij}) + r_{ij}$					<sup>a</sup> .27 (.42) <sup>ns</sup>	<sup>a</sup> -.34 (.73) <sup>ns</sup>	<sup>a</sup> -.19 (.76) <sup>ns</sup>	<sup>a</sup> -.01 (1.26) <sup>ns</sup>					
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (SC\ variability_j) + U_{0j}$	3.31 (.41) <sup>**</sup>	.36 (.71) <sup>ns</sup>	.67 (.74) <sup>ns</sup>	<b>-.22</b> (1.23) <sup>ns</sup>	<sup>b</sup> .12 (.43) <sup>ns</sup>	<sup>b</sup> -.01 (.73) <sup>ns</sup>	<sup>b</sup> -.17 (.76) <sup>ns</sup>	<sup>b</sup> -.16 (1.26) <sup>ns</sup>	.19	.004	.0003	<sup>a</sup> .017 <sup>b</sup> .009	<sup>a</sup> .03 <sup>b</sup> .02
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (SC\ variability_j) + U_{1j}$					<sup>c</sup> .29 (.43) <sup>ns</sup>	<sup>c</sup> -.25 (.75) <sup>ns</sup>	<sup>c</sup> -.50 (.76) <sup>ns</sup>	<sup>c</sup> .21 (1.27) <sup>ns</sup>				<sup>c</sup> .059 <sup>d</sup> .004	<sup>c</sup> .04 <sup>d</sup> .02
Level 2: $\beta_{2j} = \gamma_{20} + \gamma_{21} \times (SC\ variability_j) + U_{2j}$					<sup>d</sup> .34 (.42) <sup>ns</sup>	<sup>d</sup> -.28 (.72) <sup>ns</sup>	<sup>d</sup> -.24 (.75) <sup>ns</sup>	<sup>d</sup> -.06 (1.24) <sup>ns</sup>					
Level 2: $\beta_{3j} = \gamma_{30} + \gamma_{31} \times (SC\ variability_j) + U_{3j}$					<sup>a</sup> .28 (.35) <sup>ns</sup>	<sup>a</sup> -.36 (.59) <sup>ns</sup>	<sup>a</sup> -.19 (.13) <sup>ns</sup>						
<b>H2-1 Model 2 (df = 72)</b>													
Level 1: $Safety\ Behavior_{ij} = \beta_{0j} + \beta_{1j} \times (P-SC_{ij})$ + $\beta_{2j} \times (tenure_{ij}) + \beta_{3j} \times (P-SC_{ij}) \times (tenure_{ij}) + r_{ij}$					<sup>b</sup> .13 (.35) <sup>ns</sup>	<sup>b</sup> -.03 (.60) <sup>ns</sup>	<sup>b</sup> -.28 (.13) <sup>*</sup>					<sup>a</sup> .017 <sup>b</sup> .005	<sup>a</sup> .03 <sup>b</sup> .02
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (SC\ variability_j) + U_{0j}$	3.29 (.34) <sup>**</sup>	.38 (.57) <sup>ns</sup>	.70 (.14) <sup>**</sup>	<b>-.26</b> (.11) <sup>*</sup>	<sup>c</sup> .32 (.36) <sup>ns</sup>	<sup>c</sup> -.31 (.62) <sup>ns</sup>	<sup>c</sup> -.37 (.14) <sup>**</sup>	-	.19	.003	.0007	<sup>c</sup> .053 <sup>d</sup> .003	<sup>c</sup> .04 <sup>d</sup> .02
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (SC\ variability_j) + U_{1j}$					<sup>d</sup> .35 (.34) <sup>ns</sup>	<sup>d</sup> -.31 (.58) <sup>ns</sup>	<sup>d</sup> -.28 (.12) <sup>*</sup>						
Level 2: $\beta_{2j} = \gamma_{20} + \gamma_{21} \times (SC\ variability_j) + U_{2j}$					<sup>a</sup> .07 (.08) <sup>ns</sup>		<sup>a</sup> -.20 (.13) <sup>ns</sup>						
Level 2: $\beta_{3j} = \gamma_{30} + \gamma_{31} \times (SC\ variability_j) + U_{3j}$					<sup>b</sup> .12 (.08) <sup>ns</sup>		<sup>b</sup> -.28 (.13) <sup>*</sup>					<sup>a</sup> .017 <sup>b</sup> .009	<sup>a</sup> .03 <sup>b</sup> .02
<b>H2-1 Model 3 (df = 68) - Final model</b>													
Level 1: $Safety\ Behavior_{ij} = \beta_{0j} + \beta_{1j} \times (P-SC_{ij})$ + $\beta_{2j} \times (tenure_{ij}) + \beta_{3j} \times (P-SC_{ij}) \times (tenure_{ij}) + r_{ij}$					<sup>c</sup> .15 (.09) <sup>ns</sup>	-	<sup>c</sup> -.37 (.13) <sup>**</sup>	-	.19	.003	.0001	<sup>c</sup> .060 <sup>d</sup> .004	<sup>c</sup> .04 <sup>d</sup> .02
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (SC\ variability_j) + U_{0j}$	3.45 (.09) <sup>**</sup>	.11 (.08) <sup>ns</sup>	.70 (.14) <sup>**</sup>	<b>-.26</b> (.10) <sup>*</sup>	<sup>d</sup> .18 (.08) <sup>*</sup>		<sup>d</sup> -.28 (.12) <sup>*</sup>						
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (SC\ variability_j) + U_{1j}$													
Level 2: $\beta_{2j} = \gamma_{20} + \gamma_{21} \times (SC\ variability_j) + U_{2j}$													
Level 2: $\beta_{3j} = \gamma_{30} + \gamma_{31} \times (SC\ variability_j) + U_{3j}$													

**Notes.**

- Full information maximum likelihood (FIML) estimation was used; S.E. = standard error; P-SC = psychological-level safety climate; tenure = employee's company tenure at the individual level (5 response categories: 1<sup>st</sup> category = less than 1 year; 2<sup>nd</sup> category = 1-5 years, 3<sup>rd</sup> category = 6-10 years, 4<sup>th</sup> category = 11-15 years, and 5<sup>th</sup> category = 16 or more years); SC = safety climate;
- $\gamma_{00}$  = intercept of the model;  $\gamma_{01}$  = coefficient for SC variability;  $\gamma_{10}$  = coefficient for P-SC;  $\gamma_{11}$  = coefficient for P-SC and SC variability interaction term;
- $\gamma_{20}$  = coefficient for employee tenure; <sup>a</sup>  $\gamma_{20}$  = the effect of employee tenure on employee safety behavior for the tenure category 2 compared to the category 1; <sup>b</sup>  $\gamma_{20}$  = the effect of employee tenure on employee safety behavior for the tenure category 3 compared to the category 1; <sup>c</sup>  $\gamma_{20}$

- = the effect of employee tenure on employee safety behavior for the tenure category 4 compared to the category 1; <sup>d</sup>  $\gamma_{20}$  = the effect of employee tenure on employee safety behavior for the tenure category 5 compared to the category 1;
- $\gamma_{21}$  = coefficient for employee tenure and SC variability interaction term; <sup>a</sup>  $\gamma_{21}$  = the effect of SC variability on employee safety behavior for the employee tenure category 2 compared to the category 1; <sup>b</sup>  $\gamma_{21}$  = the effect of SC variability on employee safety behavior for the employee tenure category 3 compared to the category 1; <sup>c</sup>  $\gamma_{21}$  = the effect of SC variability on employee safety behavior for the employee tenure category 4 compared to the category 1; <sup>d</sup>  $\gamma_{21}$  = the effect of SC variability on employee safety behavior for the employee tenure category 5 compared to the category 1;
  - $\gamma_{30}$  = coefficient for P-SC and employee tenure interaction term; <sup>a</sup>  $\gamma_{30}$  = the effect of P-SC and employee tenure interaction term on employee safety behavior for the tenure category 2 compared to the category 1; <sup>b</sup>  $\gamma_{30}$  = the effect of P-SC and employee tenure interaction term on employee safety behavior for the tenure category 3 compared to the category 1; <sup>c</sup>  $\gamma_{30}$  = the effect of P-SC and employee tenure interaction term on employee safety behavior for the tenure category 4 compared to the category 1; <sup>d</sup>  $\gamma_{30}$  = the effect of P-SC and employee tenure interaction term on employee safety behavior for the tenure category 5 compared to the category 1;
  - $\gamma_{31}$  = coefficient for P-SC, employee tenure, and SC variability interaction term; <sup>a</sup>  $\gamma_{31}$  = the effect of P-SC, employee tenure, and SC variability interaction term on employee safety behavior for the tenure category 2 compared to the category 1; <sup>b</sup>  $\gamma_{31}$  = the effect of P-SC, employee tenure, and SC variability interaction term on employee safety behavior for the tenure category 3 compared to the category 1; <sup>c</sup>  $\gamma_{31}$  = the effect of P-SC, employee tenure, and SC variability interaction term on employee safety behavior for the tenure category 4 compared to the category 1; <sup>d</sup>  $\gamma_{31}$  = the effect of P-SC, employee tenure, and SC variability interaction term on employee safety behavior for the tenure category 5 compared to the category 1;
  - $r_{ij}$  = residual;  $U_{0j}$  = random intercept (between workgroup variance of  $\beta_{0j}$ );  $U_{1j}$  = random slope (between workgroup variance of  $\beta_{1j}$ );  $U_{2j}$  = random slope (between workgroup variance of  $\beta_{2j}$ );  $U_{3j}$  = random slope (between workgroup variance of  $\beta_{3j}$ );  $\sigma^2 = \text{var}(r_{ij})$ ;  $\tau_{00} = \text{var}(U_{0j})$ ;  $\tau_{11} = \text{var}(U_{1j})$ ;  $\tau_{22} = \text{var}(U_{2j})$ ;  $\tau_{33} = \text{var}(U_{3j})$ ;
  - \*\*  $p < .01$ ; \*  $p < .05$ ; <sup>ns</sup> non-significant

Table 6. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 2-1

	AIC	BIC	Log likelihood	Deviance	REML deviance	Model comparison
H2-1 Model 1	2666	3091	-1257	2514	2569	-
H2-1 Model 2	2658	3062	-1257	2514	2570	H2-1 Model 1 vs. H2-1 Model 2: $\Delta\chi^2 = .80$ ( $\Delta df = 4$ , $p = .93$ )
H2-1 Model 3	2653	3034	-1259	2517	2569	H2-1 Model 2 vs. H2-1 Model 3: $\Delta\chi^2 = 2.82$ ( $\Delta df = 4$ , $p = .89$ )

*Notes.* Full information maximum likelihood (FIML) estimation was used; AIC = Akaike information criterion; BIC = Bayesian information criterion; REML = restricted maximum likelihood estimation



*Notes.*

- Full information maximum likelihood (FIML) estimation was used; S.E. = standard error; P-SC = psychological-level safety climate; tenure = workgroup's company tenure at the workgroup level (5 response categories: 1<sup>st</sup> category = less than 1 year; 2<sup>nd</sup> category = 1-5 years, 3<sup>rd</sup> category = 6-10 years, 4<sup>th</sup> category = 11-15 years, and 5<sup>th</sup> category = 16 or more years); SC = safety climate;
- $\gamma_{00}$  = intercept of the model;  $\gamma_{10}$  = coefficient for P-SC;  $\gamma_{12}$  = coefficient for P-SC and SC variability interaction term;
- $\gamma_{01}$  = coefficient for workgroup tenure; <sup>a</sup>  $\gamma_{01}$  = the effect of workgroup tenure on employee safety behavior for the tenure category 3 compared to the category 2 (c.f., For the variable workgroup company tenure, none of the workgroups fall into the 1<sup>st</sup> category, indicating average company tenure less than 1 year. Hence, the workgroup tenure category 2 served as the reference group.); <sup>b</sup>  $\gamma_{01}$  = the effect of workgroup tenure on employee safety behavior for the tenure category 4 compared to the category 2; <sup>c</sup>  $\gamma_{01}$  = the effect of workgroup tenure on employee safety behavior for the tenure category 5 compared to the category 2;
- $\gamma_{02}$  = coefficient for SC variability;
- $\gamma_{03}$  = coefficient for workgroup tenure and SC variability interaction term; <sup>a</sup>  $\gamma_{03}$  = the effect of SC variability on employee safety behavior for the workgroup tenure category 3 compared to the category 2; <sup>b</sup>  $\gamma_{03}$  = the effect of SC variability on employee safety behavior for the workgroup tenure category 4 compared to the category 2; <sup>c</sup>  $\gamma_{03}$  = the effect of SC variability on employee safety behavior for the workgroup tenure category 5 compared to the category 2;
- $\gamma_{11}$  = coefficient for P-SC and workgroup tenure interaction term; <sup>a</sup>  $\gamma_{11}$  = the effect of P-SC and workgroup tenure interaction term on employee safety behavior for the tenure category 3 compared to the category 2; <sup>b</sup>  $\gamma_{11}$  = the effect of P-SC and workgroup tenure interaction term on employee safety behavior for the tenure category 4 compared to the category 2; <sup>c</sup>  $\gamma_{11}$  = the effect of P-SC and workgroup tenure interaction term on employee safety behavior for the tenure category 5 compared to the category 2;
- $\gamma_{13}$  = coefficient for P-SC, workgroup tenure, and SC variability interaction term; <sup>a</sup>  $\gamma_{13}$  = the effect of P-SC, workgroup tenure, and SC variability interaction term on employee safety behavior for the tenure category 3 compared to the category 2; <sup>b</sup>  $\gamma_{13}$  = the effect of P-SC, workgroup tenure, and SC variability interaction term on employee safety behavior for the tenure category 4 compared to the category 2; <sup>c</sup>  $\gamma_{13}$  = the effect of P-SC, workgroup tenure, and SC variability interaction term on employee safety behavior for the tenure category 5 compared to the category 2;
- $r_{ij}$  = residual;  $U_{0j}$  = random intercept (between workgroup variance of  $\beta_{0j}$ );  $U_{1j}$  = random slope (between workgroup variance of  $\beta_{1j}$ );  $\sigma^2 = \text{var}(r_{ij})$ ;  $\tau_{00} = \text{var}(U_{0j})$ ;  $\tau_{11} = \text{var}(U_{1j})$ ;
- \*\*  $p < .01$ ; \*  $p < .05$ ; <sup>ns</sup> non-significant

Table 8. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 2-2

	AIC	BIC	Log likelihood	Deviance	REML deviance	Model comparison
H2-2 Model 1	2652	2765	-1306	2612	2659	-
H2-2 Model 2	2649	2744	-1307	2615	2659	H2-2 Model 1 vs. H2-2 Model 2: $\Delta\chi^2 = 2.59$ ( $\Delta df = 3$ , $p = .46$ )
H2-2 Model 3	2645	2724	-1309	2617	2661	H2-2 Model 2 vs. H2-2 Model 3: $\Delta\chi^2 = 2.45$ ( $\Delta df = 3$ , $p = .48$ )
H2-2 Model 4	2644	2706	-1311	2622	2654	H2-2 Model 3 vs. H2-2 Model 4: $\Delta\chi^2 = 4.63$ ( $\Delta df = 3$ , $p = .20$ )
H2-2 Model 5	2646	2691	-1315	2630	2649	H2-2 Model 4 vs. H2-2 Model 5: $\Delta\chi^2 = 7.96$ ( $\Delta df = 3$ , $p < .05$ )

*Notes.* Full information maximum likelihood (FIML) estimation was used; AIC = Akaike information criterion; BIC = Bayesian information criterion; REML = restricted maximum likelihood estimation

Table 9. Hierarchical linear modeling (HLM) models and results for Hypothesis 3

Model	Parameter estimates (S.E.)										
	$\gamma_{00}$	$\gamma_{01}$	$\gamma_{02}$	$\gamma_{03}$	$\gamma_{10}$	$\gamma_{11}$	$\gamma_{12}$	$\gamma_{13}$	$\sigma^2$	$\tau_{00}$	$\tau_{11}$
<i>H3 Model 1 (df = 12)</i>											
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$											
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{idpt}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{0j}$	3.57 (.07)**	-.004 (.09) <sup>ns</sup>	.26 (.11)*	-.17 (.15) <sup>ns</sup>	.60 (.10)**	-.29 (.14)*	<b>-.42</b> (.15)**	.32 (.21) <sup>ns</sup>	.20	.01	.01
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{idpt}_j) + \gamma_{12} \times (\text{SC variability}_j) + \gamma_{13} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{1j}$											
<i>H3 Model 2 (df = 11)</i>											
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$											
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{idpt}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{0j}$	3.62 (.05)**	-.10 (.03)**	.17 (.07)*	-	.59 (.10)**	-.28 (.14)*	<b>-.41</b> (.15)**	.31 (.21) <sup>ns</sup>	.20	.01	.01
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{idpt}_j) + \gamma_{12} \times (\text{SC variability}_j) + \gamma_{13} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{1j}$											
<i>H3 Model 3 (df = 17) - Final model</i>											
Level 1: <i>Safety Behavior</i> <sub>ij</sub> = $\beta_{0j} + \beta_{1j} \times (\text{P-SC}_{ij}) + r_{ij}$											
Level 2: $\beta_{0j} = \gamma_{00} + \gamma_{01} \times (\text{idpt}_j) + \gamma_{02} \times (\text{SC variability}_j) + \gamma_{03} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{0j}$	3.63 (.05)**	-.11 (.03)**	.16 (.07)*	-	.47 (.07)**	-.08 (.04)*	<b>-.24</b> (.10)*	-	.20	.01	.01
Level 2: $\beta_{1j} = \gamma_{10} + \gamma_{11} \times (\text{idpt}_j) + \gamma_{12} \times (\text{SC variability}_j) + \gamma_{13} \times (\text{idpt}_j) \times (\text{SC variability}_j) + U_{1j}$											

*Notes.* Full information maximum likelihood (FIML) estimation was used; S.E. = standard error; P-SC = psychological-level safety climate; idpt = task independence (0 = reference group; 1 = highly independent task group); SC = safety climate;  $\gamma_{00}$  = intercept of the model;  $\gamma_{01}$  = coefficient for task independence;  $\gamma_{02}$  = coefficient for SC variability;  $\gamma_{03}$  = coefficient for task independence and SC variability interaction term;  $\gamma_{10}$  = coefficient for P-SC;  $\gamma_{11}$  = coefficient for P-SC and task independence;  $\gamma_{12}$  = coefficient for P-SC and SC variability interaction term;  $\gamma_{13}$  = coefficient for P-SC, task independence, and SC variability interaction term;  $r_{ij}$  = residual;  $U_{0j}$  = random intercept (between workgroup variance of  $\beta_{0j}$ );  $U_{1j}$  = random slope (between workgroup variance of  $\beta_{1j}$ );  $\sigma^2 = \text{var}(r_{ij})$ ;  $\tau_{00} = \text{var}(U_{0j})$ ;  $\tau_{11} = \text{var}(U_{1j})$ ;  
- \*\*  $p < .01$ ; \*  $p < .05$ ; <sup>ns</sup> non-significant

Table 10. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 3

	AIC	BIC	Log likelihood	Deviance	REML deviance	Model comparison
H3 Model 1	2633	2701	-1305	2609	2642	-
H3 Model 2	2632	2694	-1305	2610	2641	H3-Model 1 vs. H3-Model 2: $\Delta\chi^2 = 1.25$ ( $\Delta df = 1, p = .26$ )
H3 Model 3	2633	2689	-1306	2613	2642	H3-Model 2 vs. H3-Model 3: $\Delta\chi^2 = 2.84$ ( $\Delta df = 1, p = .13$ )

*Notes.* Full information maximum likelihood (FIML) estimation was used; AIC = Akaike information criterion; BIC = Bayesian information criterion; REML = restricted maximum likelihood estimation



*Notes.* Full information maximum likelihood (FIML) estimation was used; S.E. = standard error; P-SC = psychological-level safety climate; idv1 = individualistic task (0 = reference group; 1 = highly individualistic task group); SC = safety climate;  $\gamma_{00}$  = intercept of the model;  $\gamma_{01}$  = coefficient for individualistic task;  $\gamma_{02}$  = coefficient for SC variability;  $\gamma_{03}$  = coefficient for individualistic task and SC variability interaction term;  $\gamma_{10}$  = coefficient for P-SC;  $\gamma_{11}$  = coefficient for P-SC and individualistic task;  $\gamma_{12}$  = coefficient for P-SC and SC variability interaction term;  $\gamma_{13}$  = coefficient for P-SC, individualistic task, and SC variability interaction term;  $r_{ij}$  = residual;  $U_{0j}$  = random intercept (between workgroup variance of  $\beta_{0j}$ );  $U_{1j}$  = random slope (between workgroup variance of  $\beta_{1j}$ );  $\sigma^2 = \text{var}(r_{ij})$ ;  $\tau_{00} = \text{var}(U_{0j})$ ;  $\tau_{11} = \text{var}(U_{1j})$ ;  
- \*\*  $p < .01$ ; \*  $p < .05$ ; <sup>ns</sup> non-significant

Table 12. Comparison of Hierarchical Linear Modeling (HLM) Models for Hypothesis 4

	AIC	BIC	Log likelihood	Deviance	REML deviance	Model comparison
H4-Model 1	2652	2719	-1314	2628	2657	-
H4-Model 2	2650	2711	-1314	2628	2656	H4-Model 1 vs. H4-Model 2: $\Delta\chi^2 = .007$ ( $\Delta df = 1, p = .93$ )
H4-Model 3	2648	2704	-1314	2628	2653	H4-Model 2 vs. H4-Model 3: $\Delta\chi^2 = .63$ ( $\Delta df = 1, p = .43$ )
H4-Model 4	2647	2698	-1314	2629	2652	H4-Model 3 vs. H4-Model 4: $\Delta\chi^2 = .71$ ( $\Delta df = 1, p = .40$ )
H4-Model 5	2646	2691	-1315	2630	2649	H4-Model 4 vs. H4-Model 5: $\Delta\chi^2 = .90$ ( $\Delta df = 1, p = .34$ )

*Notes.* Full information maximum likelihood (FIML) estimation was used; AIC = Akaike information criterion; BIC = Bayesian information criterion; REML = restricted maximum likelihood estimation

Table 13. Results for Hypothesis 5

item #	<sup>a</sup> item-level mean	<sup>b</sup> item-level SC variability mean	<sup>c</sup> mean of item-level variance below workgroup mean	<sup>d</sup> mean of item-level variance above workgroup mean	<sup>e</sup> <i>r</i> between item rating & SB
1	3.28	.99	1.72	.91	.23
2	3.56	.89	1.65	.92	.24
3	3.63	.92	2.07	.85	.26
4	3.17	.90	1.39	.97	.23
5	3.32	.92	1.48	.87	.25
6	3.27	1.01	1.77	1.07	.23
7	4.09	.75	1.36	.72	.27
8	2.54	.91	1.33	1.08	.19
9	2.75	1.01	1.33	1.35	.15
10	2.67	.96	1.49	1.11	.18
11	3.20	1.04	1.69	1.30	.25
12	3.62	.99	2.22	.98	.25
13	4.18	.69	1.69	.65	.29
14	2.85	.94	1.79	1.05	.23
15	2.94	1.04	2.07	1.15	.14
16	3.91	.90	3.89	1.32	.26
17	2.78	.97	2.77	1.36	.20
18	3.71	.79	3.71	1.67	.28
19	3.32	.97	3.36	1.75	.25

*Notes.* SC = safety climate; SB = safety behavior; *r* = correlation; for all of the 19 items, correlation between item mean and safety behavior was statistically significant ( $p < .01$ )

- <sup>a</sup>item-level mean = mean of ratings on a particular item across all respondents

- <sup>b</sup>item-level SC variability mean = mean of within-workgroup standard deviation on a particular item across all workgroups

- <sup>c</sup>mean of variance below workgroup mean = mean of  $(\text{item rating} - \text{workgroup item mean})^2$  across workgroups only for the  $(\text{item rating} - \text{workgroup item mean})$  values that are below zero

- <sup>d</sup>mean of variance above workgroup mean = mean of  $(\text{item rating} - \text{workgroup item mean})^2$  across workgroups only for the  $(\text{item rating} - \text{workgroup item mean})$  values that are above zero

- <sup>e</sup>*r* between item rating & SB = correlation coefficient between safety climate scale item rating and participant safety behavior (all *r* coefficients were statistically significant at  $p < .01$ )

- *r* between <sup>a</sup> and <sup>b</sup> =  $-.67$  ( $p < .01$ )

-  $\rho$  between <sup>a</sup> and <sup>e</sup> =  $.91$  ( $p < .01$ )

-  $\rho$  between <sup>b</sup> and <sup>e</sup> =  $-.62$  ( $p < .01$ )

-  $\rho$  between <sup>c</sup> and <sup>e</sup> =  $.32$  ( $p = .19$ )

-  $\rho$  between <sup>d</sup> and <sup>e</sup> =  $-.29$  ( $p = .23$ )

Figure 1. Graphical illustration of the study hypotheses

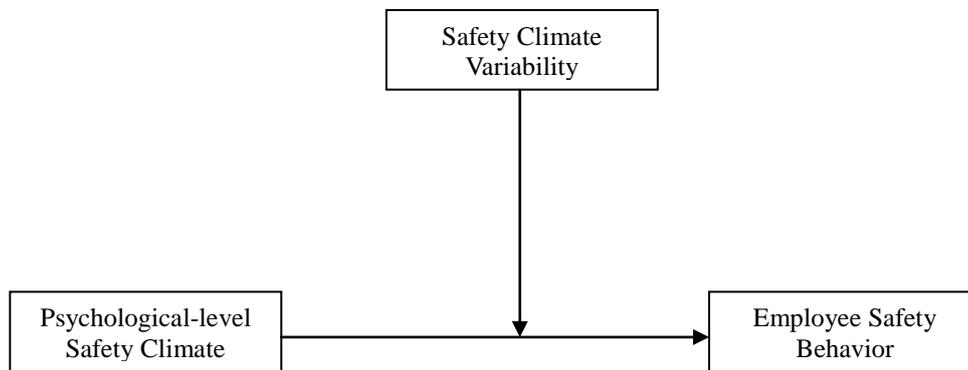


Figure 1-A. Hypothesis 1

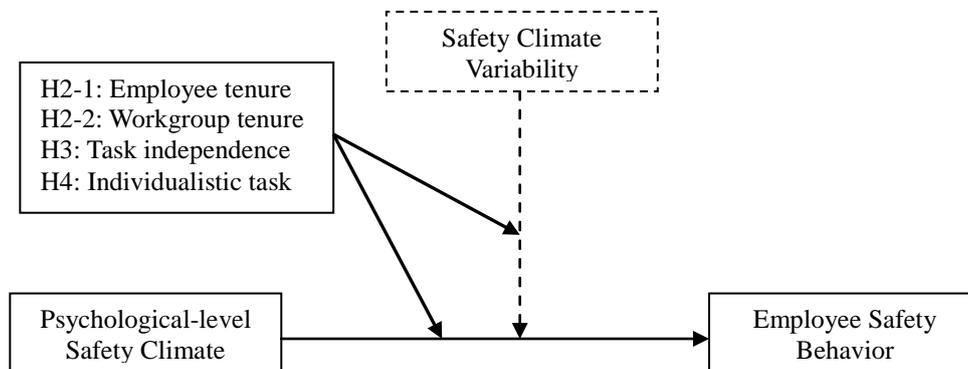
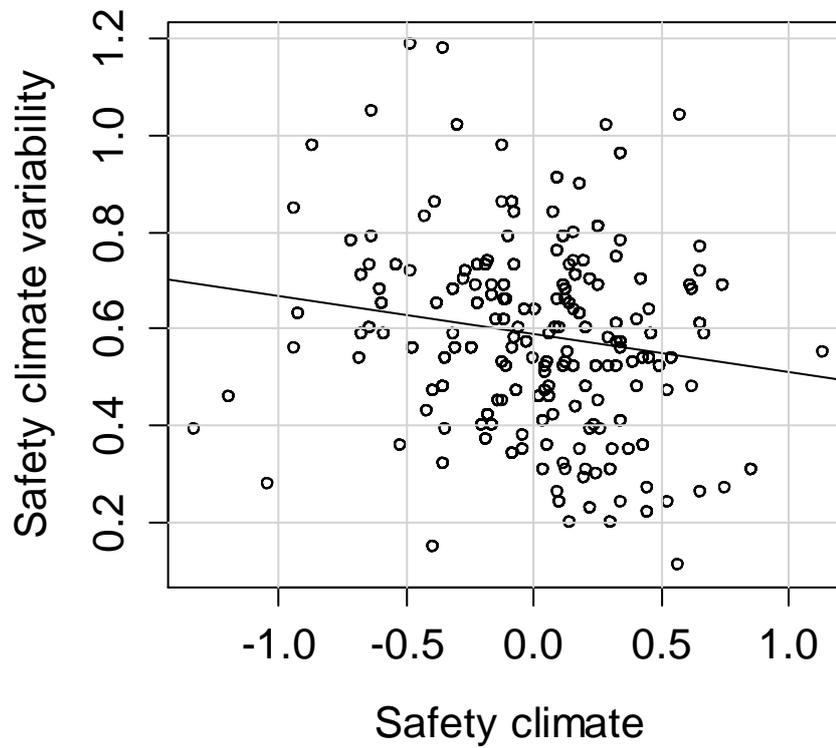


Figure 1-B. Hypotheses 2-4

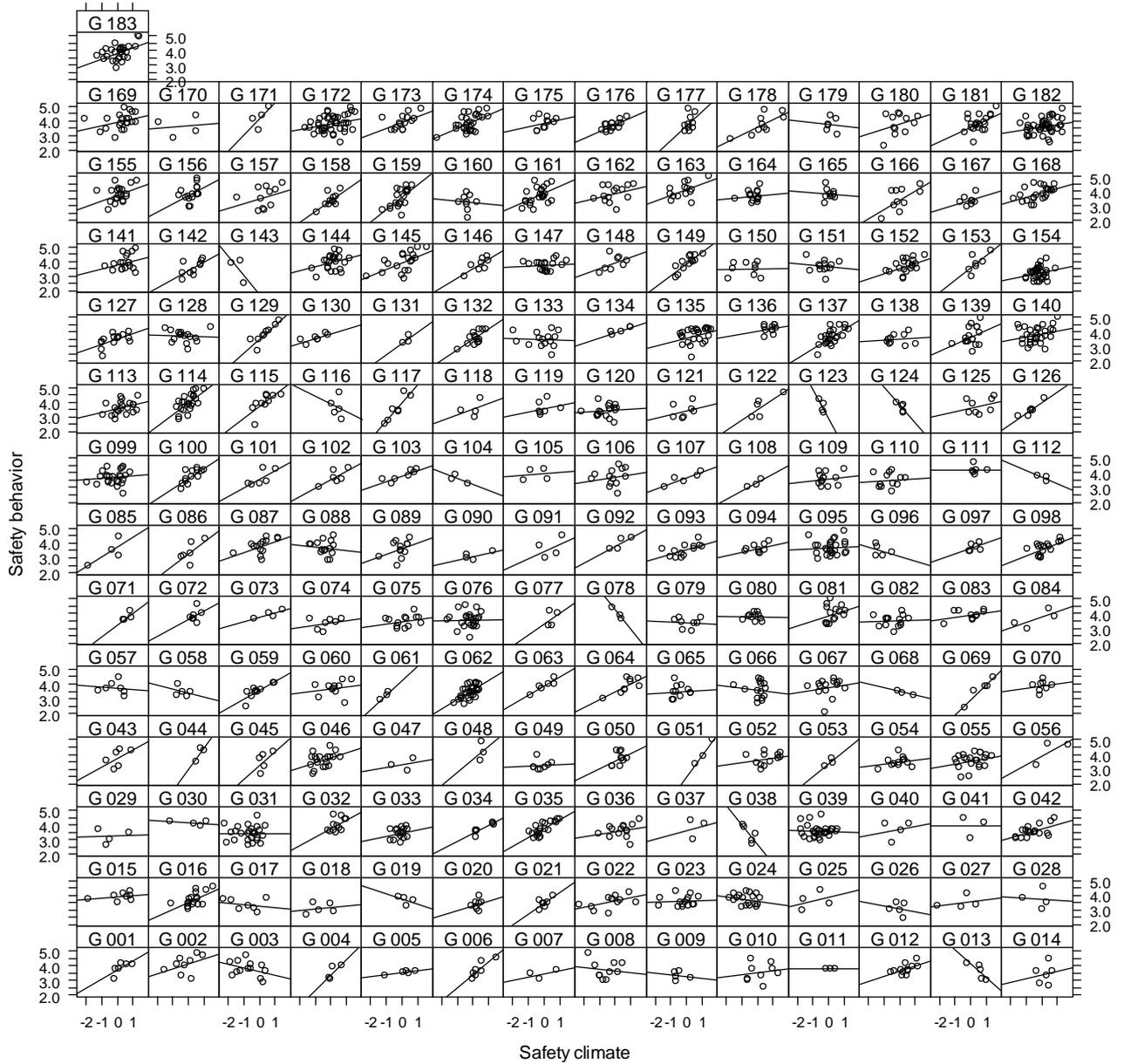
*Notes.* Safety climate variability and its moderation effect were described in dotted lines because introduction of tenure or task characteristics to the original moderation model (Figure 1-A) may result in non-significant moderation effect of safety climate variability

Figure 2. Safety climate level (at workgroup-level) and variability relationship



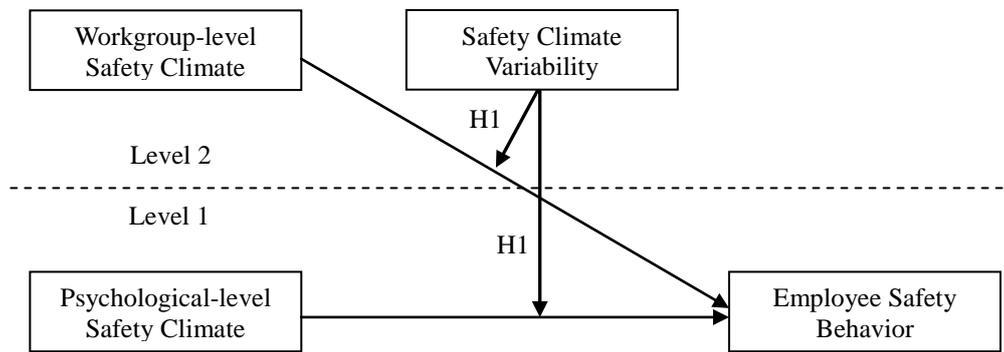
*Notes.* Data point = workgroup ( $n = 183$ ); Safety climate level: workgroup-level (aggregated) and grand mean centered where 0 means overall mean across the 183 workgroups; Safety climate variability: standard deviation of within-workgroup members' safety climate perception; Extrapolation line shown in the figure indicates a linear relationship between the safety climate level and variability ( $r = -.20, p < .01$ ).

Figure 3. Safety climate level (at psychological-level) and variability relationship across 183 work groups



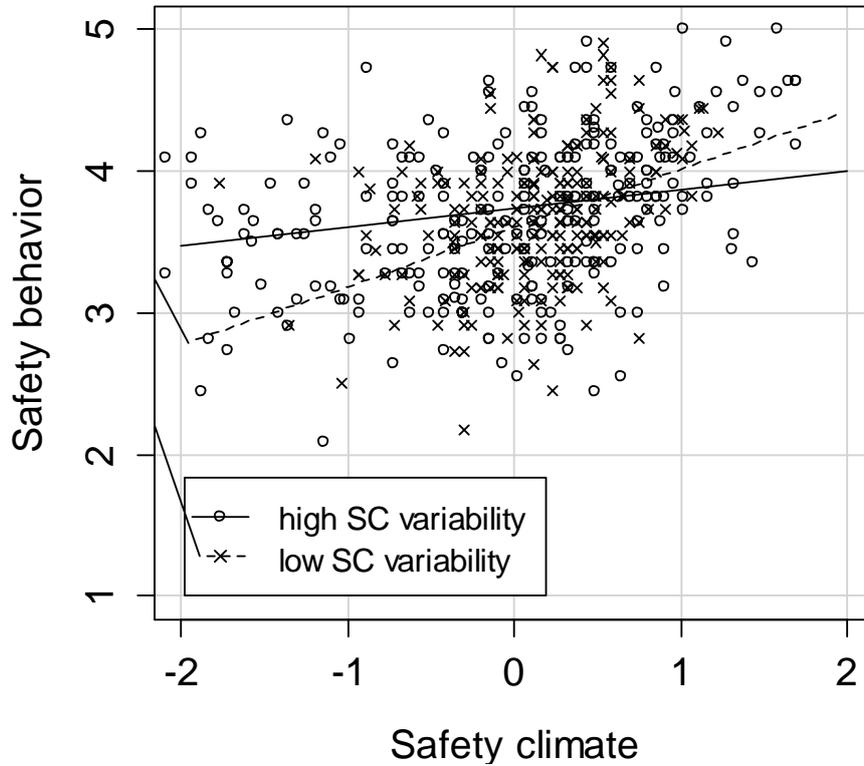
Notes. Data point = individual employee (n = 2,049); Safety climate level is at the psychological-level (not aggregated); Safety climate variability: standard deviation

Figure 4. Graphical illustration of Hypothesis 1



*Notes.* Level 1 = individual (psychological) level; Level 2 = workgroup level

Figure 5. Safety climate level (at psychological-level) and safety behavior relationship for the high and low safety climate variability conditions



*Notes.* SC = safety climate; High SC variability = 1 standard deviation above the mean workgroup safety climate variability, indicating 'low consensus' in safety climate perceptions among workgroup members; Low SC variability = 1 standard deviation below the mean workgroup safety climate variability indicating 'high consensus' in safety climate perceptions among workgroup members.

Figure 6. Graphical illustration of Hypotheses 2-1 and 2-2

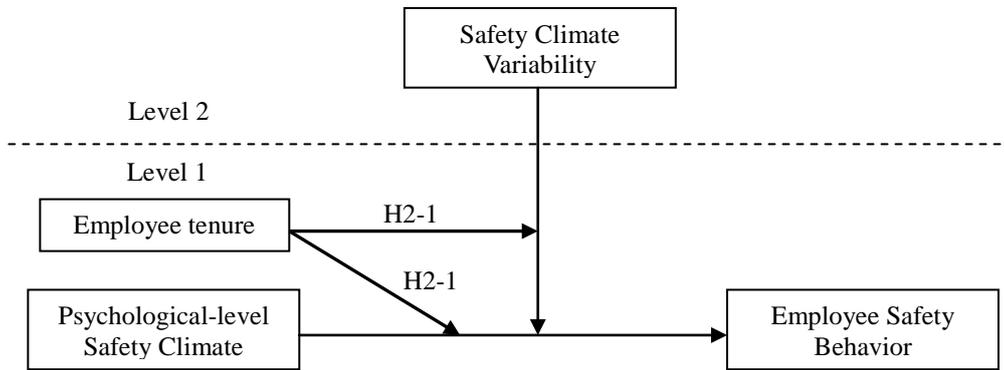


Figure 6-A. Graphical illustration of Hypothesis 2-1

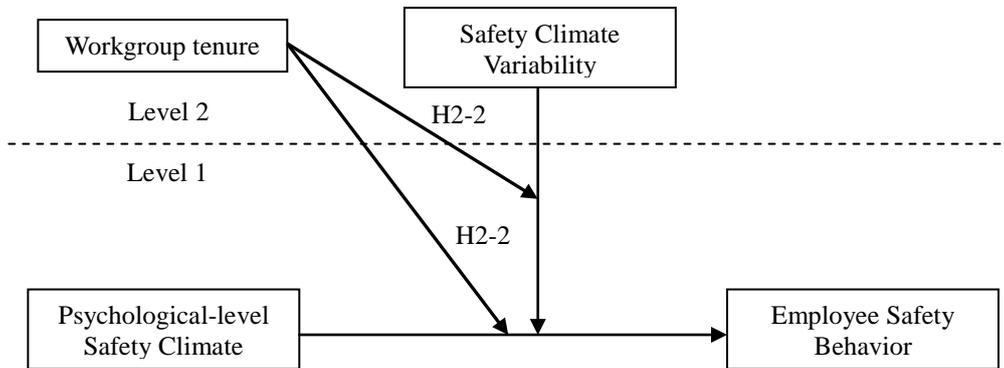
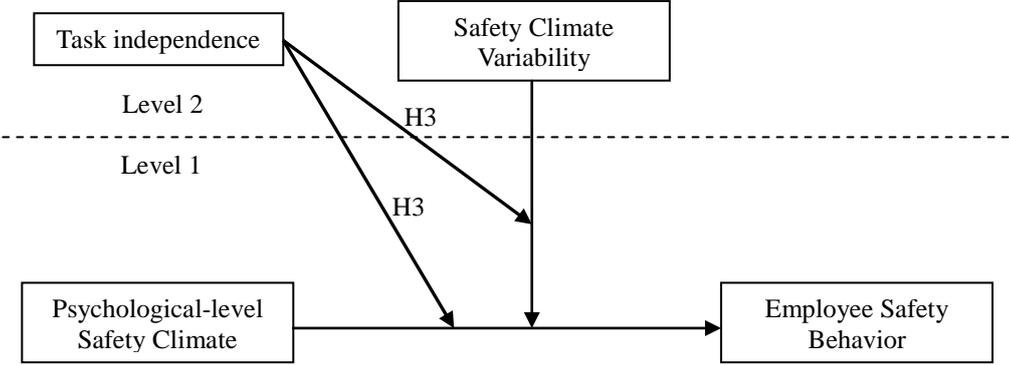


Figure 6-B. Graphical illustration of Hypothesis 2-2

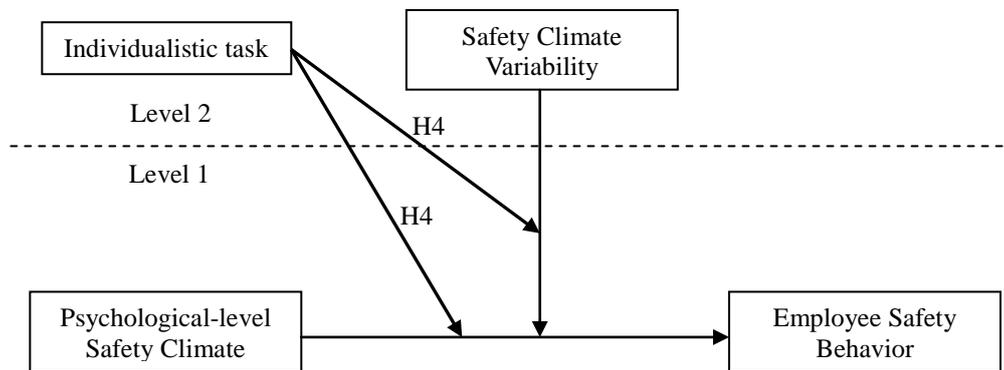
*Notes.* Level 1 = individual (psychological)-level; Level 2 = workgroup-level; Employee tenure = employee’s company tenure; Workgroup tenure = workgroup’s company tenure (computed by averaging within-workgroup employees’ company tenure)

Figure 7. Graphical illustration of Hypothesis 3



Notes. Level 1 = individual (psychological)-level; Level 2 = workgroup-level

Figure 8. Graphical illustration of Hypothesis 4



*Notes.* Level 1 = individual (psychological)-level; Level 2 = workgroup-level