# Emotional States and Their Impact on Hazard Identification Skills

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## Abstract

Every safety meeting and training program is built upon the assumption that construction workers can identify hazards. However, recent research has shown that this may not be true because construction workers and managers lack basic hazard recognition skills. Currently, there is relatively little understanding of the factors affecting hazard recognition skill. Based upon the recent discovery that emotional state impacts risk perception, this study examines the connection between emotion and hazard recognition. Using a longitudinal A+B experiment, this study measured the extent to which variability in emotional state predicts inconsistency in hazard recognition skills and subsequent safety decisions. To induce and measure the emotional state of 45 subjects, autobiographical recall was used. Subjects were asked to complete a hazard identification and a risk perception test before and after the induction. The emotional induction produced significant changes in desired emotions and the results showed that subjects induced with positive emotions showed a statistically significant decrease in hazard identification skills.

## INTRODUCTION

Carter et al. (2006) and the Center for Disease Control and Prevention (CDC 2012) found that workers lack the skills to identify hazards because of the dynamic and fragmented nature of the industry. Furthermore, Albert et al. (2013a) found that before any intervention, construction workers were able to identify only 38% of hazards on site. Similarly, Hansen (2015) found that designers could identify only 33.5% of hazards prior to any intervention.

All safety programs require strong hazard recognition skills (Albert et al 2014a). Pre-job safety meetings, for example, require workers to describe their work tasks, identify all hazards expected for their tasks, and create a plan to control hazard and work safely. The fact that hazard recognition skills are vital but poor highlights the importance of research into this domain.

Inspired by recent research that shows a connection between emotions and risk perception (Clore et al. 1994 and Keller et al. 2006), the present study tests the hypothesis that variability in emotional state predicts variability in hazard recognition skill. This means that emotion and hazard recognition are linked intrinsically. This hypothesis is built upon the fact that emotions are known to strongly influence our decision-making abilities (Elster 1998; Higgins 1997). Lowenstein et al. (2001)'s '*risk-as-feelings'* hypothesis also suggests that emotions such as fear, dread, worry, and anxiety influences individual's responses in threatening/dangerous situations. If true, understanding the connection between emotional state and hazard recognition could have a profound effect on how the industry understands the fundamental drivers of worker behavior in complex situations.

## METHODS

The primary goal of this study was to test the hypothesis: *Does a particular emotional state predicts variability in hazard recognition skill.* Intrinsically, this hypothesis assumes that hazard recognition, like risk perception, is a psychological construct and not simply a basic skill. If the hypothesis tests false, the implication would suggest that hazard recognition is, indeed, a skill. Either outcome provides important learning.

Data was collected using a longitudinal before/after (i.e., A+B) experiment to test the hypothesis. All the participants were asked to complete an initial survey to gauge their baseline emotional state, hazard identification skills, risk perception, and decision-making tolerance. Subjects were then randomly induced into specific emotional states using autobiographical recall. Following that, subjects were asked to complete a hazard recognition test using photographs of actual construction scenarios and hazard recognition, risk perception, and decision-making tolerances were measured once again. The high-level process is illustrated in Figure 1 and the details of this experiment are described below.

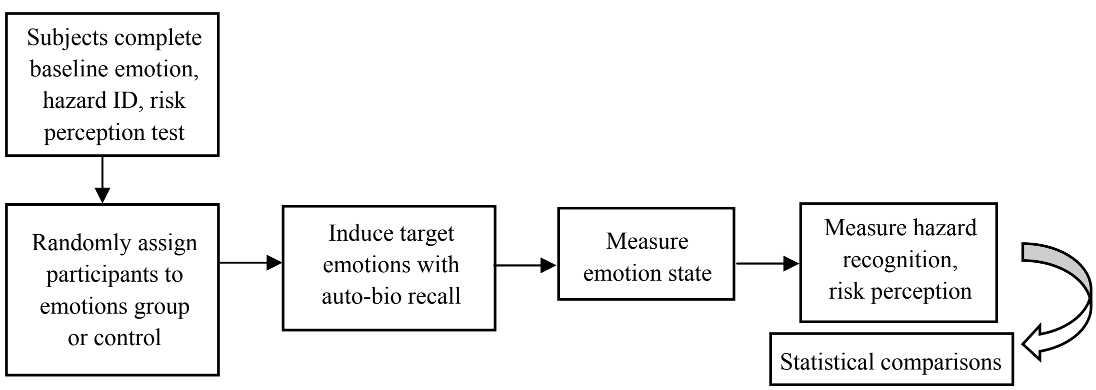


**Figure 1 – Overview of research process**

### Participant recruitment and test environment

Forty-five subjects were recruited as a convenience sample, coming predominantly from the student population at the authors' university. Participation was voluntary and no compensation was provided. The subjects were mainly male graduate engineering students. Specifically, the sample consisted of 76% males and

24% females; 93% engineering and 7% arts and sciences majors; 64% graduate and 36% undergraduate. Since, the authors were attempting to measure a basic psychological construct student participants were preferred over construction workers because they tend to lack experiential bias (Tixier et al. 2014).

The experiment was performed in engineering computing laboratory/study-rooms, a neutral environment. Great care was taken to control the environment with comfortable chairs, adequate space between each participant, temperature control, moderate lighting, and an absence of adjacent distractions. These control variables helped to minimize external influences that could compromise the validity of the results.

**Inducing target emotions with autobiographical recall**

Researchers have developed various methods for inducing emotions, ranging from video clips to storytelling. Autobiographical recall was used to induce emotions. After completing the baseline survey, participants were randomly assigned to the negative emotion or the positive emotion group. Once the participants were assigned, they were asked to recall a memory that generated the assigned emotion (e.g., recalling a memory when the participant was in a positive emotional state like elation). After two minutes of recreating the memory, they were asked to write a brief narrative, focusing on the “positivity” or “negativity” of the memory they just recalled. This procedure have been used widely in psychology research and has shown to be superior to videos and other passive strategies (Ayduk et al. 2002; Gruber et al. 2008; Gruber et al. 2009). As the subjects were informed, names were not recorded to preserve anonymity and all written recall documents were destroyed upon completion of the session.

| Please indicate the degree to which you are currently feeling these emotions | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | Not At All | | | Somewhat | | | Very | |
| ***Example*** | ○ | ○ | • | ○ | ○ | ○ | ○ | ○ | ○ |
| Amusement | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Anger | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Anxiety | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Confusion | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Contempt | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Disgust | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Embarrassment | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Fear | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Guilt | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Happiness | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Interest | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Joy | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Love | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Pride | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Sadness | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Shame | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Surprise | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Unhappiness | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**Figure 2 Emotional State Measurement Instrument**

### Measuring emotional state

To measure the emotional state, the authors used Rottenberg et al.'s (2007) questionnaire in both the baseline and post-induction surveys, which has been validated in countless studies across disciplines. The questionnaire (as shown in Figure 2) requires participants to self-report and rate the intensity of basic emotions (e.g., happiness, anger, sadness) and complex emotions (e.g., guilt, embarrassment). Emotional states were measured before and after the induction.

Emotions can dissipate as quickly as they can be instigated (Verduyn 2011). Thus, the participants were asked to begin the post induction survey immediately after completing the autobiographical recall. Verduyn (2011) suggests that emotional episodes dissipate after the first 30 min. Therefore, post survey data was captured within 20 minutes of the recall activity.

### Measuring hazard recognition and risk perception

The hazard recognition component of the survey consisted of photographs of construction workers performing discernable tasks with identifiable hazards. When creating the survey, a team of researchers identified all the hazards in each of the photographs that were used. When completing the hazard recognition skill test, participants were asked to record and identify the location of all the hazards they could identify in each photograph. Subjects reviewed five randomly assigned photographs before emotional induction and five after emotional induction.

Hazard recognition skill was measured as the proportion of hazards identified (i.e., the number of hazards identified divided by the total number of hazards in the photograph). In the case when a participant identified a hazard that the research team did not identify prior to the survey, these hazards were reviewed and, if confirmed, were added during analysis for completeness.

Once hazards were identified and recorded, participants were asked to rate their perception of the magnitude of risk posed by the situation. Using guidance from Baradan and Usmen (2006) and following the same protocol used by Hallowell (2010) and Tixier et al. (2013), participants were asked to rate the frequency with which an injury may occur at various levels of severity (e.g., how often first-aid injury would be expected in this environment). This rating was provided for each picture. A sample of the survey is shown below as Figure 3.

Following convention, risk perception was quantified for each severity level by finding the product of the frequency and the severity (see equation 1). The frequency levels were designed to correspond to tangible work periods as shown in Figure 3 and the severity scale introduced by Hallowell and Gambatese (2008) was used to quantify the respective levels of severity. The overall risk perception for a particular participant and a particular photograph was measured by taking the average across all severity levels.

$$Safety\ Risk\ \left(\frac{S}{time}\right) = Frequency\ \left(\frac{Incidents}{time}\right) * severity\ \left(\frac{Severity}{incident}\right) \qquad (1)$$

| Injuries | Once Every Week (40 w-h) | Once Every Month (167 w-h) | Once Every Year (2000 w-h) | Once Every 10 years 20,000 w-h) |
|---|---|---|---|---|
| First Aid | | | | |
| Medical Case | | | | |
| Lost Work Time | | | | |
| Permanent Disablement or Fatality | | | | |

**Figure 3 Risk Perception Measurement Instrument (w-h = worker-hours)**

**Measuring action and decision making**

After identifying hazards and recording risk perceptions, the participants were asked to answer the following questions for each photograph on a 9-point Likert scale where 1 represented 'no/definitely not and 9 represented 'yes/definitely yes':

[Q1.] If you are the supervisor on site when this task is being performed, would you 'stop work' based on how this task was being performed?

[Q2.] Assume you are working on this site: would you report how this work is being performed to your immediate supervisor?

[Q3.] Would you be willing to perform this task as it is being performed right now?

[Q4.] Would you be willing to perform this task in the exact environment?

These questions were posed to determine the action that a participant would take for each scenario. Because hazard recognition, risk perception, and risk tolerance/decision making are distinct components of situational interest (Tixier et al. 2014), they were considered independently. These data also allowed the team to make statistical comparisons of final decisions for the emotional groups.

**RESULTS AND ANALYSIS**

The experiment resulted in a rich dataset with pre- and post-induction measures of: emotional state, hazard recognition, risk perception, and action decisions. This dataset was well suited for both standard t-tests and paired t-tests, which can be used to measure differences between groups and changes within single units of analysis, respectively.

A paired t-test was employed to measure changes in the emotional state following the autobiographical recall. Since participants were randomly assigned to either the positive or negative emotions group, they were analyzed as two separate samples. The authors considered the change to be significant at 95% confidence ($p<0.05$). Table 2 shows that the autobiographical recall was successful in achieving the desired results within both groups. Participants who were given positive emotions had a statistically significant increase in happiness, joy, love and a significant decrease in confusion. Alternatively, participants who were given negative emotion recall task showed statistically significant increase in anger, disgust, embarrassment, fear, guilt, sadness, shame, unhappiness and a significant decrease in amusement, happiness, interest, joy, and love. As expected, there was no statistically significant difference in any emotional state between the groups before induction. There was no statistically significant difference between the change in emotions of participants given positive emotion recall test shown and the change in emotions of the participants given negative emotions.

Once the target emotions were confirmed, tests were performed to measure changes in hazard recognition skill and risk perception and to compare the positive and negative emotions groups. To measure the influence of these induced emotions on hazard recognition skills two comparisons were made. First, the hazard recognition skill scores before emotion induction were compared to the skills after induction. Second, the hazard recognition skills scores of the positive and negative emotions groups were compared. The same comparisons were made for risk perception and decision-making.

## Hazard Identification Skills

Of the 45 participants, 23 received positive emotional induction. The participants belonging to this group showed an overall decrease in their hazard identification skills by -18.1% after the induction ($p<0.01$). There was a clear decline in their hazard identification skills after the emotion induction exercise. However, participants who received negative emotional induction revealed no statistically significant change ($p=0.24$). In Table 1, participant's pre-survey average is compared against the post survey hazard identification average. The two groups (i.e. positive and negative group) did not have a statistically significant difference in their baseline hazard identification skills.

**Table 1 Hazard Identification Results for both Groups**

| | Positive Emotions Group | | | Negative Emotions Group | | | |
|---|---|---|---|---|---|---|---|
| **Participant ID** | **Before** | **After** | **Change** | **Participant ID** | **Before** | **After** | **Change** |
| 1A | 0.21 | 0.11 | -48% | 1B | 0.15 | 0.11 | -27% |
| 2A | 0.33 | 0.30 | -9% | 2B | 0.49 | 0.50 | 2% |
| 3A | 0.06 | 0.02 | -67% | 3B | 0.08 | 0.05 | -38% |
| 4A | 0.16 | 0.11 | -31% | 4B | 0.65 | 0.68 | 5% |
| 5A | 0.39 | 0.35 | -10% | 5B | 0.14 | 0.18 | 29% |
| 6A | 0.15 | 0.08 | -47% | 6B | 0.67 | 0.61 | -9% |
| 7A | 0.06 | 0.06 | 0% | 7B | 0.09 | 0.09 | 0% |
| 8A | 0.22 | 0.16 | -27% | 8B | 0.17 | 0.28 | 65% |
| 9A | 0.05 | 0.09 | 80% | 9B | 0.28 | 0.11 | -61% |
| 10A | 0.43 | 0.33 | -23% | 10B | 0.09 | 0.11 | 22% |
| 11A | 0.40 | 0.40 | 0% | 11B | 0.22 | 0.36 | 64% |
| 12A | 0.27 | 0.20 | -26% | 12B | 0.17 | 0.11 | -35% |
| 13A | 0.19 | 0.02 | -89% | 13B | 0.38 | 0.29 | -24% |
| 14A | 0.15 | 0.05 | -67% | 14B | 0.11 | 0.11 | 0% |
| 15A | 0.13 | 0.11 | -15% | 15B | 0.18 | 0.15 | -17% |
| 16A | 0.02 | 0.04 | 100% | 16B | 0.18 | 0.22 | 22% |
| 17A | 0.05 | 0.05 | 0% | 17B | 0.14 | 0.07 | -50% |
| 18A | 0.15 | 0.14 | -7% | 18B | 0.15 | 0.13 | -13% |
| 19A | 0.18 | 0.09 | -50% | 19B | 0.21 | 0.12 | -43% |
| 20A | 0.34 | 0.31 | -9% | 20B | 0.05 | 0.00 | -100% |
| 21A | 0.11 | 0.07 | -36% | 21B | 0.11 | 0.16 | 45% |
| 22A | 0.32 | 0.24 | -25% | 22B | 0.17 | 0.04 | -76% |
| 23A | 0.70 | 0.58 | -17% | | | | |
| Average | 0.22 | 0.17 | -18% | Average | 0.22 | 0.20 | -11% |

### Risk Perception

Risk perception was analyzed using the same statistical tests used for the hazard recognition data. Participants induced with negative emotions showed a decrease in risk perception (-34%) but the change was not statistically significant. Participants induced with positive emotions decrease in risk perception (-56%) also and it had weak statistical significance. These very large effect sizes with low statistical significance suggest that the experiment shall be conducted again with a larger sample size.

### Decision-making

Again, paired t-tests were used to compare the decision-making questions. Participants induced with negative emotions showed no statistically significant change for any of the decision-making questions. However, participants induced with positive emotions showed a statistically significant change for 2 out of 4 questions. They recorded a 12% decrease in willingness to stop work (p=0.04), a 17% decrease in willingness to report on-going work (p<0.01), and a 16% increase in willingness to perform work shown exactly as shown in the photograph (p=0.08).

**Table 2. Results from Emotional Induction**

| | Positive Emotion Group | | | | Negative Emotion Group | | | |
|---|---|---|---|---|---|---|---|---|
| **Emotions** | **Average Before** | **Average After** | **Change (%)** | **P-value** | **Average Before** | **Average After** | **Change (%)** | **P-value** |
| Amusement | 4.39 | 5.09 | 16% | 0.12 | 3.95 | 2.39 | -39% | <0.01 |
| Anger | 1.26 | 1.52 | 21% | 0.21 | 2.32 | 3.52 | 52% | 0.04 |
| Anxiety | 2.48 | 2.30 | -7% | 0.56 | 3.41 | 3.24 | -5% | 0.79 |
| Confusion | 2.61 | 1.52 | -42% | <0.01 | 3.55 | 3.62 | 2% | 1.00 |
| Contempt | 3.22 | 2.70 | -16% | 0.10 | 2.14 | 2.95 | 38% | 0.08 |
| Disgust | 1.22 | 1.26 | 3% | 0.71 | 1.32 | 2.71 | 105% | 0.01 |
| Embarrassment | 1.26 | 1.57 | 25% | 0.34 | 1.50 | 2.38 | 59% | 0.02 |
| Fear | 2.09 | 1.35 | -35% | 0.06 | 1.68 | 2.62 | 56% | 0.01 |
| Guilt | 1.48 | 1.43 | -3% | 0.82 | 1.45 | 3.14 | 117% | <0.01 |
| Happiness | 5.83 | 7.00 | 20% | <0.01 | 5.73 | 3.29 | -43% | <0.01 |
| Interest | 6.22 | 6.52 | 5% | 0.45 | 5.73 | 3.24 | -43% | <0.01 |
| Joy | 5.57 | 6.35 | 14% | 0.02 | 5.68 | 2.81 | -51% | <0.01 |
| Love | 4.87 | 5.78 | 19% | 0.03 | 4.95 | 3.33 | -33% | 0.03 |
| Pride | 4.13 | 5.09 | 23% | 0.07 | 5.00 | 2.81 | -44% | <0.01 |
| Sadness | 2.32 | 1.91 | -18% | 0.40 | 2.45 | 5.38 | 120% | <0.01 |
| Shame | 1.87 | 1.83 | -2% | 0.91 | 1.59 | 2.62 | 65% | 0.05 |
| Surprise | 2.91 | 2.35 | -19% | 0.13 | 2.82 | 2.29 | -19% | 0.25 |
| Unhappiness | 2.04 | 1.61 | -21% | 0.18 | 2.05 | 5.71 | 179% | <0.01 |

## DISCUSSION

The implications of the observed changes on hazard identification skills, risk perception, and risk tolerance are significant. Most importantly, results show that participants registered a decrease in hazard identification skills on being induced with positive emotions. *This suggests that hazard identification is not a pure skill and it can be psychologically influenced.* The findings presented here support what Taylor et al. (1988) coined as 'false optimism,' which leads to fake sense of security towards an environment when in a positive emotional state. Thus, there is increasing evidence that positive emotional state might be compromising overall situational awareness in occupational settings. Such a bold conclusion must be confirmed in repeated trials and across a larger, more diverse sample size.

In addition to changes in hazard recognition, the results revealed statistically significant changes in the decisions made with respect to the construction scenarios suggesting that risk-based decision-making is also a psychologically driven construct. Interestingly, these findings indicate that hazard recognition and decision-making are affected by emotion in the same direction and approximately the same magnitude found in past studied of risk perception (Izard 1977; Tixier et al. 2014; Öhman and Mineka 2001; Clore et al. 1994; Keller et al. 2006).

Given the magnitude of the problems associated with hazard recognition (e.g., skill less than 50% in the construction workforce found by Albert et al. 2014a), and the lack of correlation between hazard recognition training programs and hazard recognition skill (Perlman et al. 2014), practitioners must overhaul current hazard recognition strategies. The present study suggests that the design of new strategies must incorporate an understanding of the role of emotion during actual work execution.

Practitioners may find the notion that they need to support a negative emotional state as a difficult practical and ethical task. However, one should note that emotions associated with vulnerability are known to be negative emotions (Rottenberg 2007). Thus, the authors suggest that fostering a sense of vulnerability and increasing the seriousness of the construction environment would be beneficial to the workforce. Jovial behavior, jokes, and light moods may be partially responsible for low hazard recognition performance, low perceptions of risk, and high tolerance of dangerous situations.

This study is not without limitations. For example, external validity was compromised with students as the units of analysis and the relatively small sample size, which also leads to some unstable effects. To address this limitation, the authors suggest a full-scale experiment with construction workers and a control group of students. Additionally, the experiment should be conducted with a more diverse sample. For example, a greater proportion of Hispanic and women subjects and a greater distribution of age would increase generalizability. In addition, future endeavors should incorporate environments that are more naturalistic. As Perlman et al. (2014) showed, subjects identify more hazards in virtual environments than in photographs. Finally, it should also be noted that nearly all the participants from both groups kept confusing acts of safety violations (i.e. no PPE) for hazards (i.e. objects at height, using electrical equipment, and dust). Photographs with construction workers working with proper PPE were often classified as 'safe' and 'no hazards observed'. This finding needs to be furthered examined with larger sample space from the target population to see if there is a gap in knowledge in distinguishing and identifying hazards leading to false assessment.

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