The Association between Risk Perception and the Risk-Taking Behaviors of Construction Workers

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Abstract

The majority of human-factor models in construction safety assume that risk-taking behaviors, failure to perceive hazards, or misinterpreting the associated risks of hazards are the main contributing factors in accident occurrences. However, the findings for the link between risk-taking behaviors and risk perception are inconsistent. To address this knowledge gap, the current study focuses on measuring the association between risk perception and the risk-taking behaviors of construction workers. To achieve this objective, 27 undergraduate students from the University of Nebraska–Lincoln with at least 1 year of experience in the construction industry were recruited to participate in an experiment. To measure risk perception, the subjects were asked to assess the risk—in terms of likelihood and severity—associated with various scenario statements related to fall hazards. Subsequently, subjects performed the balloon analogue risk task (BART), a computerized decision-making simulation, to test the subjects' risk-taking behaviors. The results of a correlational analysis showed that there is a significant negative association between an individual's risk perception of fall hazards and his/her risk-taking behaviors. Additionally, differences in the risk-taking behaviors of subjects evaluated against their risk-perception scores were examined using a permutation simulation analysis. The results showed that there is a moderately significant difference in the risk-taking behaviors of subjects with low and high fall-risk perception. The research findings provide empirical evidence that people with lower risk perception tend to engage in more risk-taking behaviors. Furthermore, this study is one of the first attempts at using BART in the assessment of risk taking in construction safety and paves the way for a better understanding the human factors that contribute to construction accidents.

INTRODUCTION

Any given day, the construction industry employs nearly 6.7 million workers on approximately 252,000 construction sites across the United States (BLS 2017). However, workers in the construction industry are typically at a high risk of getting involved in an accident (OSHA 2016). Among the various root causes of accidents,

human factors play an important role. In fact, many recognize risk-taking behaviors as one of the main contributing human factors in accidents (Rundmo 1996; Hinze 2006). Considering the impact of these risk-taking behaviors, studying the antecedents of such behaviors has become one of the essential concerns for social and health scientists (e.g., Brewer et al. 2004; Brown 2005; Noroozinejad et al. 2013) as well as researchers exploring the roots of traffic accidents (Rundmo and Iversen 2004). In terms of construction safety, given the high incidence of accidents, such studies have far-reaching value.

One of the cognitive variables that impacts risk-taking behaviors is risk perception. While several studies have been conducted to determine differences in safety attitudes and perceptions among employees with differing managerial positions (e.g., Findley et al. 2007; Lipscomb et al. 2008; Zhang et al. 2014; and del Puerto et al. 2014), knowledge about the link between the risk perception of construction workers and their attitude in taking higher risks is limited.

This study addresses this knowledge gap by testing the following hypotheses: (1) There is no association between risk perception and the risk-taking behaviors of construction workers; and (2) There is no significant difference in the risk-taking behaviors of individuals with different risk perception (e.g., low, medium, and high). To measure risk-taking behaviors, the research team used the Balloon Analogue Risk Task (BART), a computerized decision-making simulation; risk perception was measured by asking participants to assess the frequency and severity of hazardous situations. To limit the scope of the study, this study focuses on fall hazards.

BACKGROUND

A comprehensive literature review was conducted to understand the concepts of risk perception, risk-taking behaviors, their relationships, and the different methods for measuring them. The salient findings appear below.

Risk Perception

Risk perception is defined as "the subjective assessment of the probability of a specified type of accident happening and how concerned we are with the consequences" (Sjöberg et al. 2004, p. 8) and has been found to be one of the critical factors influencing safety practices and accident involvement (Rundmo 1996; Habibnezhad et al. 2016). Evidence in the literature shows that risk perception varies among different individuals working in construction sectors (Lipscomb et al. 2008; Lopez del Puerto et al. 2014). The differences in risk perception may contribute to the accident rates of construction workers differently because how these workers perceive risk will influence their strategies to control risk on construction sites. Zhang et al. (2014) pointed out that if individuals perceive risks differently, they will likely have different perspectives on how risks should be controlled and which strategies they should implement to control these risks. In another study, by examining the impact of sociodemographic variables on the risk perception of Spanish construction workers, Rodríguez-Garz et al. (2015) found that construction workers who have received more training have higher risk perceptions than their counterparts with less training. The results of their study highlight the important role of training in not only improving worker's knowledge but also in enhancing cognitive processes such as perception.

In order to study risk perception, one needs to measure it. Two main approaches to measuring safety-risk perception can be identified in the literature: (1) presenting statements that represent risky situations to evaluate response (e.g., Rodríguez-Garz et al. 2015); and (2) using images of construction activities to observe which risks subjects identify (Zhang et al. 2014; Habibnejad and Esmaeili 2016). In this study, the research team decided to use the first approach since this study is comparable with studies in driving and psychology, both of which use the presentation of statements.

Risk-Taking Behavior

Risk-taking behavior is defined as "the engagement in behavior that is socially defined as a problem, a source of concern, or as undesirable by the norms of conventional society and the institutions of adult authority, and its occurrence usually elicits some kind of social control response" (Jessor and Jessor 1977; p. 33). Leigh (1999) described risk taking as the behaviors that focused on the balancing of potential for harm or danger to the individual with potential achievement or reward. Thus, in addition to potential negative consequences, risk takers also look forward to gaining potential rewards that compensate for their risky activities. The impact of risk-taking behavior has been studied for several risky behaviors such as alcohol consumption (Leigh 1999), driving (Rundmo and Iversen 2004), interpersonal aggression, delinquent behaviors (Boyer, 2006), and risky sexual activity (Noroozinejad 2013).

Since risk-taking behavior is a critical factor in a large number of construction accidents (Hinze 2006), understanding the factors that influence risky behaviors is very important for safety improvement on construction sites. However, a limited number of studies have investigated this topic mainly due to the absence of a reliable method for measuring risk-taking behaviors. One of the popular methods for measure risk-taking behavior is BART, a computerized, laboratory-based measure developed, tested, and validated by Lejuez et al. (2002) to test behavioral risk taking. BART involves an actual risky behavior in which, similar to real-world situations, riskiness is rewarded up until a point at which further riskiness results in poorer outcomes. Risk-behavior scores collected from BART correlates with real-world risky behaviors such as alcohol use, cigarette and drug use, gambling, stealing, unsafe sex, and measures of risk-taking behavior (Lejuez et al., 2002; 2003a,b). In addition, research conducted by White et al. (2008) suggests that BART could even be useful in studies that assess risk-taking behaviors over time, for instance, during drug treatments, interventions, or events that could physically alter risk taking on different days of the study.

Relationship Between Risk Perception and Risk-Taking Behaviors

While previous literature illustrated the link between risk-taking behaviors and risk perception (Rundmo 1996; Noroozinejad 2013; Brewer et al. 2004; Brown 2005), inconsistency in the findings manifest in the different studies. This inconsistency may stem from the lack of a strong verification for links between risk perception and risk-taking behaviors, improper measurement of those two concepts, or incorrect interpretations of data (Brewer et al. 2004). The relationship between risk perception and risk-taking behaviors is complicated, so inappropriate tests or

incorrect measurement may lead to invalid conclusions. For example, Mills et al. (2008) analyzed the data collected from 596 adolescents to examine the relationship between risk perception and risk-taking behaviors. Their findings indicated a contradictory relationship between these two constructs: The relationships between risk perception and the risk-taking behaviors of adolescents depended on the cues in the questions that the subjects were asked, which either triggered verbatim or gist processing. Such complications detracted from the veracity of the study's outcomes and speak to the challenge of identifying the relationship between perception and risky behaviors.

Brewer et al. (2004) tested the effects of perceptions of risk on changes in risk-taking behavior. Their result showed that people who perceive a situation as high risk were more likely to increase their preventive behaviors. The high-risk perception caused people to take protective actions beforehand, indicating that they were less likely to take risks. Furthermore, Brown (2005) proved a negative correlation between these two constructs by analyzing the data collected form 255 motorists to examine the relationships between risk-taking behaviors and subsequent risk perceptions. The results indicated that successive increments in risk-taking behavior will lead to progressively lower increases in personal risk perception. In contrast to this negative relationship, the findings from a study by Rundmo (1996) demonstrated that there was a significant positive correlation between perceived risk and risk-taking behaviors. However, the study's results also indicated that risk perception was not found to predict risk behavior.

The literature's inconsistent findings regarding the relationship between risk perception and risk-taking behaviors instigate questions as to whether there is a relationship between workers' risk perceptions and their risk-taking behaviors and whether peoples' perceptions about risk actually influence their risk-taking behaviors. This study addresses such concerns.

METHODOLOGY

To collect data and compare the relationship between risk perception and risk-taking behavior, the research team recruited twenty-seven students (24 males and 3 females) from the Department of Civil Engineering and the School of Architectural Engineering and Construction at the University of Nebraska-Lincoln. All participants have at least one year of working experience on construction sites either as interns or as employees, and each participant received a gift card as compensation for participating in the study. The risk-perception data were collected via a quantitative survey questionnaire whereas the risk-taking behavior data were collected using a computerized task named the Balloon Analogue Risk Task (BART). A detailed description of data-collection instruments follows.

Measure of Risk Perception

The risk-perception data were collected through a survey questionnaire including a set of 13 statements that each discussed a potential fall hazard. The subjects were asked to rate the likelihood of accident occurrence related to each statement using a 5-point Likert scale, with 1 signifying "very low likelihood" and 5 signifying "very high likelihood." Additionally, subjects were asked to rate the outcome or severity of the potential accidents related to each statement using a 5-

point Likert scale, with 1 equating to "very minor" and 5 equating to "very severe." For each subject, the risk-perception score for each statement was generated by multiplying the likelihood score by the outcome score; the overall risk-perception score of each subject was then calculated by averaging the risk perception scores of all the statements. During the experiment and after screening the data, the research team found that two statements out of thirteen statements were confusing and decided to drop them from further analysis. The risk perception questionnaire for the 11 statements appear in Table 1.

Table 1: Items included in the risk perception questionnaire

Risk statements	Likelihood	Outcome
1- Working on ladders	-	-
2- Working near an unprotected edge (roof)	-	-
3- Working near an unprotected opening	-	-
4- Working near a skylight	-	-
5- Working on a scaffold	-	-
6- Working on structural frames (e.g., steel frames)	-	-
7- Working on an aerial platform	-	-
8- Working/standing on heavy equipment	-	-
9- Working on a slippery surface	-	-
10- Working on an unsecured or unstable surface	-	-
11- Working on an uneven working surface	-	-

Measure of Risk-Taking Behavior

The risk-taking behavior data were collected using the BART test (Figure 1). Over the course of the BART test, participants saw thirty (default) balloons on the computer screen, one balloon at a time. For each balloon, the participant had two choices: (1) pump up the balloon or (2) collect the earnings (winnings). Each time participants clicked the "pump" button, the balloon would inflate a little more, with a risk of popping. For each successful pump, participants would earn money (5 cents); however, if a balloon popped before participants collected their winnings, they would lose all of their money for that balloon. Balloons would pop after a random number of pumps, so participants could not predict their probabilities of success. In this experiment, a balloon breakpoints ranged from 1 to 128 pumps. Since the participants had to stop pumping before the balloon popped in order to collect money from a balloon, participants had to decide how much to pump each balloon by weighing the risk of popping and losing all of their earnings. Once the participant either collected money or popped a balloon, a new balloon would appear. The primary score used to measure BART performance is the average number of pumps on unexploded balloons, with higher scores indicating greater risk-taking propensity. Thus, the average number of pumps on unexploded balloons represents the risk-taking behavior score of the subject.

Data Analysis

To explore the relationship between risk perception and risk-taking behaviors, the data collected from the risk-perception survey were analyzed using the Pearson

correlation analysis since this test is the most common test in behavioral research (Kraemer and Blasey 2016). After checking the possible sources of bias—namely, using the Shapiro Wilk test to confirm the linearity and normality of the data—the Pearson bivariate correlation analysis was conducted using the SPSS software to study the relationship between the workers' fall-risk perception and their risk-taking behaviors.

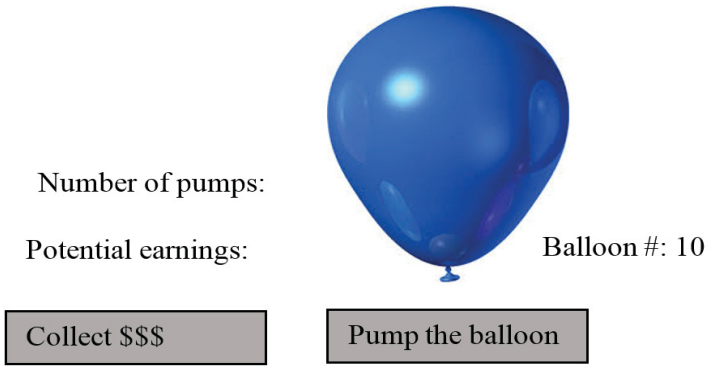

Figure 1: Screen shot of BART Test

In addition, the impact of construction workers' risk perception on their risk-taking behaviors was examined using a permutation simulation. The permutation technique can help overcome problems arising from small sample sizes and non-random sampling limitations by reshuffling and simulating actual data to 1) build larger samples (e.g., 1000 samples) using the original data, and 2) obtain p-values based on simulated distributions (Adams and Anthony 1996; Anderson 2001). This technique provides higher power compared to non-parametric tests since it relies on using actual data rather than the ranks that are used in non-parametric analyses (Ludbrook and Dudley 1998; Drummond and Vowler 2012; Gleason 2013).

To perform the permutation simulation, first, the participants were divided into three groups based on their fall risk–perception score percentiles. Two extreme groups were chosen for further investigation (those above the 75th percentile and those below the 25th percentile). Then, the DEDUCER library and a graphical data analysis with JGR (of the open-source statistical package R (R Development Core Team 2011)) were used to examine differences between the groups in terms of their risk-taking behaviors. All analyses were performed at a level of 95% as statistically significant ($p < 0.05$) and 90% as moderately statistically significant ($p < 0.1$).

RESULTS AND FINDINGS

The descriptive results show that the overall mean of the risk perception of the subjects is 13.69 (SD= 0.63), ranging from 8.14 to 22.71. The mean of the risk-taking behavior score (BART score) is 39.08 (SD= 3.27), ranging from 9.75 to 79.12. The bias check for the linearity and normality of the data showed that Pearson correlation would be an appropriate technique to be used in this study ($p_{\text{risk perception- Shapiro Wilk}} = 0.20 > 0.05$; $p_{\text{Risk-taking behavior- Shapiro Wilk}} = 0.69 > 0.05$). The results of correlation and permutation analyses are shown here.

Correlation Between Risk Perception and Risk-Taking Behaviors

The results of correlation analysis appear in Table 2. As shown, risk perception is significantly related to risk-taking behaviors (p-value = 0.026 < 0.05). The negative correlation (-0.427) indicates that individuals who perceive lower risks on construction sites generally engaged in more risk-taking behaviors than those who have higher risk perception. This finding implies that the null hypothesis that "There is no association between risk perception and the risk-taking behaviors of construction workers" would be rejected.

Table 2: Correlation between risk perception and risk-taking behaviors

		Risk-taking behavior
Risk Perception	Correlation	-0.427*
	P-value (2-tailed)	0.026
	Sum of Squares	-614.961
	Covariance	-23.652
	N	27

*p< 0.05

Impacts of Risk Perception on Risk-Taking Behaviors

To examine the influence of risk perception on construction workers' risk-taking behaviors, the research subjects were divided into three groups based on their risk-perception scores regarding fall hazards. Subjects with risk-perception scores below the 25th percentile were classified as having low risk perceptions ("low"), subjects with risk-perception scores from the 25th to the 75th percentile were classified as having medium risk perceptions ("medium"), and subjects with risk-perception scores above the 75th percentile were classified as having high risk perception ("high").

As apparent in the mean values of the risk-taking behavior scores (Table 3), the difference between the medium and high risk-perception groups is minimal ($mean_{low}$ = 35.67~ $mean_{high}$ = 35.09). Therefore, the research team decided to compare only risk-taking behavior scores between the low and high risk-perception groups. Both Welsh T permutation and non-parametric analyses were used to study the differences between these two groups in terms of their risk-taking behavior scores. The data analyses results showed that the risk-taking behavior score of the subjects with high-risk perception was moderately statistically different from the risk-taking behavior score of the subjects with low-risk perception (Welsh t-statistic = 1.91; p-value = 0.08<0.1). This finding implies that the null hypothesis that "There is no significant difference in the risk-taking behaviors of individuals with different risk perception" would be rejected.

Table 3: Risk-taking behavior scores for the three risk-perception groups

Risk-perception groups	Risk-taking behavior score			
	Mean	SD	95% Confidence Interval	
Low	51.90	18.75	32.23	71.58
Medium	35.67	16.81	24.99	46.34
High	35.09	13.11	25.01	45.17

DISCUSSION

The data analysis results in this study suggest that risk perception impacts the risk-taking behaviors of people who work in construction since construction workers with low-risk perception are more likely to engage in risk-taking behaviors than the workers with high-risk perception. This finding benefits practitioners who wish to improve the safety performance on construction sites. In particular, by understanding that workers with low risk perception engage in more risk-taking behaviors, practitioners can *identify* at-risk workers by measuring their risk perception. This study also contributes to construction safety theory by being the first to apply a computerized laboratory instrument (BART) to the measurement of construction workers' risk-taking behaviors. The use of BART helps facilitate the risk-taking behavior measurement process and addresses the limitations of other methods.

There are two main limitations in this study that must be mentioned. First, participants in the experiment were students at the University of Nebraska-Lincoln with varying exposure to specific trades in the construction industry. It would be worthwhile to repeat this experiment by recruiting construction workers from different trades (e.g., roofers) and comparing the results across trades. Second, in this study, the risk perceptions of subjects were measured using statements. Future studies could apply other methods for measuring risk perception and compare the results.

CONCLUSION

Studying the antecedents of risk-taking behaviors is gaining traction among occupational safety researchers to better understand the chain of events that lead to an accident. Although previous studies suggested that perception might impact risk-taking behaviors, no previous empirical evidence in occupational safety supported this notion. The current study filled this knowledge gap by studying the association between the risk perception and risk-taking behaviors of construction workers. Analyzing the data using Pearson correlation analysis resulted in a significant negative correlation between risk perception and risk-taking behavior, which means that people who have lower risk perception are generally involved in riskier activities than those with higher risk perception. Furthermore, the study also examined the difference in risk-taking behaviors between the low risk-perception group and the high risk-perception group. The results indicate a moderately significant difference between the risk-taking behaviors of individuals with low risk-perception and individuals with high risk-perception. The knowledge created from this study can help safety managers to detect at-risk workers and reduce likelihood of risk taking behaviors.

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