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Understanding Construction Workers' Risk Decisions Using Cognitive Continuum Theory

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ABSTRACT

The goal of the research presented in this article was to construct a theory about the influence of decision cues on intuitive and deliberative decision-making in high-hazard construction environments. Drawing from Cognitive Continuum Theory, the article specifies a framework for understanding why and how construction workers make decisions that lead to taking or avoiding physical risks when they encounter daily hazards. A secondary aim of the research was to construct a set of hypotheses about how specific decision cues influence whether a worker is more likely to engage their intuitive impulses or to use careful deliberation when responding to a hazard. These hypotheses are described in this article, and the efficacy of the hypotheses was evaluated using cross-tabulations and nonparametric measures of association. While most of the associations between decision cues and decision mode (i.e., intuition or deliberation) identified in this data set were generally modest, none of the associations were statistically zero, thus indicating that further research is warranted based on theoretical grounds. A rigorous program of theory testing is the next logical step to the research, and the article thus concludes with numerous suggestions for extending the research and testing the proposed hypotheses.

KEY WORDS

Physical risk; decision-making; cognition; decision cues

1. SIGNIFICANCE OF RISK DECISIONS ON CONSTRUCTION SITES

Construction work is inherently hazardous, and as a result, workers encounter numerous hazards on the jobsite each day. For example, an individual may discover that an eight-foot tall ladder is needed to reach the work area, but only a six-foot ladder is available – resulting in a ladder that is too short to safely complete the work. At the moment of discovering that the ladder is too short (i.e., discovering the hazard), the worker must make one of two possible choices: (1) take a risk (i.e., use the shorter ladder), or (2) avoid a risk (i.e., do not use the shorter ladder). If, in fact, the worker chooses to use the six-foot ladder and to stand on the top rung of the ladder to reach the work area, the risk of a fall is possible, which might result in broken bones, head injuries, or even death (i.e., risk-taking consequences).

This scenario describes how (1) a hazard is encountered, that results in (2) the presence of a risk, that then results in (3) the need to make a decision to take or avoid the risk, that may then (4) ultimately lead to negative consequences if the risk is taken (rather than avoided). Thus, a *hazard*, by common definition, is any source of potential harm or loss, a *risk* is the probability that a harm or loss will occur as a result of exposure to a hazard, and, a *consequence* is a potential outcome of taking the risk (Canadian Centre for Occupational Health & Safety, 2009). And while a significant number of studies have investigated construction hazards, risks, and consequences (Choudhry and Fang, 2008; Dahlback, 1991; Gibb et al., 2006; Hinze et al., 1998; Wu et al., 2010), relatively little is known about the construction risk decision-making process because judgment and decision-making (JDM) research is typically the domain of psychologists and decision scientists rather than engineers or construction researchers, and thus much of the JDM research is general in nature rather than directed at understanding decision-making in high-hazard environments. Consequently, this article seeks to make a contribution to the limited body of knowledge on construction risk decision-making. Specifically, this article introduces an information processing theory that is prevalent (but intensely debated) in the judgment and decision-making domain -- referred to as Dual-Process Theory – which is often used to explain how individuals mentally process information to arrive at a judgment or decision. The article then presents a framework for understanding why and how construction workers make decisions when they encounter a hazard that lead to taking or avoiding physical risks on the jobsite.

2. DUAL-PROCESS THEORY OF DECISION-MAKING

It is generally accepted in psychology and judgment and decision-making (JDM) domains that people process information by two independent, interactive modes of thought: the intuitive system and the analytical system (Epstein, 2003). The intuitive system is believed to be automatic, experience-based, emotionally-driven, quick, effortless, and impulsive (De Neys and Glumicic, 2008; Denes-Raj and Epstein, 1994; Inbar et al., 2010). It is also thought to be old, evolutionary, highly adaptive, and present in all higher order beings (Denes-Raj and Epstein, 1994). The intuitive system tends to be influenced strongly by experience and draws from knowledge stored in long-term memory, thus allowing for nearly automatic, unconscious responses (Betsch and Kunz, 2008). By contrast, the analytical system is believed to be deliberative, slow, controlled, effortful, and rule-based (Stanovich and West, 2000). It is also thought to be relatively new, distinctively human, and related to general intelligence (Evans, 2011). The analytical system tends to process information sequentially using conscious monitoring, and consequently, it often results in thoughtful, reflective responses. Table 1 outlines the characteristics commonly associated with intuition and deliberation. Researchers generally agree that both modes of thought are engaged during a decision-making task and that the two modes operate seamlessly and in parallel (De Neys et al., 2008; Sloman, 1996), where one mode may dominate the decision-making process while the other mode plays a subordinate role (Betsch and Kunz, 2008). For example, the intuitive system may form an immediate impression of a hazardous situation, but this impression may be carefully processed and formed into a decision, which is a function of the analytical system.

Table 1. Characteristics of intuition and deliberation

Characteristic	Intuition	Deliberation	Source
Cognitive control	Low	High	(Epstein, 2003; Hammond et al., 1987; Inbar et al., 2010)
Rate of information processing	Rapid	Slow	
Conscious awareness	Low	High	
Organizing principle	Weighted average	Task specific	
Confidence in judgment	Low	High	
Errors in judgment	Many but small	Few but large	
Processing method	Holistic	Analytic	
Decision driver	Emotion-based	Logic-based	
Connection-making	Associonistic	Cause-and-effect	
Orientation	Outcome oriented	Process oriented	
Behavior mediated by	Past experience	Conscious appraisal	
Change mechanism	Repetition, experience	Speed of thought	
How Experienced	Passively, subconscious	Actively, conscious	
Outcome Evaluability	Subjective	Objective	
Criteria	Implicit	Explicit	
Processing mode	Comes in a flash	Step-by-step	

In spite of decades of research directed at understanding the dual processes of intuition and deliberation – especially differences in efficiency, effectiveness, and validity of decisions made when engaging each mode of thought – only a few studies have attempted to directly identify and describe the extent to which individuals engage in intuition, deliberation, or a combination of both processes across a variety of tasks and across a variety of contexts. This article contributes to this limited body of work by presenting a framework that can be used to classify decision tasks and associated decision-making modes, thus allowing researchers to theorize about the types of decision tasks that are likely to induce intuitive impulses versus careful analysis, particularly when a worker encounters a hazard on the jobsite.

3. INFLUENCE OF INTUITION AND DELIBERATION ON RISK DECISION-MAKING

Numerous studies have focused on the influence of intuitive, automatic thinking on human error, with significantly fewer studies associating deliberation to error. Hinze (1996) developed a *distractions theory of accidents* that proposed that that the production tasks of construction workers consume their attention, thus causing mental pre-occupation that shifts their focus away from work hazards and makes accidents more likely. Reason (1990) further noted that the failure to redirect attentional control during moments of preoccupation or distraction is “the most common cause” of errors. He specifically noted that inattention, haste, and inadequate thought-monitoring were among the top 10 contributing factors to human error in medical surgery and other domains (Reason, 2005). Norman (1981) more specifically suggested that errors occur when: (1) habits are inadvertently substituted for intended actions; (2) thoughts proceed faster than actions, thus causing an individual to forget a step in the performance of a task or forget to perform the task altogether; or (3) environmental cues trigger an automatic (unintended) response. Alternatively, Geller (2001) focused on the role of deliberation on error, noting that most individuals are consciously aware that they are taking a risk that could lead to an incident. He observed that the reasons for deliberately risky behavior are broad and numerous, including pressure from someone else to take a risky shortcut, the inconvenience of following safety procedures, or, not wanting to take the extra time to be safe. Mitropoulos and Guillama (2010) suggest, however, that while risky behavior does, in fact, result from mental pre-occupation (such as walking backwards while performing a task), many risks are deliberate (such as standing on a board that is insufficient to support the worker’s weight), and *many more risky behaviors fall somewhere in between being an intuitive act versus an intentional act*.

From a practical perspective, we know very little about why and how construction workers use intuition and why and how they use deliberation when making a decision that leads to taking or avoiding a physical risk. However, classic research by Hammond et al. (1987) suggests that task and environmental cues trigger the mode of thinking that ultimately leads to making an intuitive or a deliberative decision.

4. COGNITIVE CONTINUUM THEORY: MATCHING DECISION CUES AND DECISION MODE

Although significant empirical support exists for dual-process modes of decision-making, dual-process theory is not without its critics. Specifically, one key criticism is its limited explanation for how the two systems interact (Dhami and Thomson, 2012). In fact, many older studies suggested that intuition and deliberation are two systems that are dichotomous (*either* intuitive *or* analytical) and opposite to one another (i.e., intuition is what analysis is not) (Cooksey, 1996). To overcome the limitations of existing dual-process theories, Hammond et al. (1987) “rejected the traditional dichotomy between intuition and analysis” and instead proposed a Cognitive Continuum that is anchored at one pole by intuition and at the other pole by analysis (Figure 1). In between the two poles are various combinations of intuition and analysis – referred to as quasi-rationality – which consist of a repertoire of modes of thinking that may be selectively used by individuals depending on the particular task being performed or operational context applicable at the moment. This theoretical research suggested that tasks that can be decomposed into logical, sequential steps are more likely to activate deliberation, whereas tasks that are not easily decom-

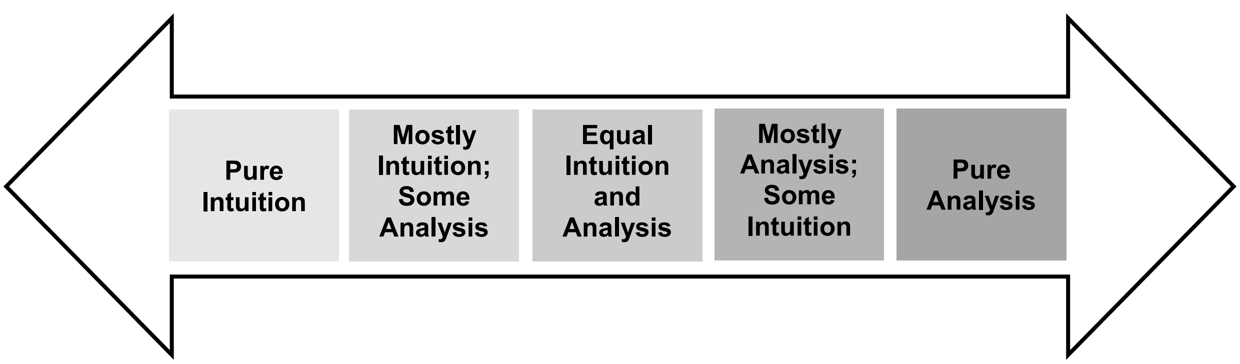

Figure 1. Cognitive Continuum (Dhami and Thomson, 2012; Hammond et al., 1987)

posed or have ambiguous features are more likely to activate intuition (Dane et al., 2012). Consequently, in addition to a Cognitive Continuum, Hammond also conceptualized a Task Continuum along which decision tasks can be ordered according to the mode of thought they are likely to induce (i.e., intuition-inducing and analysis-inducing tasks) (Table 2).

Doherty and Kurz (1996) suggest that Hammond's Cognitive Continuum Theory (CCT) is "simultaneously a theory of tasks and a theory of cognitive processes entailed in addressing those tasks" (p. 130). While modes of cognition fall somewhere along the continuum between intuition and analysis, decision tasks are also ordered along the continuum – identified as more intuition-inducing or more deliberation-inducing. Table 2 outlines a set of predictions about how specific task characteristics will influence a decision-maker's cognition – that is, whether an individual is more likely to approach the task intuitively, deliberatively, or via some combination of the two modes of thought.

Only a few studies have empirically tested the predictions of Cognitive Continuum Theory. For example, Hamm (1988) used a research technique that measured variations in tasks and cognition on a moment-by-moment basis, demonstrating that it was possible to study changes in cognition over time and across contexts, and thus it was possible to reliably demonstrate the "causal influence of task parameters on mode of cognition" (Doherty and Kurz, 1996). Similarly, Dunwoody et al. (2000) found support for the influence of task characteristics on intuitive thinking but was not able to document a similar influence on analytic thought, which was attributed to insufficient variation in the type of judgment elicited. Other studies have used Cognitive Continuum Theory as a framework for (1) understanding how individuals resolve conflicts between intuition and analysis (Inbar et al., 2010), (2) identifying situations where work performance is likely to deteriorate (Mahan, 1994), and (3) categorizing judgment tasks in healthcare (Standing, 2008). This article contributes to the body of risk decision-making research by suggesting a framework – based on Cognitive Continuum Theory – for understanding why and how construction workers use decision cues to make decisions about hazards that lead to taking or avoiding physical risks.

Table 2. Characteristics of tasks that induce intuition and deliberation

Task Characteristic	Intuition-inducing	Deliberation-inducing	Source
Number of cues	Greater than 5	Less than 5	(Doherty and Kurz, 1996; Hammond et al., 1987; Inbar et al., 2010)
Measurement of cues	Subjective	Objective	
Weighting of cues	Equal	Unequal	
Presentation format	Pictorial	Quantitative	
Display of cues	Simultaneous	Sequential	
Interpretation of cues	Subjective	Objective	
Distribution of cue values	Continuous	Unknown, discrete	
Redundancy among cues	High, dependent	Low, independent	
Relation between cues, criterion	Linear	Non-linear	
Decomposition of task	Low	High	
Degree of task certainty	Low, ambiguous	High, unambiguous	
Task complexity	Simple	Complex	
Level of task precision	Imprecise	Precise	
Familiarity with task	Familiar	Unfamiliar	
Time period	Brief	Long	
Time pressure	High	Low	
Availability of organizing principle	Unavailable	Available	
Emotion valence	Positive	Negative	
Mental feedback available	Little/none	Cognitive Feedback	

5. RESEARCH AIMS

The aim of the research was to use the theoretical predictions from Cognitive Continuum Theory (Table 2) to classify – as intuition-inducing or as deliberation-inducing – decision cues used by construction workers when they encounter a hazard on the jobsite that lead to taking or avoiding a physical risk. Thus, the primary aim of the research was to construct a theory about the influence of decision cues on intuitive and deliberative decision-making in high-hazard environments by specifying a framework for understanding why and how construction workers make decisions when they encounter a hazard. A secondary aim of the research was to construct a set of hypotheses for testing (in the future) the new risk decision-making theory. Consequently, the researchers used nonparametric tests of association to evaluate the efficacy of a set of derived hypotheses in order to speculate whether decision cues classified as intuition-inducing or deliberation-inducing did tend to be associated with intuitive and deliberative thought, respectively.

6. RESEARCH METHOD

Structured interviews were conducted with 29 construction workers from the Chicago metropolitan area. Each interview lasted approximately one hour and queried each participant about a recent risk they took during their work day. To put the participant at ease, the researchers explained the purpose of the research as well as the procedures for keeping the data confidential. Furthermore, the first stage of the interview consisted of questions about common risks that the participant had witnessed *other workers taking* while working. During the second stage of the interview, a scenario was presented and the participant was asked to describe how they would respond to the scenario. The third stage of the interview then specifically asked the participant to identify and discuss a recent risk they took while working. Stage three began by querying participants about the specific hazard they encountered and the risk they took. Then, the researchers probed seven types of decision cues that potentially influenced intuitive and deliberative decision-making when they encountered the physical hazard: (1) features of the task, (2) features of time, (3) features of the location, (4) features of the work method, (5) features of the site environment, (6) features of the safety environment, and (7) features of the social environment. Each participant was also asked to describe what they were thinking right before, during, and right after they took the risk. Then, each participant was asked to classify their decision-making in the moments leading up to and then taking the risk as (1) completely intuitive, (2) initially deliberative but alternated to intuitive, (3) initially intuitive but alternated to deliberative, or (4) completely deliberative. To complete the interview, participants were asked to respond to a baseline survey that consisted of questions about the demographic characteristics of the participant, including number of years of work experience, number of safety incidents experienced, number of safety incidents witnessed, and hours of safety training received.

7. DATA ANALYSIS METHOD

The researchers elected to use a grounded theory approach, in which theory is systematically generated from the data. More specifically, as noted by Glaser and Strauss (1967), grounded theory does not aim for the "truth" (since it is unknown) but it aims to conceptualize “what is going on” by using empirical data to derive hypotheses.

A significant portion of the data from the interviews was qualitative (i.e., open-ended questions), and as a result, the type of data collected during the interviews consisted mainly of words, highly detailed descriptions, and explanations of decisions and cues. Therefore, the researchers began the theory-building process by conducting a content analysis. The central idea behind conducting a content analysis was to classify the many words from the transcribed manuscripts of the interviews into significantly fewer content categories (i.e., variables) (Weber, 1990) that could then be analyzed using basic nonparametric statistical techniques to evaluate associations among variables. Therefore, the researchers developed a master coding system to analyze the qualitative data. According to Miles and Huberman (1994), “Codes are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study” (p. 56). The content analysis began by first counting word frequencies to understand which words (primarily nouns) were mentioned most often by the workers. However, the *recording unit* was the sentence because ideas tended to be conveyed as complete sentences rather than by individual words. Based on the word counts and review of sentences, the researchers defined a hierarchy of categories of responses to the interview questions. Similar sentences and sentences with similar meaning were combined under narrow categories, and narrow categories were then combined into broader categories. For example, “The weather was extremely cold” and “It was raining” were combined into the narrow category *Unfavorable Weather*, and then *Unfavorable Weather* was combined with *Cluttered Site* to form the broader category *Unfavorable Work Environment*.

In addition to open-ended questions, many of the interview questions permitted more discrete responses, which resulted in nominal or ordinal categorical data. For example, the question, "Did the task require a low, medium, or high level of concentration?" was coded as 1=low, 2=medium, or 3=high.

A series of spreadsheets were used to perform data reduction. Different spreadsheets represented different sections of the interview, such as *Hazard Observations* or *Hazard Experiences*. Within each spreadsheet, participants were listed in rows and interview question responses were listed in columns, and the intersection of a row and a column indicated a single participant's response to a single question. For each participant, a code from the master coding structure was entered into a cell to represent their answer for each question. Once the codes were entered into the spreadsheet, the researchers were able to use cross-tabulations and basic nonparametric measures of association to evaluate relationships among variables and thus to evaluate hypotheses about the influence of decision cues on intuitive and deliberative decision-making.

8. THEORY CONSTRUCTION: CLASSIFYING CUES USING COGNITIVE CONTINUUM THEORY

The researchers asked each construction worker 47 multiple choice and open-ended questions about the task being performed at the moment when the hazard was discovered, the specific hazard encountered, the risk that was taken, and the task and decision cues that might have influenced the worker's decision to take (or avoid) the risk. The assumption is that "ordinary" hazards are encountered daily in the course of performing the work, and as a result, the worker draws from information in the environment (i.e., environmental cues) as well as internal information (i.e., state cues) to make a decision about how to respond to the hazard. These decision cues may tend to trigger intuitive impulses, careful analysis, or some combination of the two modes of thought. Drawing from the predictions from Table 2, nine types of decision cues were identified by the researchers as potentially inducing intuitive impulses or rational analysis when they encounter a hazard. One additional decision cue (*Flow*) was hypothesized by the researchers as influencing intuition or analysis based on prior research suggesting that a relationship exists between the subjective feeling of "being in flow" and automatic, intuitive thinking (Csikszentmihalyi et al., 1993). These ten decision cues correspond to seven task characteristics (Table 2) that have been identified in previous studies as triggering greater intuition or greater deliberation during the decision-making process. Table 3 identifies: (1) the decision cue, asked in the form of an interview question, and (2) the matching task characteristic from Table 2. The ten decision cues include:

1. **Task Novelty:** The question asked was, "Was there anything unusual about this task?" An unusual or novel task implies that the worker is unfamiliar with the task, possibly because the worker does not perform the task frequently. A frequently performed task is likely to be very familiar to a worker and will appear to be "typical" or "usual". Thus, the Task Novelty variable from the interview corresponds to the theoretical task characteristic *Familiarity with Task*. Previous research has established that familiar tasks tend to induce greater intuition while unfamiliar tasks tend to induce greater deliberation (Epstein, 2003). Hence, **hypothesis 1 (H1)** is: *If a worker indicates that their task is unusual or novel, the worker is more likely to approach the task deliberatively.*
2. **Task Frequency:** The question asked was, "Is this a task you perform frequently?" Much like Task Novelty, the Task Frequency variable implies that the task is likely to be very familiar or unfamiliar to a worker, and thus corresponds to the theoretical task characteristic *Familiarity with Task*. As noted, familiar tasks tend to induce greater intuition while unfamiliar tasks tend to induce greater deliberation (Epstein, 2003). Thus, **hypothesis 2 (H2)** is: *If a worker indicates that they perform the task frequently or the task is familiar to them, the worker is more likely to approach the task intuitively.*
3. **Work Method Frequency:** The question asked was, "Do you use this work method frequently?" The corresponding theoretical task characteristic is again *Familiarity with Task*. A work method that is used frequently by the worker is likely to be very familiar to a worker, and thus actions involved in using the method become habitual or routine. Researchers have noted that repetitive and habitual processes are often automatically directed by intuitive cognition, whereas unfamiliar tasks remain under the control of the deliberative system (Epstein, 2003). Hence, **hypothesis 3 (H3)** is: *If a worker indicates that they use the work method frequently or the work method is familiar to them, the worker is more likely to engage in intuitive thinking.*

Table 3. Decision cues, decision task characteristics, and inducement codes

Decision Cue Number	Interview Question	Variable Name	Task Characteristic (from Table 2)	Intuition-Inducing (Coded as 1)	Quasi-Rational (Coded as 2)	Analysis-Inducing (Coded as 3)
1	Was there anything unusual about this task?	Task Novelty	Familiarity	Usual	N/A	Novel
2	Is this a task you perform frequently?	Task Frequency	Familiarity	Performed frequently	N/A	Not performed frequently
3	Do you use this work method frequently?	Work Method Frequency	Familiarity	Used frequently	N/A	Not used frequently
4	Was the complexity of the task high, medium or low?	Complexity	Task Complexity	Low complexity	Medium complexity	High complexity
5	Did you need a high, medium, or low level of concentration?	Concentration	Level of Task Precision	Low concentration	Medium concentration	High concentration
6	Did you need a high, medium, or low level of skill?	Skill	Level of Task Precision	Low	Medium	High
7	Is this a task you enjoy doing or dislike?	Task Enjoyment	Emotion Valence	Enjoy	Neutral	Dislike
8	Was there a strict time limit to finish the task?	Time Limit	Time Period	Time limit	N/A	No time limit
9	Were you experiencing time pressure (did you feel rushed)?	Time Pressure	Time Pressure	Felt rushed	N/A	Not rushed
10	Was your work flowing smoothly or was it disrupted?	Flow	Degree of Cognitive Flow (hypothesized)	Smooth	N/A	Disrupted

4. **Complexity:** The question asked was, "Was the complexity of the task high, medium or low?" The corresponding theoretical task characteristic is *Task Complexity*. More complex tasks tend to involve a greater number of intermediary steps and are often viewed as more demanding of effort thus requiring greater deliberation. In contrast, simpler tasks are less taxing on cognitive resources and thus can be performed more automatically and intuitively (Inbar et al., 2010). Hence, **hypothesis 4 (H4)** is: *If a worker indicates that their task has a high level of complexity, the worker is more likely to engage analytical reasoning when performing the task.*
5. **Concentration:** The question asked was, "Did you need a high, medium, or low level of concentration?" Greater concentration often results from the need for greater precision and often requires more focused attention. Consequently, the corresponding theoretical task characteristic is *Level of Task Precision*. Previous research has demonstrated that greater concentration and precision require greater deliberation while the need for less precision often triggers intuitive impulses (Inbar et al., 2010). Thus, **hypothesis 5 (H5)** is: *If a worker indicates that they need a high level of concentration to complete their work, the worker is more likely to engage in deliberative thinking when performing the work.*
6. **Skill:** The question asked was, "Did you need a high, medium, or low level of skill?" Much like Concentration, a higher skill level requires a higher level of precision and focused attention, and accordingly, the corresponding theoretical task characteristic is *Level of Task Precision.* As noted, greater precision requires greater deliberation while less precision triggers intuition (Inbar et al., 2010). Hence, **hypothesis 6 (H6)** is: *If a worker indicates that they are performing a low-skill task, the worker is more likely to draw upon their intuition when performing the task.*
7. **Task Enjoyment:** The question asked was, "Is this a task you enjoy doing or dislike?" Numerous studies have examined the influence of emotions on decisions (Betsch and Kunz, 2008; Epstein, 2003); hence, the corresponding theoretical task characteristic is *Emotion Valence*. Positive emotions tend to result in more flexible, quick, efficient, and heuristic information processing (Isen, 2001) while negative emotions invoke much more systematic, careful, and critical mental computing (Schwarz et al., 1991). Thus, **hypothesis 7 (H7)** is: *If a worker indicates that they enjoy the particular task they are performing, the worker is more likely to engage in greater intuitive thinking.*
8. **Time Limit:** The question asked was, "Was there a strict time limit to finish the task?" The related theoretical task characteristic is *Time Period*. When the time available to complete a task is brief, individuals tend to resort to using simplifying heuristics, and these simplifying heuristics tend to be associated with more intuitive thinking (Svenson, 2008). In contrast, when time is abundant, workers can, and often do, take more time to carefully think through the decision using rational analysis. Hence, **hypothesis 8 (H8)** is: *If a worker indicates that the task must be completed within a strict and limited timeframe, the worker is more likely to engage in intuitive thinking when performing the task*
9. **Time Pressure:** The question asked was, "Were you experiencing time pressure (did you feel rushed)?" Accordingly, the corresponding theoretical task characteristic is *Time Pressure*. Several studies have documented the impact of time pressure on mental effort, and these studies have demonstrated that intuitive impulses prevail when people are feeling rushed (Rothstein, 1986). Consequently, **hypothesis 9 (H9)** is: *If a worker indicates that they are experiencing time pressure or feel rushed, the worker is more likely to activate their intuitive thinking when performing the task.*
10. **Flow:** The question asked was, "Was your work flowing smoothly or was it disrupted?" The hypothesized task characteristic is *Degree of Cognitive Flow*. Flow is a subjective state that people experience when they are completely involved in an activity and thus forget about time, fatigue, or external distractors (Csikszentmihalyi, 1997). As a result, **hypothesis 10 (H10)** is: *Smooth work flow likely induces greater automatic intuitive information processing, whereas work flow disruptions are likely to cause greater focused attention and thus greater deliberation.*

9. EFFICACY OF HYPOTHESES: ASSOCIATIONS BETWEEN DECISION CUES AND DECISION MODE

The current research was conducted in order to build a theory of risk decision-making in high-hazard environments and to provide a pathway for testing the theory through future research. Consequently, to complete the theory building effort, the researchers tested the efficacy of the set of hypotheses about the theoretical association between decision cues and decision mode (i.e., intuition or deliberation). The test of efficacy involved using nonparametric tests of association (i.e., cross-tabulations) to evaluate whether

– in the current data set – decision cues classified as intuition-inducing or deliberation-inducing did, provisionally, tend to be associated with intuitive and deliberative thought, respectively, as self-reported by the participants. Self-reports were used in the current research because the study did not intend to engage in significant theory testing, and as a result, approximate measures of intuitive and deliberative information processing were considered sufficient. Future studies will need to construct and test much more reliable and valid measures of intuitive and deliberative thought.

To self-report their decision mode, each participant classified their decision-making in the moments leading up to and then taking the risk as one of four possible types (referred to as *Response Modes*):

1. Response Mode 1, Completely Intuitive: The worker reacted automatically without thinking about the risk, and then realized at a later time that they took (or avoided) a risk.
2. Response Mode 2, Initially Deliberative but Alternated to Intuitive: The worker initially thought carefully and deliberately about the risk but then proceeded more automatically and intuitively.
3. Response Mode 3, Initially Intuitive but Alternated to Deliberative: The worker initially reacted automatically and intuitively, but then at the last moment, thought carefully and deliberatively about the risk and proceeded to take the risk anyway.
4. Response Mode 4, Completely Deliberative: The worker reacted deliberately or carefully thought about the risk before they took (or avoided) it, realizing it was risky; and then, after thinking about it, they proceeded to take (or avoid) the risk anyway.

The frequency of each reported *Response Mode*, as self-reported by the construction workers, was: (1) Completely Intuitive = 17%, (2) Initially Deliberative but Alternated to Intuitive = 31%, (3) Initially Intuitive but Alternated to Deliberative = 31%, or (4) Completely Deliberative = 21%. Consequently, construction workers reported that they integrated or alternated between modes of intuitive and deliberative thinking more frequently (i.e., 62%) than using purely intuitive or purely deliberative modes of thought (i.e., 38%). For the test of efficacy, the *Response Mode* was treated as a dependent variable, while the ten decision cues outlined previously were used as independent variables. The majority of the coding performed by the researchers resulted in nominal data; that is, sets of categories with no inherent order. As a result, cross-tabulations were used to analyze the data, with *Response Mode* listed in rows (i.e., dependent variable) and *decision cues* listed in columns (i.e., independent variable). Each decision cue was cross-tabulated with each of the four response modes to evaluate possible associations between the variables (i.e., do various decision cues influence the activation and use of intuition, deliberation, or a combination of both). While cross-tabulations seem like a relatively simple form of analysis, they can be used to investigate "a startling variety of questions" (Reynolds, 1984). Although numerous measures of association exist for nominal data sets, the interpretation of the results focused on Goodman and Kruskal's tau (τ). Tau is a measure of association that reflects the proportional reduction in error when values of the independent variable (decision cues) are used to predict values of the dependent variable (response mode) (Reynolds, 1984). A value of 1 means that a decision cue (e.g., time pressure) perfectly predicts the response mode (e.g., intuitive or deliberative thinking), while a value of 0 means that the decision cue is no help in predicting the mode of thinking. As with any analysis, especially exploratory data analysis, it is important to remember that "statistical explanation is not equivalent to theoretical understanding" (Reynolds, 1984). The goal of the analysis was not to explain the relationship between decision cues and mode of thinking but instead to determine whether the new risk decision-making theory and hypotheses were theoretically plausible. The results are summarized below.

Table 4 presents the results from associating each of the 10 decision cues with the response mode (which consisted of four types). The null hypothesis (H_0) is, "There is no statistical association between the decision cue and the mode of thought used to make a decision to take or avoid a risk." Likewise, the alternative hypothesis (H_a) is, "There is a statistical association between the decision cue and mode of thought." The table reports the value of Goodman and Kruskal's tau (τ) as well as the probability that the value of tau occurred by chance alone, which is referred to as the p-value. The smaller the *p*-value, the more unlikely that the statistical association between variables is due to pure chance. To determine whether to reject the null hypothesis of *no statistical association*, the p-value is compared to a threshold value called alpha (α), where the α-level is defined as the probability of rejecting the null hypothesis when, in fact, the null hypothesis is true, and it is typically set at 0.05 or 0.10. For example, the first decision cue (task novelty) was compared to the response mode, and the test statistic τ was not significant at the $\alpha = 0.05$ or 0.10 level ($\tau = 0.020$; $p = 0.642$), indicating that there is no statistical association between the decision cue and the use of intuition, deliberation, or a combination of both when the workers were faced with making a risk decision. A careful review of each of the decision cues and the response mode (Table 4) revealed that no association reached the $\alpha = 0.05$ level or the $\alpha = 0.10$ level. However, two decision cues (Skill and Time Pressure) demonstrated a relationship that, while not statistically significant, are noteworthy because additional analysis using more rigorous measurement techniques might tease out a statistically significant association. An examination of the Spearman correlation coefficient revealed a negative correlation between skill level and mode of thinking while a positive correlation was identified between time pressure and mode of thought. Thus:

- Actions that require more advanced skills may tend to activate greater intuition while more average skills tend to activate more deliberation. One explanation for this unexpected finding is that the need for greater skills may cause an individual to draw from their longer-term memory of other (previous) work experiences, where, as noted previously, the intuitive system tends to be influenced strongly by experience and draws from knowledge stored in long-term memory, thus triggering nearly automatic, intuitive responses (Betsch and Kunz, 2008).
- Decisions made under greater time pressure may activate greater intuition. A significant amount of research supports the finding that, under conditions of time pressure or perceptions of feeling rushed, individuals will resort to more intuitive thought processes.

While most of the associations between decision cues and response mode identified in this data set were generally modest, none of the associations were statistically zero, thus indicating that further research is warranted based on theoretical – rather than statistical – grounds. A rigorous program of theory testing is the next logical step to the research to determine more definitively the nature of the association between decision cues and mode of thought when construction workers encounter hazards that trigger a decision to take or avoid a risk.

Table 4. Tests of association between decision cues and response mode

Decision Cue Number	Interview Question	Variable Name	Goodman and Kruskal's tau (τ)	P-Value
1	Was there anything unusual about this task?	Task Novelty	0.020	0.642
2	Is this a task you perform frequently?	Task Frequency	0.018	0.675
3	Do you use this work method frequently?	Work Method Frequency	0.046	0.278
4	Was the complexity of the task high, medium or low?	Complexity	0.018	0.960
5	Did you need a high, medium, or low level of concentration?	Concentration	0.035	0.403
6	Did you need a high, medium, or low level of skill?	Skill	0.120	0.121
7	Is this a task you enjoy doing or dislike?	Task Enjoyment	0.058	0.561
8	Was there a strict time limit to finish the task?	Time Limit	0.038	0.360
9	Were you experiencing time pressure (did you feel rushed)?	Time Pressure	0.061	0.164
10	Was your work flowing smoothly or was it disrupted?	Flow	0.043	0.306

10. LIMITATIONS OF THE RESEARCH AND NEED FOR ADDITIONAL STUDIES

While most associations between decision cues and response mode identified in this data set were generally modest, these theoretical associations should be investigated in future research using more sophisticated techniques to determine whether, in fact, an association exists. Although a number of reasons exist that might explain the inability to definitively identify the theorized associations, a few are especially worth mentioning. Identified below are suggestions for extending the research and testing the proposed hypotheses.

1. The purpose of the study was to construct a theory rather than to test it, and consequently, the data collection was qualitative in nature. Quantitative data will be needed to test the theory and the hypotheses developed through this research.
2. The response variable was subjective – essentially the self-reported mode-of-thought of each worker – and the self-reports were given retrospectively, no doubt introducing recall bias into the process. Hammond et al. (1987) suggest that the only valid way to determine the mode of thought is to measure it moment-by-moment while the individual is performing the decision task. Consequently, future research should combine direct observations with immediate interviews or should use momentary surveys (i.e., diary methods) to capture thoughts as they occur when a hazard is encountered and a decision must be made.
3. The response variable required that a participant select only one mode of thought, but given that intuition and deliberation might both be activated and combined during a decision task, separate scales that measure the extent of engaging each one would likely produce more valid results.
4. This research queried construction workers about specific decision cues that theoretically are believed to induce greater intuition or deliberation based on previous studies. However, research has long suggested that individuals do not use all of the information that is available to make a decision. Instead, they tend to focus on only a few cues. Consequently, future theory testing should focus less on *the number of cues available* and instead focus on *exactly which cues are used* to make a decision. It is possible that the cues that are specifically used to make the decision do, in fact, induce intuition or deliberation as theorized by numerous researchers.
5. By focusing on which cues are actually used to make a decision, new cues may be discovered that were not part of this investigation but that influence intuitive and deliberative thought, directly or indirectly. For example, cold weather (i.e., a physical condition) may influence an individual's sense of time (i.e., feeling rushed) as well as their emotions (i.e., negative, dislike the task), which may influence the mode of thought (e.g., use of greater intuition). Hence, physical conditions may *moderate* the association between variables. Such moderating influences should be included in future studies on the influence of decision cues on decision mode.
6. Individual characteristics were largely ignored during this study but may influence whether decisions are made more intuitively or more deliberatively. For example, personality, preferences, and experience may influence decisions, and thus, these variables should be accounted for during future studies.

11. SUMMARY

The research presented in this article is the first steps toward developing a better understanding of the decision-making process of construction workers when they encounter daily hazards on the jobsite. The article suggests a framework that can be used to classify risk decision-making cues as intuition-inducing or as deliberation-inducing and also to capture the associated decision-making mode employed when actually making a decision. More specifically, the framework can be used to understand why and how construction workers make decisions when they encounter a hazard that lead to taking or avoiding physical risks on the jobsite. Using Hammond et al.'s (1987) Cognitive Continuum Theory to guide the effort, the researchers developed a set of predictions (i.e., hypotheses) about the types of decision cues that would likely induce intuition, deliberation, or a combination of both modes of thought when making a risk decision. The efficacy of these predictions was tested using cross-tabulations and measures of association. The modest associations suggest the need for additional work that extends beyond the current theory-building research and thus engages in theory testing – that is, developing rigorous tests of the hypotheses that form the new theory of risk decision-making on construction sites. The proposed direction of the research program is expected to extend the body of knowledge in three interdisciplinary fields: (1) psychology, by contributing to the measurement of intuitive and deliberative modes of thought and the interaction between the two modes; (2) judgment and decision-making (JDM), by connecting specific decision cues to specific modes of thinking; and, (3) construction safety and physical risk management, by identifying hazards and associated decision cues that lead to taking or avoiding physical risks daily on the jobsite.

12. REFERENCES

Betsch, C., Kunz, J.J., 2008. Individual strategy preferences and decisional fit. Journal of Behavioral Decision Making 21, 532-555.

Canadian Centre for Occupational Health & Safety, 2009. Hazard and risk. Canadian Centre for Occupational Health & Safety, Hamilton, Ontario, Canada; Accessed at http://www.ccohs.ca/oshanswers/hsprograms/hazard_risk.html.

Choudhry, R.M., Fang, D., 2008. Why operatives engage in unsafe work behavior: Investigating factors on construction sites. Safety Science 46, 566-584.

Cooksey, R.W., 1996. Judgment analysis: Theory, methods, and applications. Academic Press, Inc., San Diego, CA.

Csikszentmihalyi, M., 1997. Finding flow: the psychology of engagement with everyday life. Basic Books, New York.

Csikszentmihalyi, M., Rathunde, K., Jacobs, J.E., 1993. The measurement of flow in everyday life: Toward a theory of emergent motivation, Nebraska Symposium on Motivation, 1992: Developmental perspectives on motivation. University of Nebraska Press, Lincoln, NE US, pp. 57-97.

Dahlback, O., 1991. Accident-proneness and risk-taking. Personality and Individual Differences 12, 79-85.

Dane, E., Rockmann, K.W., Pratt, M.G., 2012. When should I trust my gut? Linking domain expertise to intuitive decision-making effectiveness. Organizational Behavior and Human Decision Processes 119, 187-194.

De Neys, W., Glumicic, T., 2008. Conflict monitoring in dual process theories of thinking. Cognition 106, 1248-1299.

De Neys, W., Vartanian, O., Goel, V., 2008. Smarter than we think: Our brains detect that we are biased. Psychological Science 19, 483-489.

Denes-Raj, V., Epstein, S., 1994. Conflict between intuitive and rational processing: When people behave against their better judgment. Journal of Personality and Social Psychology 66, 819-829.

Dhami, M.K., Thomson, M.E., 2012. On the relevance of Cognitive Continuum Theory and quasirationality for understanding management judgment and decision making. European Management Journal 30, 316-326.

Doherty, M.E., Kurz, E.M., 1996. Social judgment theory. Thinking & Reasoning 2, 109-140.

Dunwoody, P.T., Haarbauer, E., Mahan, R.P., Marino, C., Tang, C.-C., 2000. Cognitive adaptation and its consequences: A test of Cognitive Continuum Theory. Journal of Behavioral Decision Making 13, 35-54.

Epstein, S., 2003. Cognitive-experiental self-theory of personality, In: Millon, T., Lerner, M.J. (Eds.), Comprehensive handbook of psychology, Volume 5: Personality and social psychology. John Wiley & Sons, Hoboken, N.J., pp. 159-184.

Evans, J.S.B.T., 2011. Dual-process theories of reasoning: Contemporary issues and developmental applications. Developmental Review 31, 86-102.

Gibb, A., Haslam, R., Gyi, D., Hide, S., Duff, R., 2006. What causes accidents? Proceedings of the Institution of Civil Engineers. Civil Engineering 159, 46-50.

Glaser, B.G., Strauss, A.L., 1967. The discovery of grounded theory: Strategies for qualitative research. Aldine Publishing Company, Chicago.

Hamm, R.M., 1988. Moment-by-moment variation in experts' analytic and intuitive cognitive activity. IEEE Transactions on Systems, Man, & Cybernetics 18, 757-776.

Hammond, K.R., Hamm, R.M., Grassia, J., Pearson, T., 1987. Direct comparison of the efficacy of intuitive and analytical cognition in expert judgment. IEEE Transactions on Systems, Man, & Cybernetics 17, 753-770.

Hinze, J., 1996. The distraction theory of accident causation, In: Diaz, L.M.A., Coble, R.J. (Eds.), International Conference on Implementation of Safety and Health on Construction Sites, CIB Working Commission W99: Safety and Health on Construction Sites, Rotterdam, The Netherlands, pp. 357-384.
Hinze, J., Pedersen, C., Fredley, J., 1998. Identifying root causes of construction injuries. Journal of Construction Engineering and Management 124, 67-71.
Inbar, Y., Cone, J., Gilovich, T., 2010. People's intuitions about intuitive insight and intuitive choice. Journal of Personality & Social Psychology 99, 232-247.
Isen, A.M., 2001. An Influence of Positive Affect on Decision Making in Complex Situations: Theoretical Issues With Practical Implications. Journal of Consumer Psychology (Lawrence Erlbaum Associates) 11, 75-85.
Mahan, R.P., 1994. Stress-induced strategy shifts toward intuitive cognition: A cognitive continuum framework approach. Human Performance 7, 85-118.
Miles, M., Huberman, A., 1994. Qualitative data analysis, Thousand Oaks, CA.
Norman, D.A., 1981. Categorization of action slips. Psychological Review 88, 1-15.
Reason, J., 2005. Safety in the operating theatre - Part 2: Human error and organisational failure. Quality & Safety in Health Care 14, 56-60.
Reason, J.T., 1990. Human error. Cambridge University Press, Cambridge.
Reynolds, H.T., 1984. Analysis of nominal data (2nd Edition), Sage University Paper Series on Quantitative Research Methods, Volume 7. Sage, Newbury Park, CA.
Rothstein, H.G., 1986. The effects of time pressure on judgment in multiple cue probability learning. Organizational Behavior and Human Decision Processes 37, 83-92.
Schwarz, N., Bless, H., Forgas, J.P., 1991. Happy and mindless, but sad and smart? The impact of affective states on analytic reasoning, Emotion and social judgments. Pergamon Press, Elmsford, NY US, pp. 55-71.
Sloman, S.A., 1996. The empirical case for two systems of reasoning. Psychological Bulletin 119, 3-22.
Standing, M., 2008. Clinical judgement and decision-making in nursing--Nine modes of practice in a revised cognitive continuum. Journal of Advanced Nursing 62, 124-134.
Stanovich, K.E., West, R.F., 2000. Individual differences in reasoning: Implications for the rationality debate? Behavioral and Brain Sciences 23, 645-665.
Svenson, O., 2008. Decisions among time saving options: When intuition is strong and wrong. Acta Psychologica 127, 501-509.
Weber, R.P., 1990. Basic content analysis, second edition, Sage University Paper Series on Quantitative Applications in the Social Sciences, Second ed. Sage, Newbury Park, CA.
Wu, W.W., Gibb, A.G.F., Li, Q.M., 2010. Accident precursors and near misses on construction sites: An investigative tool to derive information from accident databases. Safety Science 48, 845-858.