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# Construction Workers' Sensation-Seeking and Inattentiveness to Warning Alarms from Construction Vehicles

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**Abstract:** In road work zones, pedestrian workers' habituated inattention to warning alarms from construction vehicles can lead to fatal accidents. Previous studies have theorized that human factors such as personality traits may affect workers' inattentiveness to workplace hazards. However, there has been no study that directly examined how road construction workers' personality traits affect their attention to warning alarms within a work zone and the likelihood of engagement in a struck-by accident. This study examines how workers' sensation-seeking (especially boredom susceptibility) is related to inattention to warning alarms while performing a task in road work zones. An experiment with actual road construction workers was conducted using a virtual road construction environment. Workers' attention to repeatedly presented warning alarms was measured using eye-tracking sensors. In response to workers' frequent inattentive behaviors, a virtual accident was simulated. Results revealed a significant association between boredom susceptibility and workers' engagement in the virtual accident, a consequence of inattentiveness to warning alarms. The findings suggest that workers' personality traits predispose them to tune out warning alarms and become vulnerable to accidents in road work zones. The findings of this study can be used to develop targeted interventions aimed at preventing workers' inattention to repeatedly exposed workplace hazards, thereby contributing to reducing fatal accidents in road work zones.

**Keywords:** Sensation-seeking, Unsafe behavior, Personality traits, Construction safety, Virtual reality

## 1. INTRODUCTION

Fatalities at road work zones account for about 9% of all fatalities in the construction industry [1]. Specifically, runovers or backovers by construction vehicles are the leading causes of worker fatalities in road work zones [1,2]. In many instances of these fatal accidents, vehicles were moving at a slow speed, and backup alarms were functioning. Workers, however, failed to avoid the accidents because they were focusing only on work tasks and did not pay attention to approaching vehicles [3]. Previous studies found that, in road work zones, pedestrian workers tend to become

inattentive to warning alarms from construction vehicles that constantly beep and ring around them [4,5]. Workers' attention to repeated warning alarms gradually decreases with the increase of exposure to those alarms [6,7]. Consequently, such attention failures to warning alarms from construction vehicles is one of the main causes of runover or backover accidents between construction vehicles and pedestrian workers in road work zones [5]. To prevent such accidents, construction workers are asked to complete periodic safety training, and they are informed of the risks of being run or backed over by construction vehicles in road work zones. However, working around construction vehicles for a protracted time period can numb workers to warning alarms from construction vehicles [8]. Thus, understanding factors that affect road construction workers' inattentiveness to repeatedly presented warning alarms plays a critical role in work zone safety management.

An existing body of literature in psychology has established a relationship between individual differences in personal traits and the ability to maintain attention to prolonged/repeated external stimuli [9,10]. Specifically, sensation-seeking is highly associated with individuals' engagement in risky behaviors [11–13]. Recent studies in construction safety have also supported that workers who have high levels of sensation-seeking are more likely to become less attentive to frequently exposed workplace hazards and engage in risky behaviors during a construction task [14,15]. However, there have been no controlled studies that investigated the relationship between construction workers' sensation-seeking and inattention to repeatedly encountered workplace hazards in the context of work zone safety management. Furthermore, most previous studies were performed with naïve participants (i.e., student subjects). To this end, this study aims to (1) investigate whether actual construction workers' sensation-seeking is associated with inattentiveness towards repeated auditory warning alarms from approaching construction vehicles and (2) examine the relationship between sensation-seeking and engagement in a struck-by accident using a virtual reality (VR) experimental environment. The findings of this study provide an important opportunity to advance the understanding of workers' inattention to warning alarms from construction vehicles in road work zones, thereby contributing to the design of effective struck-by accident prevention strategies in road work zones.

## 2. BACKGROUND

### 2.1. Workers' inattention to warning alarms from construction vehicles

Workers at road work zones are constantly exposed to a risk of being struck by construction vehicles (e.g., dump trucks, milling machines, rollers, and sweepers) because road construction and maintenance tasks include frequent worker-vehicle interactions [16]. Every year, about 100 fatal accidents occur in road work zones in the United States [1]. In particular, struck-by accidents between a pedestrian worker and a construction vehicle account for more than 50% of those fatalities in road work zones [1,16]. Previous studies have highlighted pedestrian workers' inattention to approaching vehicles as one of the main causal factors of runover/backover accidents. In many instances of those fatalities in road work zones, dump trucks were backing and sounding warning alarms. However, workers tuned out the approaching dump trucks [3,7].

Individuals' evoked responses to repeated external stimuli decrease when those stimuli are perceived as not harmful [17,18]. This bias in risk perception may lead pedestrian workers to selectively pay less attention to repetitive warning alarms from construction vehicles in road work zones and thereby become involved in a runover/backover accident [8]. Therefore, preventing workers' inattention to warning alarms from construction vehicles is essential to improve safety in road work zones.

### 2.2. Personality and safety behaviors

A robust literature exists on the relationship between individual personality traits and risky human behaviors [11,19,20]. Previous studies in construction safety explained the cause of workers' unsafe behaviors from the perspective of personality. Toscano and Windau found that about 90% of all accidents in the construction industry were accounted for by nearly 50% of workers in 1992 [21]. Hasanzadeh et al. [22] determined that introverted workers are more attentive to workplace hazards. Similarly, Gao et al. [23] statistically confirmed that construction workers' conscientiousness is positively correlated with safety behaviors at work. Overall, these studies highlight the need for safety training that considers individual differences in personality as an essential human factor.

### 2.3 Sensation seeking and inattentiveness to workplace hazards

Sensation seeking is "a trait defined by the seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risks for the sake of such experience" [24]. Sensation seekers tend to underestimate or take a risk to achieve their goals [25]. Individuals' sensation-seeking can be measured by Zuckerman's self-report standardized scale that consists of four subscales: Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Disinhibition (Dis), and Boredom Susceptibility (BS) [25]. Among those four subscales of sensation seeking, boredom susceptibility is highly correlated with workers' inattention to workplace hazards. Boredom susceptibility represents a low level of tolerance for routine work tasks or repetitive experience [25]. Data from several studies demonstrated that individuals with high boredom susceptibility tend to show a low vigilance—ability to sustain attention to changes in working environments [26–28]. Therefore, they may be more vulnerable to safety-related injuries and accidents at work.

## 3. POINT OF DEPARTURE AND RESEARCH HYPOTHESES

Pedestrian workers in road work zones become less attentive to warning alarms that constantly beep across the work zones. Such inattention to warning alarms from approaching construction vehicles increases the risk of being struck by the vehicles. Previous studies have demonstrated a relationship between construction workers' personality traits and unsafe behaviors at work and have theorized that such individual differences in sensation-seeking can increase workers' engagement in injuries or accidents [15,22,29]. However, no study has empirically examined this relationship through a controlled experiment. To this end, the present study examines the association between sensation-seeking—specifically boredom susceptibility—and pedestrian workers' inattentiveness toward repeated warning alarms and engagement in struck-by accidents with construction vehicles in road work zones. We performed an experiment with actual road construction workers and tested the below hypotheses:

- *Hypothesis 1*: Pedestrian workers' boredom susceptibility has a negative correlation with their attention to repeated warning alarms from construction vehicles.

- *Hypothesis 2*: Pedestrian workers' boredom susceptibility has a positive correlation with an occurrence of a struck-by accident with construction vehicles.

## 4. METHOD

### 4.1. Participants

Thirty-five road construction workers (32 males and 3 females; $M_{age} = 27.26$ and $SD_{age} = 6.09$) participated in the experiment. All participants were pedestrian workers and employed by a heavy civil construction company in the US. During the experiment, two participants dropped out the experiment because of motion sickness. Thus, data from thirty-three participants were included in the data analysis. The experiment was conducted at a safety training room of the company.

### 4.2. Sensation seeking measurement

Participants completed Zuckerman's *Sensation Seeking Scale Form V* (SSS-V), the most widely adopted standardized self-report measure of sensation-seeking [25]. The scale consists of forty items that are formulated as statements and measures four sub-dimensions of sensation-seeking. The following examples are possible answers for one of the survey items: (Question 23: Statement-A) "I would like to try parachute jumping," and (Question 23: Statement-B) "I would never want to try jumping out of a plane, with or without a parachute." The total score ranges from 0 to 40, and the maximum of each sub-dimension is 10. A high score corresponds to a high level of risk-taking tendency.

### 4.3. Experimental environment

To measure workers' attentiveness to repeatedly presented warning alarms without the actual risk of injury, the experiment was performed using a VR environment that simulates a virtual highway maintenance project. During the experiment, participants were asked to perform a virtual road cleaning task as a part of the asphalt milling crew. Participants' real sweeping actions were synchronized in the VR environment. While a participant was doing the task, one of the construction vehicles behind the participant continuously moved closer and further away from them, thereby exposing the participant to the risk of being run over. The vehicle sounded warning alarms only when it moved toward a participant.

### 4.4. Attentive behavior measurement and virtual accident

In the VR environment, participants' attention to the approaching vehicle was measured through eye-tracking sensors embedded in a VR head-mounted display. One reciprocal movement of the vehicle was defined as one exposure to the struck-by hazard. During one exposure to the struck-by hazard, if a participant gazed at the approaching vehicle to check its proximity, that was documented as an attentive behavior. Then, individuals' attentive behavior rate was used as a parameter for evaluating participants' inattentiveness. A virtual struck-by accident was simulated when a participant exhibited frequent inattentiveness toward warning alarms from the approaching vehicle. The inattentiveness of each participant was calculated using the following equation:

$$Attentive\ behavior\ rate = \frac{Number\ of\ exposures\ that\ a\ participant\ \text{showed the attentive behavior}}{Totan\ number\ of\ exposures} \quad (1)$$

### 4.5. Experiment procedure

To reduce the impact of differences in individual participants' VR experience on their behavioral responses in the experiment, all participants were asked to practice the VR task before the experiment. Participants were instructed to be attentive to warning alarms from construction vehicles. The experiment was terminated once the virtual accident occurred. Otherwise, the experiment was terminated 20 minutes after the beginning of the experiment.

### 4.6. Hypotheses testing

Hypothesis 1 was tested through a bivariate linear regression analysis. The bivariate regression model predicts attentive behavior rate from sensation-seeking.

$$\widehat{y_i} = B_0 + B_1 S + r \quad (1)$$

where $\widehat{y_i}$ is attentive behavior rate at sensation-seeking score $S$; $B_0$ is the intercept of the regression line at $S = 0$; and $B_1$ is the slope of the regression that indicates the change in attentive behavior rate $\widehat{y_i}$ for each 1-point increase in sensation-seeking $S$. If the test result of the coefficient $B_1$ is significantly negative, the relationship between participants' sensation-seeking and inattentiveness toward repeated warning alarms can be determined.

To test Hypothesis 2, a bivariate logistic regression analysis model was used. The predictor variable was boredom susceptibility, and the dependent variable was the occurrence of the virtual accident during the experiment. A participant's engagement in the virtual accident was added as a dichotomous variable (dummy-coded: 0 = "no accident", 1 = "accident").

## 5. RESULTS

In the experiment, twenty out of thirty-three participants engaged in the virtual accident as the consequence of their inattention to warning alarms, and thirteen participants did not because they were attentive toward warning alarms from the approaching construction vehicle.

Hypothesis 1 was confirmed by the bivariate regression model for predicting attentive behavior rate from the score of boredom susceptibility. Although the association between the total score of sensation-seeking and attentive behavior rate was not significant (Fig. 2(a); $R^2$= 0.11, $F(1, 31)$ = 3.75, $p$ = 0.062), the association between the score of boredom susceptibility and attentive behavior rate was significant (Fig. 2(b); $R^2$= 0.29, $F(1, 31)$ = 12.85, $p$ = 0.0011). The score of boredom susceptibility negatively predicted attentive behavior rate, $B_1 = -0.11$, $p$ = 0.0011. The results indicate that participants with a high level of boredom susceptibility are more likely to be inattentive toward repeatedly presented warning alarms from construction vehicles in road work zones.

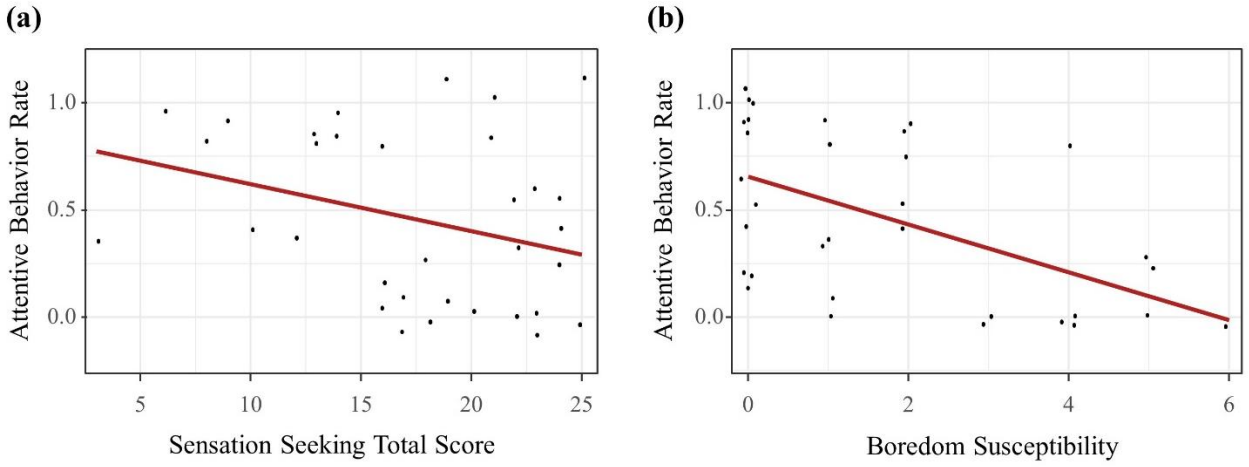


**Figure 2**. Attentive behavior rate plotted as a function of sensation-seeking (dots are jittered to prevent overlapping)

Hypothesis 2 was confirmed by the logistic regression analysis. The model was statistically significant, $\chi^2$ = 5.2, $p$ = 0.023. The model explained 27.6% (Nagelkerke $R^2$) of the variance in the virtual accident occurrence and correctly classified 72.7% of accident occurrence. As boredom susceptibility increases by one point, the odds of accident occurrence were multiplied by 1.92

(*Odds ratio* = 1.92, *95% CI* [1.18, 3.79]). In other words, the increase in boredom susceptibility score was associated with an increased likelihood of engagement in the virtual accident during the experiment.

## 6. DISCUSSION

The results indicate that road construction workers' inattentiveness to repeatedly exposed warning alarms from construction vehicles and corresponding engagement in struck-by accidents is highly correlated with boredom susceptibility. Specifically, attentive behavior rate decreased as the boredom susceptibility score increased. Consequently, workers with a high level of boredom susceptibility were more likely to engage in the virtual accident. These findings suggest that workers who have a tendency to become more easily bored in daily life are more likely to be inattentive to warning alarms from construction vehicles in road work zones. The results also broadly support the work of the previous studies in psychology linking individuals' boredom susceptibility with inattention to surrounding environments.

Although this study was conducted using a VR environment, the results hold potential utility in improving safety in road work zones. The findings may help safety practitioners understand workers' natural disposition that may cause inattentive behaviors at work, thereby contributing to designing and providing safety training that effectively intervenes with workers' habituated inattention in workplaces. Furthermore, the assessment of workers' sensation-seeking would allow workers to be aware of how their personality can affect their risk for unsafe behaviors.

These findings may be somewhat limited by the unevenly distributed sample size. In the experiment, the virtual accident was triggered in response to participants' behavioral responses. Thus, the number of participants who did not engage in the virtual accidents was limited. The findings could be corroborated further by performing experiments with additional participants.

## 7. CONCLUSION

This is the first study that empirically measures the association between road construction workers' sensation-seeking and the likelihood of workers' engagement in runover/backover accidents as a consequence of their inattentiveness toward warning alarms from construction vehicles in road work zones. The experiment was performed with actual road construction workers using a virtual road construction environment. Workers' responses to warning alarms were measured using eye-tracking sensors. The findings broadly support previous studies that have theorized the impact of individual differences in personality traits on workers' unsafe behaviors. Workers' sensation-seeking—specifically boredom susceptibility—was significantly correlated with their inattentive behaviors and engagement in the virtual accident. The findings of this study provide an important opportunity to advance the understanding of workers' inattention to warning alarms from construction vehicles in road work zones, thereby contributing to the design of effective struck-by accident prevention strategies in road work zones. Future research will explore how workers' sensation-seeking affects their inattentiveness toward other types of hazards in construction sites such as electrocution hazards and fall hazards.

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