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Effects of Safety Training on Risk Tolerance: An Examination of Male Workers in the Surface Mining Industry

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Biographies

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Joel M. Haight, Ph.D., P.E. recently took over as Branch Chief of the Mining Injury Prevention Branch in the Centers for Disease Control and Prevention's (CDC)-NIOSH, Pittsburgh Research Center in Pittsburgh, PA. Dr. Haight recently left The Pennsylvania State University after nearly 10 years where he was an Associate Professor of Energy and Mineral Engineering. He has a Ph.D. in Industrial and Systems Engineering from Auburn University. Dr. Haight worked as an engineer and manager for the Chevron Corporation for 18 years prior to joining the faculty at Penn State. He does human error research and process intervention effectiveness research. He is a licensed engineer in Pennsylvania and Alabama and is professional member of ASSE, AIHA and the Human Factors and Ergonomics Society.

Judd Michael, Ph.D. is Professor of Sustainable Enterprises at Penn State's Institutes of Energy and the Environment and is affiliated with Penn State's Management Development Programs and Services. Much of Dr. Michael's current research deals with organizational behavior, organizational change, corporate social responsibility, and how manufacturers can improve safety performance. Judd received a B.S. (Management) and MBA from Texas A&M University and a PhD from Penn State.

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Abstract

Employers often assume that safety training facilitates safe behaviors. This assumption does not account for the role that risk tolerance plays in workplace decision-making. This study investigated whether there is a relationship between the quantity of safety training a worker has had within the previous 24 months and that worker's risk tolerance. A survey was used to assist in the evaluation of risk tolerance levels for stone mining workers in Pennsylvania. Results indicate that workplace safety training is not related to a worker's risk tolerance and that as the reported number of hours of non-workplace safety training increases, so too does a worker's tolerance for high personal risk situations. No relationship was detected between a worker's risk tolerance and self-reported safety-related events. Workers with non-workplace safety training are more risk tolerant than their counterparts who did not report non-workplace safety training. Workers with dependents were less tolerant of high personal risk situations than those without dependents. These results suggest that workplace safety training alone should not be used by employers to ensure appropriate risk-related decision-making by employees.

Keywords: Risk Tolerance, Safety Training, Mining

1. Introduction

People are presented with opportunities to engage in risky behavior nearly every day. Our tolerance for risk, defined by Hunter (2002) as the amount of risk an individual is willing to assume in pursuit of a goal, is thought to be a key component determining the actions we are willing to take in our daily lives; such actions may include how we drive or even what food we eat. Per Barsky et al., (1997) risk tolerance is positively related to engaging in risky behaviors. So, while risk tolerance has been shown to have influence on our personal lives, it is not a well-studied factor in workplace settings. Such behavior is driven by both our individual personality traits and the situations with which we are presented (Mischel et al., 2004); as we do not leave these traits and situations at the workplace threshold, there is the potential that risk tolerance can play a role in the behaviors we are willing to engage in on the job.

Risk tolerance is an important issue for safety professionals because employees are often faced with workplace risks, and those willing to take more risks have been shown to be more accident prone (Maiti et al., 2004). Despite our best efforts to engineer a hazard-free workplace, residual risks must be mitigated. The Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) require, and employers rely on, worker training programs to educate workers to "do the right thing" on the shop floor, thereby managing residual risks. Many worker training programs fall under the general category of hazard recognition (i.e., risk perception); the assumption made is that if workers and their management are aware of workplace risks and are trained on how to manage the risks, there will be fewer workplace illnesses and injuries due to these risks. However, the typical workplace training process does not consciously address another facet of risk – that of risk tolerance. Of the identified objectives of safety training described by Cohen and Colligen (1998), risk tolerance is not among them. This nexus between risk tolerance and safety training is the focal point of this study.

Knowledge of hazards, provided by worker training programs, is presumed to result in fewer incidents and accidents (Montgomery, 2002). But are these assumptions valid? Does a worker's awareness of a risk ensure that he or she will avoid the hazard? What effect does training about workplace risks have on workers' motivation to avoid them? Can a worker's individual risk tolerance be affected by safety training? The premise, that awareness of a hazard, as conveyed via safety training, will result in a safer workplace, is inherent in current health and safety regulatory requirements. However, no studies were found that examined the relationship of a worker's risk tolerance to safety training.

This study attempts to enhance our understanding of risk tolerance in the workplace by investigating whether relationships exist between a worker's tolerance for risk in the workplace and the worker's level of safety training. Because workers may also voluntarily engage in activities that provide safety training, the study includes work-

related safety training as well as non-work training (e.g., volunteer firefighters, scout leaders, emergency medical technicians, etc.). We attempted to determine what effect, if any, such non-work related safety training may have on job-related risk tolerance and behavior. We also sought to investigate whether the level of safety training impacts an employee's behavior in the form of safety-related events (i.e., near misses). Finally, we evaluated specific demographic characteristics (education level, military service, marital status and dependents) and their relationship with workers' tolerance for risk.

2. Aspects of Risk

Risk is a complicated construct which affects our lives on a daily basis. Each time a person makes a choice that person's past experiences and present motivations come into play. Devlin (1995) notes that with respect to financial risk, a person's attitude is typically multidimensional and complex. In the realm of professional safety, risk is considered to have two components: severity and probability (Clemens and Simmons, 1998). When assessing risk and guarding against it, business decisions are often made based on the probability of a hazard occurring, and/or the severity of the loss, which will be inflicted by the hazard. Just as individuals make daily judgments about what risks are acceptable to them outside of work, judgments are made by workers regarding what risks are acceptable in a workplace. These judgments are often controlled by two distinct factors – risk tolerance and risk perception.

2.1 Risk Tolerance

In order to control a situation, a worker must understand the specified limits of the work process (e.g., company expectations, process constraints, compliance goals, product quality requirements, etc.); these limits are determined by the employer and define the employer's expectations. By setting specified limits, the employer has, in part, defined risk boundaries for the worker.

The willingness to take on risk is driven by many internal and external factors, and differing risk tolerances can influence one's decision-making. Based on the principle of interactionism, an individual's experiences and behaviors are understood by examining the dynamic interaction between personality and the specific situation (Mischel et al., 2004). Moreover, an individual's disposition plays a part in how he or she reacts to a given situation (Mischel, 1971), and job-related attitudes may have an even greater effect on risk-taking (Paul and Maiti, 2007).

Barsky's (Barsky et al., 1997) study of financial risk tolerance reports notable differences in risk tolerance category based on age, education level, gender, race, and religion. Their study also found a link between the willingness to engage in financial risks and the willingness to engage in other risky behavior such as smoking, drinking, and not having insurance. A study of cardiac physicians has shown that risk tolerance can differ with knowledge level. Highly-trained cardiology experts are more likely to deviate from

practice guidelines than less experienced physicians (i.e., lower knowledge level is associated with lower risk tolerance) (Reyna and Lloyd, 2006).

2.2 Risk Tolerance and Behavior

A literature review revealed few studies that specifically addressed risk tolerance and an employee's workplace behavior. One example suggested that a greater tolerance for risk may result in longer tenure working in a hazardous industry such as mining (Heemskerk, 2003), while another found that risky behavior is a common thread in cases in which someone is injured (Krause and Russel, 1994). Risk tolerance has, however, been studied in a variety of other behavioral contexts ranging from managerial (e.g., Judge et al., 1999) to individual investors (e.g., Simons, 1999). Mischel et al. (2004) assert that an individual's behavior is driven by both individual personality traits as well as the situation with which the individual is presented. Risk tolerance is an individual personality trait that can factor into Mischel et al.'s (2004) considerations of behavioral drivers. Therefore, a worker's tolerance for risk may be reflected by the worker's behavior.

2.3 Risk Perception

Not all persons perceive the same level of risk from the same situation; persons with differing risk perceptions gather different information (Hunter, 2002). An examination of risk tolerance and risk perception in self-selected pilots found that an individual's perception of risk is inversely related to the individual's tolerance for risk. In other words, the lower the hazard level a person believes is presented by a specific situation, the more willing that person is to engage in risky behavior related to that hazard (Hunter, 2002). In another study, risk perception was not found to predict risk behavior, although perceived risk affected behavior through the effect of stress (Rundmo, 1996). Clearly, like risk tolerance, an individual's risk perception is based on multiple factors and the research results on the relationship between risk perception and behavior is mixed. While the Hunter (2002) article does not note a correlation between a pilot's risk tolerance and behavior, our study sought to determine if, like the Barsky et al., (1997) study, we could find such a relationship with the miners surveyed.

3. Safety Training

The phrase "safety training" as used in this study encompasses the activities of instructing workers with regard to known hazards, how to use available methods of protection (worker training), and educating workers on how to deal with potential hazards (worker education) (Cohen and Colligen, 1998). These authors describe safety training as a core activity, affecting other elements of health and safety programs (Figure 1). Safety training, coupled with other intervention activities such as inspections and safety

meetings, is often implemented at work sites to prevent the occurrence of accidents or to reduce their likelihood or severity as part of a safety and health program (Iyer et al., 2005).

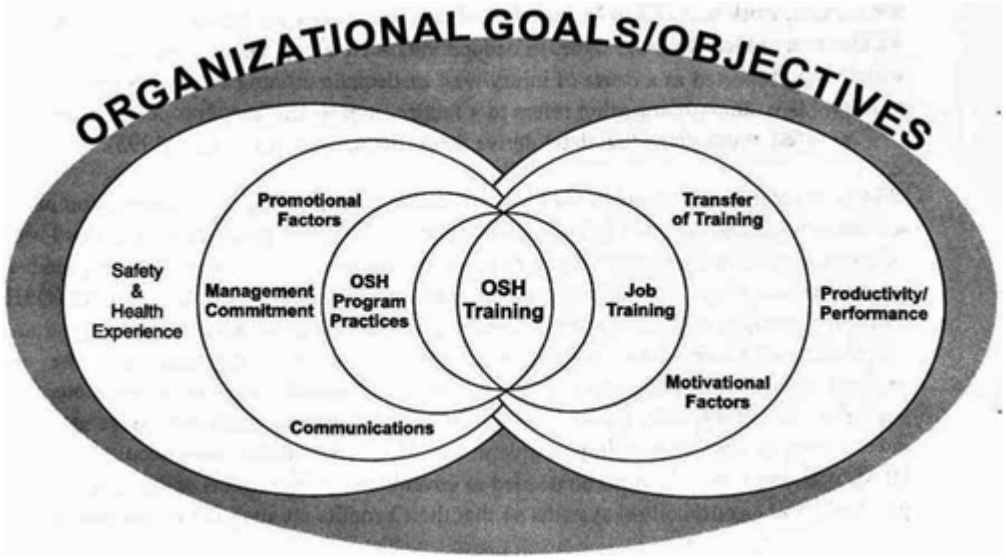

Figure 1. Safety Training at the Core of the Safety and Health Program
(Source: Cohen and Colligen, 1998)

Kirkpatrick and Kirkpatrick (2006) note that trainees should acquire new skills, knowledge, and improved attitudes, and that trainee behavior should change. The authors note, however, that this can only happen if the person desires to change and if the work climate is conducive to supporting the change in behavior. Due to trainee attendance and participation in the training program, the company's desired results (e.g., increase in productivity, improved understanding of diversity, or enhanced safety performance) should also be achieved.

3.1 Training Frequency

OSHA and MSHA require that training occurs, but their standards do not dictate the method of delivery for safety training – that is left to each employer to decide what is most effective for the specific work site. Many occupational health and safety regulations that require worker training also specify the frequency with which the complete training program should be repeated, or specify the frequency at which refresher programs (often abbreviated) must be delivered. In a study conducted by Robins et al., (1990) 60% of workers trained on the OSHA hazard communication standard reported a continued change in work practices one year after the training occurred, and 42% reported the continued change two years after the training. Based on this two-year carry over of

training effects, our analysis of safety training and risk tolerance included safety training that occurred during the previous 24-month timeframe.

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3.2 Training Outcomes

In the context of an individual's risk tolerance, safety training may play a role as an antecedent to behavior by providing the individual with knowledge of the hazards and consequences of risky behavior. Training can result in a behavior change if the person desires that change, and if the work climate is supportive of the change (Kirkpatrick and Kirkpatrick, 2006).

Conceptually, safety training should result in a safer, healthier workplace. However, an analysis of 80 studies in which safety training was used as an intervention tool to reduce the risk of work-related injury and disease found that evidence does not clearly establish how safety training (alone) results in reduced injury, lost time, and medical costs (Cohen and Colligen, 1998). Moreover, there has been a lack of confirmation for reports suggesting that a deficit of safety training contributed to worker injuries, health complaints and fatalities (Cohen and Colligen, 1998). Additionally, their study reported that because safety training is typically coupled with other aspects of a facility's hazard control program (e.g., worker feedback, organizational practices, management commitment to safety, etc.) the effectiveness of safety training is dependent on the success and effectiveness of these other factors.

Despite the findings of the Cohen and Colligen (1998) analysis, there are specific examples in the safety literature that describe safety training activities which have produced changes in worker's behaviors (Cleveland et al., 1979; Geldart et al., 2005; Harvey et al., 2001; Zohar et al., 1980), although these authors acknowledge the potential influence of other safety management techniques.

4. Methodology

4.1 Company and Worker Information

Data were collected in January 2007, from a heavy construction services and products company in Pennsylvania. The survey participants were non-union employees of the company and were engaged in the surface mining of stone aggregate at five locations in Pennsylvania. Of the 145 employees who were present for the training sessions, 123 male volunteers returned completed, useable, surveys (85%). Data from two female respondents were not used in these analyses to avoid any potential differences in risk tolerance due to gender. Typical tasks of the workers included crushing, milling, transport and shop activities associated with surface stone mining. The sites represented

are automated, and the company considers these sites to be updated, modern examples of the industry.

4.2 Data Collection

Employee data were collected at the beginning of three company-sponsored safety training sessions. The investigators requested that volunteers complete a multi-item survey; those who chose to participate completed the surveys prior to the start of the formal training program. Respondents were given the choice to not answer any question. The research team collected the completed surveys, secured them, and immediately removed them from the company's property. All volunteers were hourly workers engaged in surface mining of stone.

Data associated with variables such as safety awareness, perceived job dangerousness, safety-related events, and hours spent in off-the-job safety training within the past two calendar years were collected. Respondents were also asked to provide their employee identification number so that their company training records could be accessed to determine the number of hours of company-sponsored safety training the worker had participated in during the previous 24 months.

After the survey data had been collected, a list of the respondents' employee numbers was generated and provided to the company. Company personnel queried their training database to provide data for this variable in the analysis. Twenty-three workers chose not to provide their employee identification number, inhibiting the ability of the research team to determine accurate work-related safety training for these employees. In order to use data from the surveys without an employee identification number, an estimate of the safety training hours within the past two years was made by company personnel, based on the respondents' job title and time with the company. Results from analyses performed using data from all workers did not differ statistically significantly from analyses performed using data only from workers who provided their employee identification number.

Of the five mining locations represented by survey respondents, one facility, Plant Site #1, was particularly well represented. Of 55 total employees, 53 completed surveys and the employer provided employee identification numbers. This high response rate and the ability to accurately retrieve work-related safety training data provided a natural unit team with high quality data for formal analysis, in addition to the analyses performed on the aggregation of respondents.

4.3 Measures

4.3.1 Risk Tolerance

A review of the safety literature revealed no construct by which to measure risk tolerance in the general workforce. We therefore adopted the approach used by Reyna and Lloyd (2006), Hunter (2002), and Barsky et al. (1997) in which relevant, hypothetical scenarios were presented to respondents. Respondents then indicated their comfort level with the hypothetical situations. Comfort level was used as an indicator of potential behavior. We did not want to inquire about actual behavior, which could have potentially placed a respondent in a situation in which responding truthfully could be an admission of a safety violation. By directing the respondents to provide an indication only of their comfort level we may have not fully captured an indication of actual behavior, however, this methodology closely aligns with Hunter's (2002) process in which he presented pilots with hypothetical aviation scenarios and then scored the pilots' responses. We created three hypothetical workplace scenarios, with assistance from supervisory personnel at the participating company, designed to reflect varying levels of personal risk to the individual respondent:

> **Risk Scenario 1: Low Personal Risk**
> It is the end of the work shift. On the way out a worker notices a broken electrical conduit. It is not in his area of the work site. Reporting the problem will make him late getting home. He leaves without reporting what he saw.
>
> If you did this, how comfortable would you be?
>
> **Risk Scenario 2: Medium Personal Risk**
> It is Friday, the end of the work week. The person responsible for doing the pre-shift inspections is rushed for time. Today, he hurries through the pre-shift inspection in just a few minutes. Usually, the inspection takes much longer to complete thoroughly.
>
> If you did this, how comfortable would you be?
>
> **Risk Scenario 3: High Personal Risk**
> A worker is in the process of changing a screen and he drops a wrench onto the conveyor belt. Instead of locking out the conveyor belt first, he climbs onto the belt, picks up the wrench and continues working.
>
> If you did this, how comfortable would you be?

Risk Scenario 1 (Risk1) presents a situation in which the respondent is likely not to be at risk, but the next crew coming into that work area could be. Risk Scenario 2 (Risk2) presents a situation with more personal risk than the first, primarily because the safety inspection occurs in the area where the respondent works. Risk Scenario 3 (Risk3) describes a situation in which the respondent is at significant personal risk. In each case, the survey respondent is asked to indicate his level of comfort with the behavior

presented with four options presented: very comfortable, comfortable, uncomfortable, and very uncomfortable. These responses were coded as 1, 2, 3, and 4, respectively, and then averaged together to gain an overall score of risk tolerance (Risk Sum). The research team analyzed whether or not relationships existed between safety training and a worker's overall score of risk tolerance (Risk Sum), as well as whether or not relationships existed between the worker's risk tolerance for each scenario (Risk1, Risk2, Risk3) and their safety training hours. The Cronbach's alpha for the Risk Sum variable was .76. A Cronbach's alpha value of at least 0.7 indicates acceptable internal consistency within the construct, suggesting that the separate items can be treated as a single variable (Nunnally, 1994). Based on this analysis, we felt it reasonable to develop the variable labeled RiskSum, as an overall indication of the respondent's tolerance to different forms of workplace risk.

4.3.2 Hours of Work-Related Safety Training

Based on the employee identification numbers, the company Safety Director provided information on the formal, company-sponsored safety training programs provided for the survey respondents within the previous 24 months (calendar years 2005 and 2006). Such programs included annual MSHA training (8 hours/year) for all persons, as well as respirator training, tow motor training, first aid/CPR, incident investigation, fall protection, confined space, and/or excavation training depending on job description. Routine safety tailgate talks may have provided safety instructions and alerts but were not captured in the company's training database. Therefore, these training sessions were not included in our analyses.

The employer involved in this study contracts with a professional training firm to conduct its annual 8-hour MSHA training. The training occurs in classrooms at the company's training facility, which is located near its largest stone mining operations. The trainers use a combination of general slides, company-specific slides, a handout (20 – 30 pages), and interactive activities to facilitate the training session. Handouts for the programs conducted in 2005 and 2006 were reviewed. Although the number of topics covered may differ from year to year, each annual training session occurs over an 8-hour period. The programs presented could be categorized as a combination of a Fundamentals Program and a Recognition Program, using the Cohen and Colligen (1998) classification system. The programs' goals were to refresh the workers' previous training, to remind them of the various hazards present at their workplace, and re-enforce safe work practices, in order to prevent future injuries and incidents. Reducing tolerance for risky behavior was not specifically addressed by the training materials, however the emphasis on hazard recognition (i.e., risk perception) and hazard control suggests an underlying theme of the programs was to ensure that the workers would be able to discern workplace risks and respond accordingly.

4.3.3 Hours of Non-Work-Related Safety Training

Based on our understanding of the local workforce, coupled with discussions with the company's management, we had determined a priori that many workers participated in non-work-related activities that could expose them to additional safety training (e.g., volunteer fire department and emergency medical technician programs, military reserve training, etc.). Our survey asked workers to provide an estimate of the number of safety training hours received from such activities during the previous 24 months.

4.3.4 Military Service

In the region of Pennsylvania where the company is located, it is not unusual for young men to enter the military after high school. Because the research team theorized that discipline imparted by such military training could positively affect a worker's adherence to rules and standards (i.e., make the worker more reluctant to engage in behavior not allowed by company procedures), respondents were asked to provide their years of military service.

4.3.5 Safety-Related Events

Safety-related events were measured by using 10 revised items from the Barling et al., (2002) safety-related events scale, made relevant to the stone mining industry. Respondents indicated the frequency with which each event had occurred during the last 12 months on a five-point scale (1 = never and 6 = more than 8 times). Examples of safety-related events discussed in this construct include: tripped over something on the ground and had an object stuck in my hand (e.g., metal, splinter, staple, etc.) while working. The Cronbach's alpha for this construct was .75.

4.3.6 Perceived Job Dangerousness

Perceived dangerousness was measured using one item from Morrow and Crum's (1998) scale. Employees were asked to rate how dangerous they feel their particular job is. A 5-point Likert scale was used to measure their responses with anchors ranging from not at all dangerous to extremely dangerous. Past research suggests that employees are generally accurate when subjectively rating the actual risk/danger levels in their workplaces (Rundmo, 1995).

4.3.7 Personal Safety Awareness

Safety awareness was measured by modifying Evans et al.'s (2005) scale, as adapted from Barling et al. (2002). Seven items were assessed on a 5-point Likert scale with anchors ranging from strongly disagree to strongly agree. The Cronbach's alpha for this construct was .83.

4.3.8 Demographics

Respondents were also asked to provide demographic information about themselves, in part because Barsky et al.'s (1997) study of financial risk found a relationship with demographics and risk tolerance. This information included current marital status (single or married), highest level of formal education, and number of dependents (both living with them and living elsewhere). From this response, two variables were derived and used in the analyses. Number of Dependents at Home was used as a control variable; Dependents (yes vs. no) was used as a categorical variable.

4.3.9 Industry Tenure

Finally, we included industry tenure of employees since similar variables (e.g., company tenure, job tenure) were significant in various safety-related outcomes and are regularly used as controls in other safety-related workplace surveys (e.g., Evans et al., 2005; Hansen, 1989; Paul and Maiti, 2007). The mixed results found with mining industry experience in particular illustrate the value in controlling for tenure (e.g., Bennett and Passmore, 1986; Maiti and Bhattacharjee, 1999).

4.4 Data Analysis

Regression was used to determine if the independent variables of Work Safety Training, Non-Work Safety Training, and Safety Training Sum were related to the dependent variables of Risk Sum, Risk1, Risk2, and Risk 3. Regression testing included controls for industry tenure and, separately, industry tenure, job dangerousness, personal safety awareness, and number of dependents at home. Analyses of variance were used to evaluate whether the means of the risk tolerance variables (Risk Sum, Risk1, Risk2, Risk3) varied based on demographic categorical variables (Military Service Status, Marital Status, Education Level, and Dependents). This testing also included controls for industry tenure and, separately, industry tenure along with job dangerousness, personal safety awareness, and number of dependents at home.

5. Results

The Pearson correlation coefficients shown in the correlation matrix in Table 1 indicate that the risk measures of Risk1, Risk2, Risk3, and Risk Sum are highly correlated, as would be expected. The correlation of Risk1, Risk 2, and Risk3 suggests that creating the new variable of RiskSum is a valid method for representing a worker's overall risk tolerance. Similarly, work safety training and non-work safety training are highly correlated to the Safety Training Sum variable. Non-work safety training is significantly negatively correlated with work safety training, suggesting that those workers who have jobs which require the least amount of on-the-job safety training engage in non-work-related activities which require the most safety training.

Table 1. Variable Correlation Data

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Risk1	--														
2. Risk 2	.570*	--													
3. Risk 3	.494*	.480*	--												
4. Risk Sum	.814*	.800*	.822*	--											
5. Personal Safety Awareness Average	.121	.234*	.167	.190**	--										
6. Safety-Related Events Average	.098	.040	-.024	.063	-.008	--									
7. Work Safety Training	-.011	-.060	.099	.013	.106	-.048	--								
8. Non-Work Safety Training	-.156	-.011	-.150	-.134	-.028	-.042	-.239**	--							
9. Safety Training Sum	-.153	-.022	-.145	-.125	-.019	-.027	-.047	.978*	--						
10. Job Dangerousness	-.147	-.027	-.051	-.096	.246**	.216*	.108	-.041	-.008	--					
11. Marital Status (0,1)	-.089	.098	.010	.007	.117	-.092	.127	-.166	-.130	.236*	--				
12. Ed. Level (0,1,2,3)	.047	.023	.018	.035	-.007	-.053	.011	.053	.047	.037	-.129	--			
13. Military Service (0,1)	-.074	-.064	-.089	-.085	-.037	.042	-.013	.035	.035	-.027	.088	-.141	--		
14. Dependents (0,1)	-.006	-.007	.141	.082	.099	.099	.111	-.224**	-.172	.136	.582*	-.098	.091	--	
15. Industry Tenure	-.159	-.066	-.175	-.164	-.113	.038	.259	-.114	-.045	.287*	.306*	.165	.139	.180	--

alpha = 0.01; * = p value < 0.01; ** = p value < 0.

The work-related hours of training ranged from zero to 24, with a mean of 14.3 hours. Fifty-five employees reported non-work related training, with a maximum of 200 hours of training (mean of 34.3 hours). Several workers were new / recent hires to the company; other workers who service the company's mining operations were participating in the company's MSHA training for the first time.

Regression analysis was used to detect potential relationships between the dependent variables of Risk Sum, Risk1, Risk2, and Risk3 and the independent variables of Work Safety Training, Non-work Safety Training, and Safety Training Sum. When controlling for the effects of the worker's industry tenure, no linear relationship was found between a worker's risk scores and the quantity of work-related safety training a worker has had in the previous 24 months (Table 2). An examination of the relationship between a worker's risk scores and the square of the work safety training quantity detected no non-linear relationship. These analyses were run using data from all survey respondents, as well as using data from just those respondents from Plant Site #1; the results were the same for each set of respondents. Separate analyses were conducted controlling for industry tenure, personal safety awareness average, job dangerousness, and number of dependents at home, with no difference in outcome.

Conducting these analyses using the independent variable of Non-Work Safety Training, and controlling for industry tenure yielded a statistically significant relationship between a worker's tolerance for high personal risk (Risk Scenario #3) and the quantity of non-work safety training hours within the previous 24 months (p value = 0.048). The regression equation indicates that as non-work safety training increases, there is a small decrease in a worker's risk tolerance score for high personal risk. Note that this relationship was found only with the high personal risk scenario (Risk3) and not with the other scenarios; it suggests that the more non-work safety training a worker has had, the more tolerant he is of high personal risk.

Repeating the analyses described above using the independent variable of Safety Training Sum (work + non-work safety training), and controlling for industry tenure yielded no statistically significant relationships, nor did the analyses when industry tenure, job dangerousness, personal safety awareness average, and number of dependents at home were factored in as controls.

Regression analysis was used to detect potential relationships between the dependent variable Safety-Related Events Average and the independent variables Risk Sum, Risk1, Risk2, or Risk3. When controlling for the effects of the worker's industry tenure, no linear relationship was found between a worker's self-reported safety-related events record and the worker's risk scores. Repeating this analysis and controlling for industry tenure, job dangerousness, personal safety awareness average, and number of dependents at home also yielded no statistically significant relationships.

Analysis of variance of the pool of all workers, when controlling for industry tenure, detected a difference in the risk tolerance levels between those workers who have had non-work safety training and those workers who have not. Those with non-work related safety training in the past two years were found to be more risk tolerant overall (Risk Sum, p value 0.041) (Figure 2), more tolerant of low personal risk (R1, p value 0.039) and more tolerant of high personal risk (R3, p value 0.027) (Figure 3). Performing the same ANOVA on just the workers from Plant Site #1 resulted in a statistically significant difference in risk tolerance for overall risk (Risk Sum, p value 0.04) and high personal risk (R3, p value 0.025). For Plant Site #1 statistically significant differences were also detected for overall risk tolerance (Risk Sum, p value 0.027), low personal risk (R1, p value 0.04) and high personal risk (R3, p value 0.035), when controlling for industry tenure, job dangerousness, number of dependents at home, and personal safety awareness average.

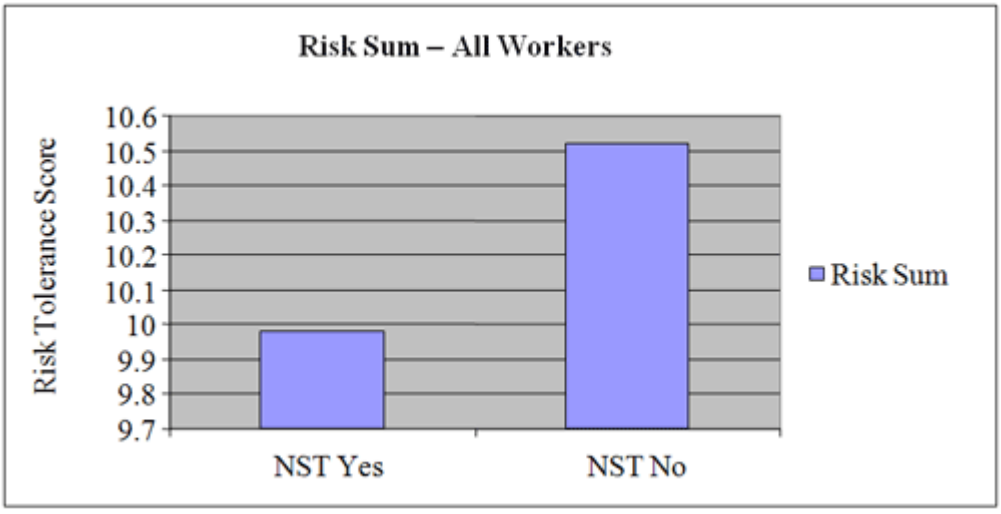

Figure 2. Comparison of Risk Sum between workers having non-work safety training and those who have no, when controlling for Industry Tenure. A lower risk score indicates a highter toleratnce for risk. "NST" = Non-Work Safety Training.

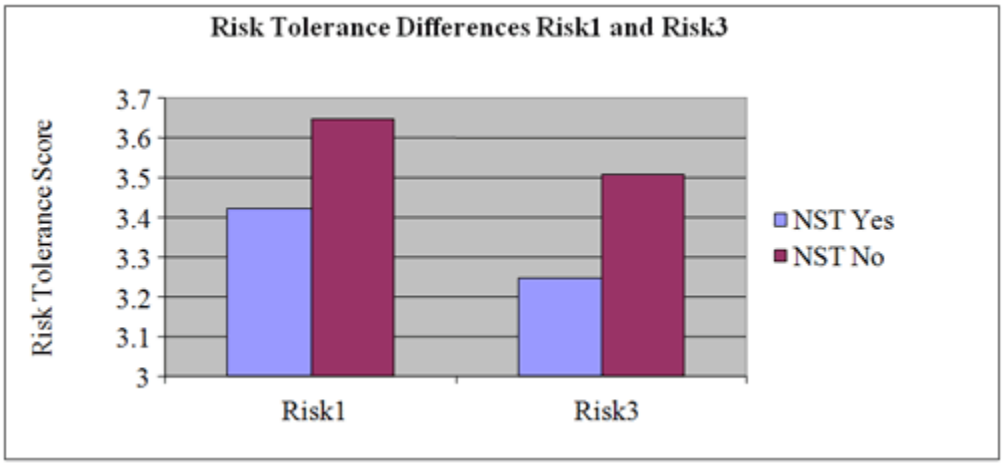

Figure 3. Comparison of Risk1 and Risk3 for all workers. A lower risk score indicates a higher tolerance for risk.

Workers who have dependents are less risk tolerant for high personal risk situations (Risk3) than their co-workers without dependents, when controlling for industry tenure (p value 0.045) (Figure 4). Even when controlling for the variables industry tenure, job dangerousness, and personal safety awareness average, workers with dependents are still less risk tolerant for high personal risk situations (Risk3) (p value 0.038). There is no statistically significant difference of risk tolerance for low or medium personal risk situations (Risk1 and Risk2) between workers with dependents and those without dependents.

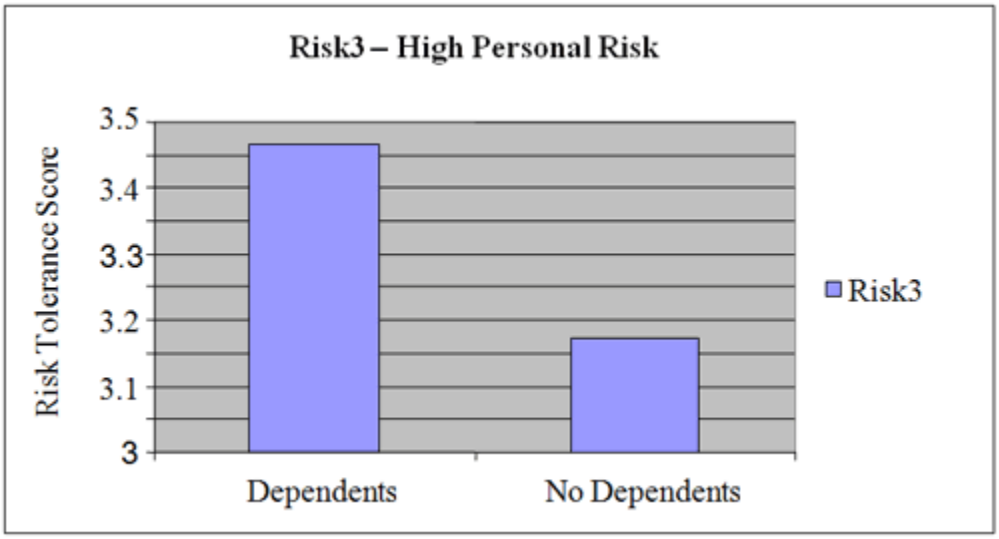

Figure 4. Comparison of Risk3 for all workers with and without dependents. A lower risk score indicates a higher tolerance for risk.

Workers who have served in the military are not statistically significantly more risk tolerant than those without military service at alpha values of 0.05 and 0.01 (p values > 0.05). Single workers did not appear to be more risk tolerant than their married counterparts at alpha values of 0.05 and 0.01 (p values > 0.05).

6. Discussion

Our results suggest that safety training by itself does not lessen a worker's tolerance for workplace risk. This finding supports the Cohen and Colligen (1998) premise that safety training alone should not be relied upon to increase workplace safety. Our results, however, may also reflect the findings of Maiti et al. (2004) and Paul and Maiti (2007) that more specialized (i.e., psychological or behavior-based) training is necessary for changing safety-related attitudes and behaviors. With one exception, our study did not detect a relationship between the quantity of safety training a worker has had within the previous two years and that worker's tolerance for risk in workplace settings. These results may reflect a "decay" of training effects similar to that found by Williams et al. (2007). An extensive review of safety training studies conducted by Cohen and Colligen (1998) found that the effectiveness of safety training is dependent upon the success of other aspects of a workplace safety program (worker feedback, organizational practices, management commitment to safety, etc.). Similarly, other studies stress that safety training should not be viewed as the sole element of a health and safety management program. Grindle et al., (2000) and Iyer et al., (2005) emphasize that effectiveness of safety training can be enhanced with complementary interventions such as performance feedback, and goal-setting, and that training must be coordinated with other aspects of a health and safety program.

Although no relationship was detected between a worker's safety-related events (near misses) and his risk tolerance score, further investigation may be useful. The workers involved in this research do not routinely track near misses; the company safety program has not focused on these events as part of an incident prevention program. Examination of risk tolerance, in conjunction with other safety program aspects (safety communication, management commitment to safety, etc.) at a worksite that actively tracks and manages near miss events may produce different results.

Workers with dependents are significantly less risk tolerant than their co-workers without dependents, indicating that some components of an employee's non-work life can affect his tolerance for work-related risk. This conclusion is consistent with Barsky et al.'s (1997) study, which found that demographic characteristics affect financial risk tolerance.

6.1 Implications

Our results have several implications for industry. Employers should recognize that work-related safety training activities may not affect a worker's tolerance for risk on the job, and that workers with recent non-work-related safety training can have a higher tolerance for risk than other workers. This study does not address if the non-work safety training causes the higher risk tolerance, nor does it examine if persons who engage in such activities have a natural tendency for higher risk tolerance. However, a worker's risk tolerance has not been shown to be correlated with his propensity for near-misses on-the-job. Our research did not address questions regarding the costs and benefits of safety training programs, nor did we evaluate delivery methods. For these reasons, our findings are limited to the results discussed above and should not be viewed as commentating on the overall efficacy of safety training.

While direct use of these results in the classroom may be limited, it is expected that through reading this paper, students will see that much effort is needed and can be applied to the process of learning the existence and magnitude of mathematical relationships that exist between variables that are traditionally applied to safety related activities. This paper can become a foundation for students interested in understanding the concept of risk tolerance and its interrelationships with traditional safety program outcomes.

6.2 Limitations & Future Research

Our findings are somewhat limited because data came from one company in one industry. Further, the survey constructs used to measure risk tolerance were tailored to the specific workplace. Requesting that respondents provide their comfort level with hypothetical risk scenarios may not fully capture workplace risk tolerance; surveys coupled with workplace observation may more accurately reveal workplace risk tolerance. Because 23 male respondents did not provide their employee identification number on the survey, the quantity of workplace safety training hours for these workers had to be estimated,

introducing some uncertainty into the analyses Workers estimated their non-work safety training hours for the previous two years, introducing another source of uncertainty into this study. The study team did not request information regarding the non-work related activities which provided the safety training; hence the quality and applicability to the workplace could not be discerned.

To delineate the effects of risk tolerance on workplace behavior, future researchers may wish to include measures of risk perception to determine any influence it may have on risk tolerance, or vice-versa. The findings that non-workplace safety training may result in workers having an increased tolerance for high personal risk warrant further examination. As noted (Mischel et al., 2004), an individual's actions must be understood by examining the person's personality as well as the specific situation. Gaining a better understanding of the personality traits of persons who engage in non-work activities which afford safety training opportunities may enable employers to better understand any pre-dispositions toward risk that workers may have.

Further exploration of the relationship between non-work safety training and risk tolerance should be explored in order to determine the pervasiveness of this finding across other industries, and to determine which specific non-work activities produce this result. Additional examination of the link between risk tolerance and workplace safety behavior with a larger sample size, across multiple industries, and/or including other safety variables such as age and work experience may produce different results.

7. Conclusions

Our study demonstrates that it is possible to develop measures of workers' risk tolerance and then use those measures to determine if worker risk tolerance is related to the quantity of safety training a worker has had, as well as a worker's self-reported safety-related events. In both of these analyses, we found that a worker's risk tolerance is not related to participation in workplace safety training, nor is there a relationship between a worker's risk tolerance and the number of safety-related events a worker self-reports (i.e., near misses). The study did find, however, that worker risk tolerance is related to non-employment variables, such as having dependents and participation in non-workplace safety training.

While workplace training alone may not be able to temper a worker's willingness to place himself at risk, a worker's risk tolerance level has not been found to correlate to his near-miss incident rate. Training coupled with the presence of a strong safety culture, motivating consequences, open safety communication, and supervisors with strong leadership skills may produce the desired safe work behavior, but training alone should not be relied upon to lessen a worker's tolerance for workplace risk.

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References

Barling, J., Loughlin, C., Kelloway, E.K., 2002. Development and test of a model linking safety-specific transformational leadership and occupational safety. Journal of Applied Psychology 87(3), 488-496

Barsky, R.B., Juster, F.T., Kimball, M.S., Shapiro, M.D., 1997. Preference Parameters and Behavioral Heterogeneity: An Experimental Approach in the Health and Retirement Study. The Quarterly Journal of Economics 112(2), 537-579.

Bennett, J.D., Passmore, D.L., 1986. Multinomial logit analysis of injury severity in U.S. underground bituminous coal mines. Accident Analysis and Prevention 17(5), 399-408.

Clemens, P.L., Simmons, R.J., 1998. Safety System and Risk Management, A guide for Engineering Educators. U. S. Department of Health and Human Services (NIOSH) Publication No. 96-37768.

Cleveland, R., Cohen, H., Smith, M., Cohen, A., 1979. Safety Program Practices in Record-Holding Plants. U.S. Department of Health, Education, and Welfare. (NIOSH) Publication No. 79-136.

Cohen, A., Colligan, M.J., 1998. Assessing Occupational Safety and Health Training– A Literature Review. DHHS (NIOSH) Publication No. 98-145.

Devlin, S.J., 1995. Three Myths of Risk Tolerance: What Clients are Not Telling You. Journal of the American Society of CLU&ChFC 49(1), 33-37.

Evans, D.D., Michael, J. H., Weidenbeck, J. K., Ray, C. D., 2005. Relationships between organizational climates and safety-related events at four wood products manufacturers. Forest Products Journal 55 (6), 23-28.

Geldart, S., Shannon, H.S., Lohfeld, L., 2005. Have Companies Improved Their Health and Safety Approaches Over the Last Decade? A Longitudinal Study. American Journal of Industrial Medicine 47(3), 227-236.

Grindle, A.C., Dickinson, A. M., Boettcher, W., 2000. Behavioral Safety Research in Manufacturing Settings: A Review of the Literature. Journal of Organizational Behavior Management 20(1), 29 – 68.

Hansen, C.P., 1989. A causal model of the relationship among accidents, biodata, personality and cognitive factors. Journal of Applied Psychology 74, 81-90.

Harvey, J., H. Bolam, D. Gregory, G. Erdos, 2001. The effectiveness of training to change safety culture and attitudes within a highly regulated environment. Personnel Review 30, 615-636.

Heemskerk, M. 2003. Risk attitudes and mitigation among gold miners and others in the Suriname rainforest. Natural Resources Forum 27(4), 267-273.

Hoffman, D.A., Stetzer, A., 1996. A cross-level investigation of factors influencing unsafe behaviors and accidents. Personnel Psychology 49(7), 307-340.

Hunter, D.R., 2002. Risk Perception and Risk Tolerance in Aircraft Pilots. Federal Aviation Administration Report No. PB2003100818.

Iyer, P.S., Haight, J.M., Del Castillo, E., Tink, B.W., Hawkins, P.W., 2005. A research model – forecasting incident rates from optimized safety program intervention strategies. Journal of Safety Research 36, 341 – 351.

Judge, T.A., Thoreson, C.J., Pucik, V., T. Welbourne, 1999. Managerial coping with organizational change: a dispositional perspective. Journal of Applied Psychology 84, 107 122.

Kirkpatrick, D.L., Kirkpatrick, J.D., 2006. Evaluating Training Programs: The Four Levels, Berrett-Koehler Publishers, Inc., San Francisco.

Krause, T.R., Russel, L.R., 1994. The behavior-based approach to proactive accident investigation. Professional Safety 39 (3).

Maiti, J., Bhattacharjee, A., 1999. Evaluation of risk of occupational injuries among underground coal mine workers through multinomial logit analysis. Journal of Safety Research 30(2), 93-101.

Maiti, J., Chatterjee, S., Bangdiwala, S.I., 2004. Determinants of work injuries in mines: an application of structural equation modeling. Injury Control and Prevention 11(1), 29-37.

Mischel, W., 1971. Introduction to Personality, Holt, Rinehart and Winston, Inc., New York, pp. 14-15.

Mischel, W., Shoda, Y., Smith, R., 2004. Introduction to Personality: Toward an Integration. John Wiley & Sons, Hoboken, New Jersey, pp. 80-81.

Montgomery, J.F., 2002. Safety and Health Training. In Plog, B. A., Quinlan, P.J. (Eds.), Fundamentals of Industrial Hygiene, National Safety Council, Itasca, Illinois, pp. 680 – 681

Morrow, P., Crum, M. R., 1998. The Effects of Perceived and Objective Safety Risk on Employee Outcomes. Journal of Vocational Behavior, 53, 300-313.

Nunnally, J.C., 1994. Psychometric Theory 3rd ed. McGraw-Hill, New York. Paul, P.S., Maiti, J., 2007. The role of behavioral factors on safety management in underground mines. Safety Science 45, 449-471.

Robins, T.G., Hugentobler, M.K., Kaminski, M., Klitzman, S., 1990. Implementation of the Federal Hazard Communication Standard: Does Training Work? Journal of Occupational Medicine 32(11), 1133-1141.

Reyna, V.F., Lloyd, F.J., 2006. Physician Decision Making and Cardiac Risk: Effects of Knowledge, Risk Perception, Risk Tolerance, and Fuzzy Processing. Journal of Experimental Psychology: Applied 12(3), 179-195.

Rundmo, T., 1995. Perceived risk, safety status, and job stress among injured and noninjured employees on offshore petroleum installations. Journal of Safety Research 26(2), 87-97.

Rundmo, T., 1997. Associations Between Risk Perception and Safety. Safety Science 24(3), 197-209.

Simons, K., 1999. Should U.S. investors invest overseas? New England Economic Review Nov/Dec, 29-39.

Williams, W., S.C. Purdy, L. Storey, M. Nakhla, G. Boon, 2007. Towards more effective methods for changing perceptions of noise in the workplace. Safety Science 45, 431-447.

Zohar, D., Cohen, A., Azar, N., 1980. Promoting Increased Use of Ear Protectors in Noise Through Information Feedback. Human Factors 22(1), 69-79.