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A sociotechnical systems approach to enhance safety climate in the trucking industry: Development of a methodology

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ABSTRACT

The systems approach is increasingly used as a framework within which to examine safety climate. Utilizing a macroergonomics approach to design work systems can help identify aspects of human-technology-organization interfaces that impact workers' perceptions of safety, both positively and negatively. Such an approach also supplements traditional uses of safety climate as a leading indicator of safety and helps expand research toward an approach that can determine problems impacting safety. The purpose of this study was to develop a methodology that extends safety climate beyond just an overall score by using the framework of macroergonomics to examine the entire system in a more comprehensive manner. The proposed methodology can be used as a way to identify gaps in the specific work system, and this information can be used to design interventions to change the safety climate, and ultimately the culture, of an organization in order to reduce negative safety outcomes.

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1. Introduction

According to the Bureau of Labor Statistics (BLS, 2015), the number of fatal work injuries in the United States has been declining, from 6217 fatalities in 1992 to 4600 fatalities in 2014. Additionally, the rate of fatal work injuries has seen an overall decline from 4.2 worker deaths per 100,000 full-time equivalent workers in 2006 to 3.3 worker deaths per 100,000 full-time equivalent workers in 2013 (BLS, 2015). While these statistics are encouraging, there may be external factors in play that impact safety statistics, such as manufacturing jobs being moved overseas. Regardless, more work needs to be done to prevent the considerable number of workplace fatalities and injuries still occurring. Such work includes innovative methodologies and programs to address issues that are still being faced by many workers in different industries. Interdisciplinary collaborations can spark innovation in safety research by integrating different bodies of knowledge and methods to examine a wide array of factors that may affect safety outcomes. As first discussed by Murphy et al. (2014), two bodies of knowledge with notable histories that can be integrated to improve safety outcomes are safety climate and macroergonomics.

Macroergonomics research has been contributing to the ergonomics literature since its conceptualization in the 1970s (Kleiner, 2006). Dr. Brian Kleiner, a leading researcher in the field of macroergonomics, outlines the history of the subdiscipline in his 2006 article. He starts by describing the Human Factors Society "Futures Study" committee, formed in the late 1970s, that identified a number of trends with the potential to influence the field of ergonomics throughout the 1980s and 1990s. The committee determined that microergonomics was not capable of achieving "relevant and sufficient results" to counter such trends as increased technology, more diverse demographics, and increased world competition, and so macroergonomics was created (Kleiner, 2006, p. 82). Kleiner (2006) does point out that researchers, such as Dr. Mac Parsons in the U.S. and Dr. Nigel Corlett in the U.K., were using a systems perspective in their ergonomics-related work previous to the creation of macroergonomics, and that systems ergonomics has been practiced in the U.K. for over 50 years.

Safety climate research also has a considerable history and has been ongoing for over 35 years. A majority of safety climate studies

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have been dedicated to developing safety climate measures and gathering empirical evidence demonstrating that a poor safety climate can contribute to negative safety outcomes. In fact, numerous meta-analyses have shown robust findings that safety climate is a leading indicator of accidents and injuries (Beus et al., 2010; Christian et al., 2009; Nahrgang et al., 2011). The study of safety climate is based on the perception of workers, with the major factors relating to (a) management commitment to safety and (b) communication pertaining to safety as a true priority from both top management and direct supervisors (Dejoy et al., 2004). More specifically, safety climate is defined as workers' shared perception regarding their organization's policies, procedures, and practices in relation to the value and importance of safety within that organization (Griffin and Neal, 2000; Zohar, 1980, 2000, 2002, 2003). Safety climate is the measurable aspect of safety culture, and a safety climate measure is used to obtain an overall safety climate score for an organization. Therefore, safety climate is usually described as high (positive) or low (negative) depending on the safety climate score, often measured using a Likert scale from 1 to 5. Overall, a positive safety climate influences employees' motivation and knowledge to act in a safe manner, leading to safer behaviors that result in fewer accidents and injuries (Christian et al., 2009; Griffin and Neal, 2000).

The gaps to be filled in the field of safety climate include how safety climate emerges and how safety climate is influenced or changed (Zohar, 2010). In order to conduct research to fill these gaps, this study discusses the development of a methodology rooted in macroergonomics that can be utilized to gain insight into the complex work system of an organization and how that work system affects safety climate. It is necessary to understand the complete work system because safety is an emergent property of an organization, which means that not all accidents can be planned for and therefore prevented (Leveson, 2004). Additionally, safety is unique in each organization and the same factors leading to an accident in one workplace may not lead to negative consequences in a different workplace.

Because safety is context-specific, there are methodological challenges in safety research that make it difficult to have a survey instrument, like those used in safety climate research, that can identify where specific safety issues reside in a particular organization. More specifically, items found in many safety climate measures are limited in their ability to identify exact underlying causes of poor safety outcomes because the restricted number of items in a measure usually address more global safety concerns (Murphy et al., 2014). Even if there are more detailed items, they only address a small number of safety issues because there are only so many items in a measure. It is especially problematic to identify safety issues that are context-specific because a majority of safety climate scales are general measures that are not specific to a particular industry (Murphy et al., 2014). This study focuses on the long-haul trucking industry because of the challenges such a context poses to traditional safety climate measures. For example, long-haul truck drivers may be on the road for weeks at a time (Huang et al., 2005), which impacts the social interactions drivers have with other organizational members. Also, drivers' perceptions are influenced by long hours and low wages (Belzer, 2000), considerations that are typically outside the scope of safety climate factors.

This paper is the first in a series that extends safety climate theory through the assessment of trucking companies using macroergonomic principles. The second paper will present the results of the systems analysis that was conducted using the methodology outlined in this paper. This study provides three contributions to the safety literature. First, this study used the theoretical underpinning and framework offered by macroergonomics to explore the work system as a complement to safety climate measurement to create a stronger safety assessment. Therefore, this study bridges the gaps between the two different domains and integrates macroergonomics, related to sociotechnical systems theory, and safety climate research. The methodology that has been developed extends the construct of safety climate beyond the safety climate scores themselves. Receiving one safety climate score from a specified set of items does not give organizations many options for modifying the work environment to improve safety outcomes. As of now, there are few safety climate intervention studies because the literature related to antecedents of safety climate is sparse (Zohar, 2010). Integrating a systems approach will allow researchers to conduct studies to better understand how safety climate emerges, leading to more safety climate interventions that create positive changes. Second, qualitative methods were used to gain insight into the complex work system of an organization. The methodology provided in this article lays the groundwork for potential organizational interventions because the outcome of the systems analysis is a greater understanding of inadequacies to target that affect safety. Finally, results of the study will provide and demonstrate two different types of important outputs: Results from affinity mapping that synthesize qualitative information into conceptual groupings/major themes/issues and results from the contextual inquiry technique that were used to construct a functional role diagram of the system in order to examine different work system components that affect safety outcomes. These results will allow researchers to identify issues in a number of different subsystems that are particular to one company.

2. Theoretical framework

2.1. Macroergonomics

A systems perspective allows for a more comprehensive evaluation of an organization, rather than examining components in isolation (Haro and Kleiner, 2008). More specifically, macroergonomics is a comprehensive process that allows for the assessment of personnel, technology, the external environment, the internal environment, the organizational and management structure, and the interactions between all components (Haro and Kleiner, 2008). Macroergonomics views an organization as an open system that adapts to external changes or forces in order to be in a steady state (Kleiner, 2004). As discussed previously, safety is an emergent property of a system and it changes as system components, and perhaps most critically, the interrelationships between those components change (Hettinger et al., 2015). Changes in one subsystem (e.g., personnel subsystem) may affect a different subsystem (e.g., technological subsystem), and these changes may be directly related to safety or may impact safety. Therefore, taking all subsystems into consideration is necessary when conducting safety assessments.

When there is a negative change in a system component, it is called a variance. Hendrick and Kleiner (2001) defined a variance as "an unexpected or unwanted deviation from standard operating conditions, specifications, or norms" (p. 76). Kleiner (2004) suggested that variances could be controlled through such things as selection, training, technological support, and organizational design. When there is a variance in the system, often there is a gap between the way an organization expects its employees to behave and employees' actual behavior (Kleiner, 2004). When there is a gap between the operation of the actual work system and the expectations of how the desired or ideal work system should function, Kleiner (2004) has found that those gaps are usually gaps of perception (e.g., a written procedure is not the safest or most efficient way to complete a task), and those gaps can be diminished

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