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THE RELATIONSHIP BETWEEN CONSTRUCTION
WORKER SAFETY AWARENESS AND PERSONALITY

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THE RELATIONSHIP BETWEEN CONSTRUCTION WORKER SAFETY AWARENESS AND PERSONALITY

By

Suzann S. von Bernuth

A THESIS

Submitted to
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ABSTRACT

THE RELATIONSHIP BETWEEN CONSTRUCTION WORKER SAFETY AWARENESS AND PERSONALITY

By:

Suzann S. von Bernuth

Despite the industry's best efforts to minimize risks, hazards, injuries and fatalities in construction, it remains a hazardous occupation. Research into accident causation has been performed and is ongoing, and new ideas surface everyday. This thesis is a foray toward the integration of psychology into the predominantly engineering field of construction by investigating the relationship between construction worker personality and hazard perception. Thirty ironworkers were surveyed and data pertaining to their sensitivity to hypothetical hazards, their strategy (risk response criterion) in reacting to those hazards and their personality were measured. Signal Detection Theory was utilized to determine sensitivity and response bias (strategy), and the Five Factor Model was used to evaluate personality. Twenty-six out of thirty workers surveyed had a conservative strategy. Multiple regressions performed on all variables relating to sensitivity (d') resulted in an $R^2 = .34$ and $p = .06$ for experience, Extraversion, Agreeableness, Conscientiousness and Emotional Stability, taken together, and concerning strategy (β) were $R^2 = .37$ and $p = .017$, for age, accidents, Agreeableness, and Emotional Stability, taken together. The workers in this study who scored in the low range on the Five Factors were found to have lower than average sensitivity, and tended to have more conservative strategies. The null hypothesis (there is no relationship) was rejected for both d' and β.

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INTRODUCTION

1. INTRODUCTION

"What lies behind us and what lies before us are small matters compared to what lies within us." (Ralph Waldo Emerson, circa 1880) In the context of this research, *what lies before us* is our work future, hopefully accident free. *What lies behind us* is our work history (hopefully also accident free,) life experiences and genetically heritable attributes. *What lies within us*, our personality, has been shaped by *what lies behind us*, and will have an effect on *what lies before us*. The aim of this research was to discover the link between *what lies within us* (personality) and the way we see the world; specifically, how construction workers interpret the safety of situations that surround them each and every day on the jobsite.

1.1 Motivation

According to the Bureau of Labor Statistics (BLS), the construction industry employed approximately 5.2% of all U.S. workers in 2003, yet accounted for 22.4% of occupational fatalities in the same year (BLS, 2005). In 2004, the construction industry employed approximately 6% of all U.S. workers, yet accounted for 10.5% of nonfatal occupational injuries, and 24.3% of occupational fatalities (BLS, 2005). These statistics show that, with respect to its representation of the total workforce, construction accounts for a disproportionate segment of occupational injuries and fatalities. The 2005 BLS data show 1131 construction fatalities and 408,300 nonfatal injuries and illnesses. In fact, the U.S. Department of Labor classifies construction as a high-risk occupation due to the incidence of injuries and fatalities that occur in the construction industry every year.

In the recent past, the number of fatalities per 100,000 workers has dropped from a high of 5.3 in 1994 to 4.0 in both 2002 and 2003. In 2004, an increase (the first since 1994) was seen, from 4.0 to 4.1. These statistics are represented in Figure 1.1. The fact is that the construction industry is a high-risk occupation. However, the question is, what is being done to address these disparate statistics?

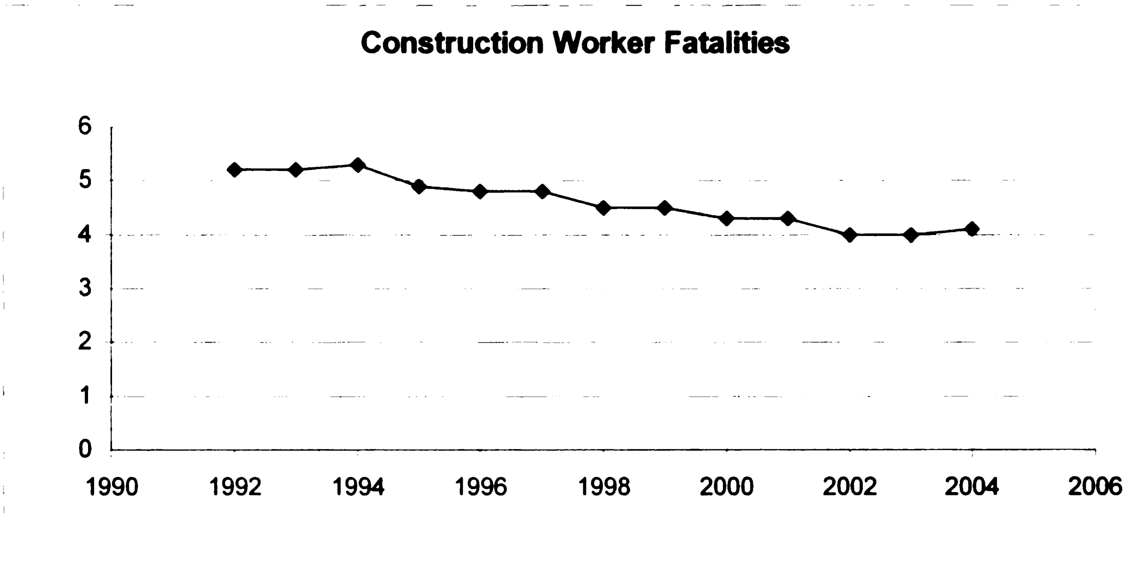


Figure 1.1 Construction Worker Fatalities per 100,000 Workers (U.S.)

(Bureau of Labor Statistics, 2005)

1.2 Prior Research

The existing research literature has typically investigated accident type categorization and the perceived causes of these accidents (Culver et al, 1992; Hinze, 1996; Hinze et al., 1998; Suraji et al., 2001). These investigations have mainly addressed "what" happens concerning accidents, and "how" it happens. Few studies have addressed "why" the accidents occur, however, three categories of "why" theories have been proposed by Sanders and McCormick (1993). These categories are: 1. Accident Proneness Theories, 2. Job Demand vs. Worker Capability Theories and 3. Psychosocial Theories.

1.2.1 Sanders and McCormick Theory Categories

In category one, Accident Proneness Theories, Sanders and McCormick discuss the theory that "some people are more prone to have accidents than others because of a peculiar set of constitutional characteristics", meaning there is some type of permanent characteristic that certain people possess that makes them have more accidents than others, and more accidents than they could be expected to have according to pure chance. This particular type of theory was later challenged by McKenna (1983) on the grounds that it assumed that all the workers were subject to identical job and environmental factors. McKenna felt that the higher than chance occurrence of accidents for some workers might be indicative of a higher risk occupation.

On the heels of the Accident Proneness Theories, the Accident Liability Theory arose. This theory suggests that accident occurrence fluctuates with age. Multiple studies (Broberg, 1984, National Academy of Science, 1982 and Shahani, 1987) found that younger workers have more accidents than older workers, and though there is an increase in accident occurrence for workers over 50, the rate of accident occurrence was still less than that of the youngest workers. Some explanations for these findings are that younger workers tend to be more inattentive, impulsive and reckless, have less discipline, and tend to overestimate their own abilities more than older workers (Lampert 1974).

Sanders and McCormick define the theories in category two (Job Demand vs. Worker Capability Theories) as including the basic assumption that "accident liability increases when job demands exceed worker capabilities" (Sanders and McCormick, 1993). Simply put, the more demanding a job is, the more accidents can be expected. The Adjustment to Stress Theory, also in this second category, hypothesizes that accident rates will increase when the level of stress exceeds the worker's ability to cope with stress. Sanders and McCormick identify these stressors as noise, poor illumination, anxiety, lack of sleep, anger, etc. It is indicated that the research concerning these factors is mixed, and not definitive.

Another theory in category two is the Arousal-Alertness Theory, and it involves inappropriate arousal levels: either too high, such as excessive motivation, or too low, such as boredom or apathy. A study by Brown (1990) indicates that care should be taken to differentiate between stress and arousal, saying that the stress is defined as harmful, but arousal is not necessarily so.

Psychosocial Theories (category three) includes the Goals-Freedom-Alertness Theory, which indicates that when workers are given more control over work goals and management is decentralized, accident occurrence is lower. This category also includes a subset of theories, called psychoanalytical theories, which view accidents as "self punitive acts caused by guilt and aggression" (Sanders and McCormick, 1993). It is argued that this Freudian view of accident causation is generally dismissed as a poor indicator of generalized accident causes.

Sanders and McCormick opine that no single theory or model of accident causation is sufficient to represent the full scale of accident situations, and point to an amalgamated model, developed by Sanders and Shaw, which they believe is broad enough to encompass virtually every possible contributing factor from the other models they reviewed, but specific enough to still be useful. The Sanders/Shaw model (as represented by Sanders and McCormick) is included as Figure 1.2.

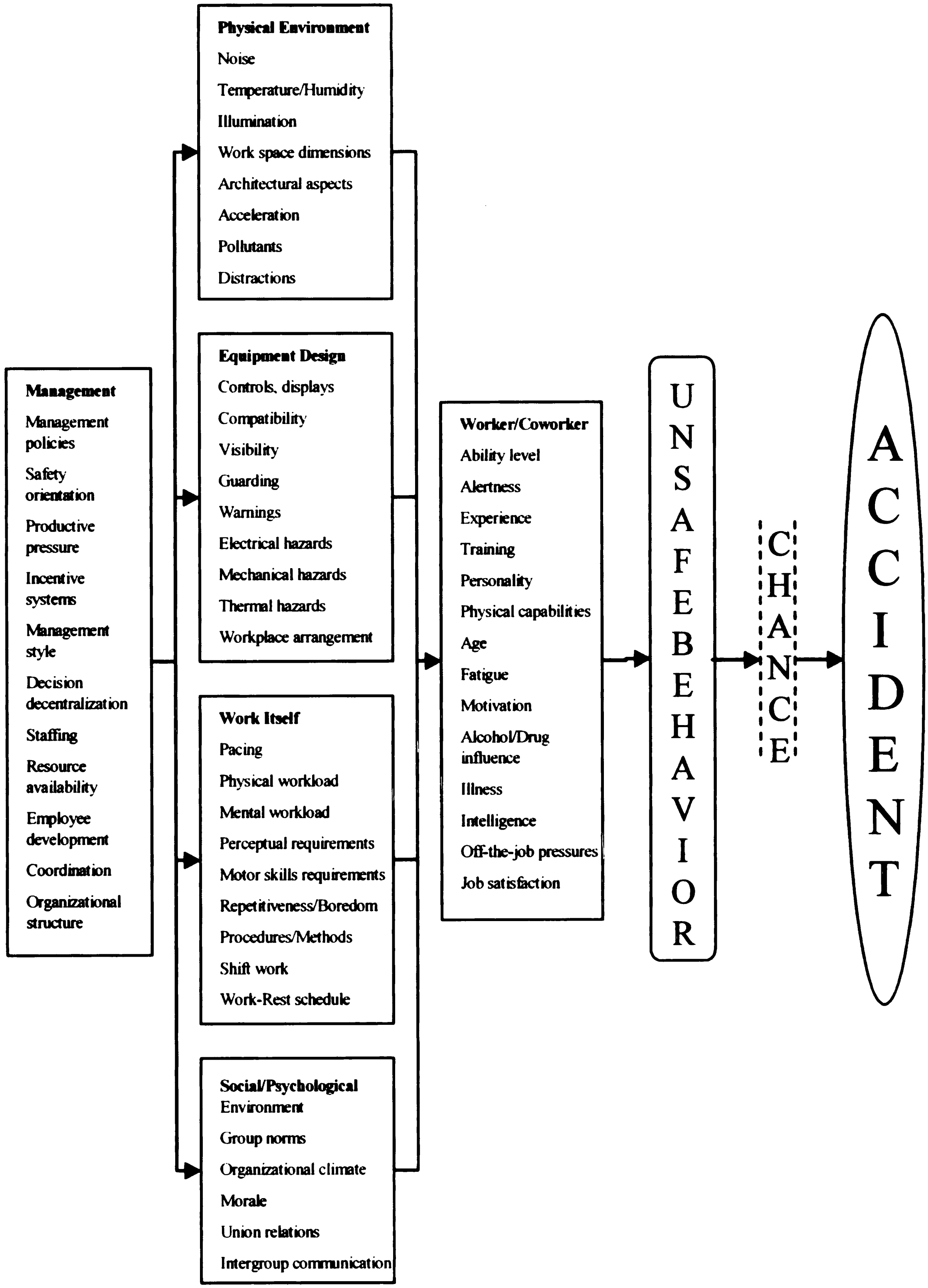


Figure 1.2 Model of Contributing Factors in Accident Causation (CFAC) (Sanders and McCormick, 1993)

1.3 OHSA Accident Definition and Categories

The Occupational Safety and Health Administration (OSHA) defines an accident as occurring "when a person or object receives an amount of energy or hazardous material that cannot be safely absorbed" (OSHA, 2005). OSHA also offers Figure 1.3 as an illustration of what it calls the three Accident Cause Levels: basic, indirect and direct. The direct cause is the actual energy or hazardous material. Indirect causes usually result from unsafe acts and/or conditions, and effect the direct cause. The basic causes are factors such as poor management policies and decisions, or personal or environmental factors.

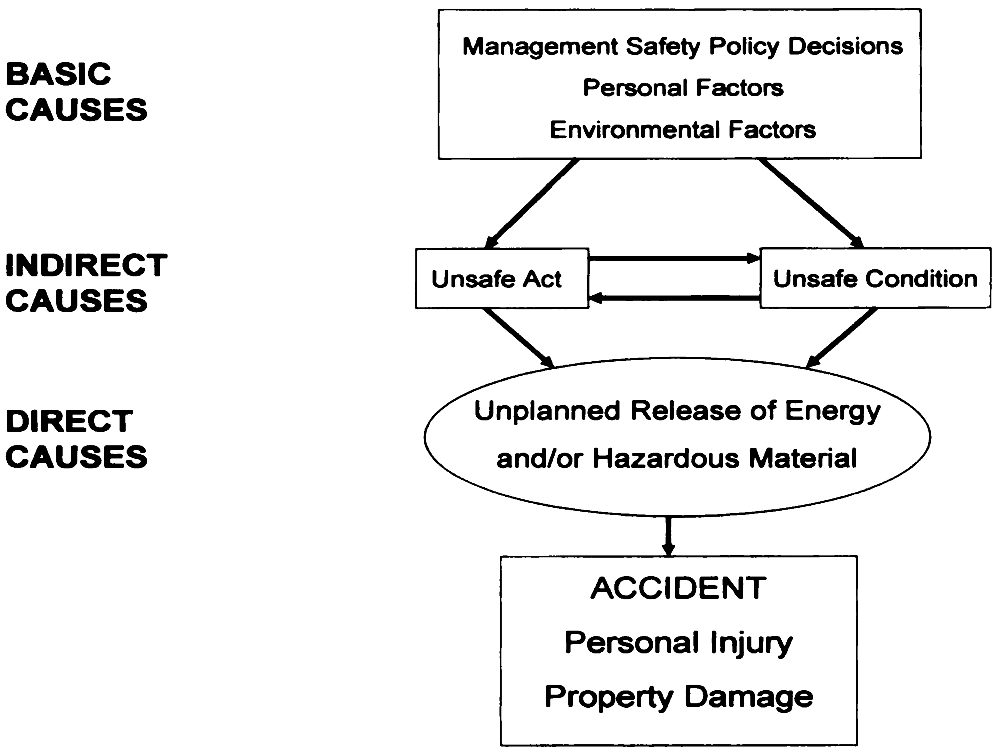


Figure 1.3 Accident Cause Levels (OSHA Accident Investigation, 2005)

OSHA's accident investigation guidelines specify procedures for accident investigators to follow, and step 9a of these procedures requires the investigator to "determine why the accident occurred." This is a huge idea, encompassed in one little step.

In an attempt to clarify the OSHA accident categories, Hinze et al. (1998) investigated OSHA's five basic cause categories: falls, struck-by, caught in/between, electric shock and other. The objective was to create a coding system that would better allow injuries to be grouped by the cause of the injury, and therefore allow for the development of preventative strategies. A system was created that included 20 codes, and proved to be a marked improvement over OSHA's current system. Hinze et al. (1998) felt that further differentiation could be made, though better preventative measures could be developed using the 20-code system.

1.4 Problem Statement

Although much progress has been made toward reducing the presence of hazards in construction occupations, construction remains a high-risk industry. Reviewing the information compiled by the Bureau of Labor Statistics, the construction industry accounts for a disproportionate number of the total yearly occupational fatalities, and the rate of construction worker fatalities per 100,000 workers actually saw an increase from 2003 to 2004 (see Figure 1.1).

It seems apparent that the industry as a whole has begun to place safety in a position of high priority, as evidenced by the decreasing trend in the rate of fatalities per 100,000 workers from 1992 to 2004. It is also apparent that the traditional safety methods that brought this decrease to bear are not sufficient to eliminate construction fatalities altogether. In light of the recent increase in fatalities, it is logical that research should attempt to uncover new ways to prevent as many occupational accidents as possible. There are many domains that have not been investigated, and it is only beneficial to investigate as many as possible to preserve the lives and livelihood of the construction industry workforce. This research has focused on one of these numerous possibilities: the relationship and correlation between the personality and safety awareness of construction ironworkers.

1.5 Goals and Objectives

The main goal of this research was to enhance the understanding of the factors that influence the hazard identification of workers in construction situations. The following objectives were proposed to realize this goal.

1. Develop a conceptual model to express the relationship between personality traits, situations and the hazard recognition of the construction worker.
2. Investigate the relationship between personality traits and the hazard recognition level of the construction worker.

It was and still is the author's opinion that further understanding of the relationship between workers' personality and their sensitivity to hazards and hazardous situations will go far in the ongoing quest to maximize the efficacy of safety training and accident prevention measures, and provide a basis for further research in this area. The exploration of these measures could prove to be quite valuable to the development of effective managers and management strategies, the development, delivery and effectiveness of training programs and beneficial introspection for workers themselves.

1.6 Scope of the Research

Ideally, the effect of the worker's trade and type of work should be captured. This would recognize that workers from different trades face very different occupational hazards, and would attempt to identify and measure them. Though normalization across the industry would be ideal, such normalization would be difficult, if not impossible. For this reason, this study consulted a population of ironworkers, similar to the samples investigated by Patel (2003) and Narang (2006).

1.7 Thesis Overview

This research has utilized the constructs of Signal Detection Theory and the Five Factor Model to assess not only workers' personality and their ability to identify a safe situation, but to also produce two measurable data sets that could then be compared to show a possible relationship between personality and safety awareness.

This thesis is comprised of five chapters. The first chapter offers a brief introduction to the problem area and relevant research, as well as the motivation, goals, objectives, and limitations of the proposed research. The second chapter gives background information on Signal Detection Theory, the Five Factor Model and the research application of personality in the arena of occupational safety. Chapter three presents the methods proposed to achieve the goals and objectives presented in Chapter One. Chapter Three also includes the expected results and contributions of this research. Chapter Four presents the results of the survey and a discussion of the survey data analysis. The fifth and final chapter offers the summary and conclusions drawn from the research as well as suggestions for future research.

Chapter 2
BACKGROUND

2. BACKGROUND

In Chapter One, a brief overview of prior research concerning accident prevention was presented, as well as the need for further research in this area. In this chapter, an introduction to Signal Detection Theory (SDT) and the Five Factor Model (FFM) will be given and the research concerning SDT and FFM individually will be presented. This chapter concludes with a discussion of personality and safety research.

2.1 Accident Causation Research

As stated in section 1.3, accident causation has been a topic of extensive research, though only a small segment has been devoted to the concept of 'why' accidents occur. This is a very complex area, and it has been approached from very different angles. Various researchers have attributed this 'why' to multiple factors, and the following is a brief overview of some pertinent accident causation research, in addition to what was discussed in section 1.2.

- McClay (1989): three elements of accident causes: the presence of hazards, human actions, and the act of exceeding functional limitations (of humans or equipment). McClay referred to this as a universal framework.
- Hinze (1996): high levels of distraction that a worker experiences on the job increases the chance that an accident will occur. This distraction can be attributed to various factors, similar to the stressors indicated in section 1.2 category two.
- Reese and Eidson (1999): six factors can contribute to the occurrence of construction accidents: actual physical hazards, environmental hazards, human

factors, lack of or poorly designed safety standards, failure to communicate within and between trades.

- Abdelhamid and Everett (2000): the ability of the worker to identify unsafe conditions caused by management inadequacies or the worker's own actions.
- Suraji et al. (2001): proximal and distal factors affect the way a worker responds to on-the-job stimuli.

It must be stated, however, that the search for the causes of accidents is far from over, and there are many sectors in which further research can take place. One such domain is the relationship between situation and personality, which is discussed in depth in section 2.6 and 2.7, concerning the scholarship of Geller and Weigand (2006) and Cellar et al. (2001).

Rasmussen identified three work zones: the Safe Zone, where work can continue normally with no undue hazard present; the Hazard Zone, where workers are "working at the edge" (walking on thin ice); and the Loss of Control Zone, where accidents occur. Rasmussen believed that the boundary between the Safe Zone and the Hazard Zone should be identified to, and by, workers. Furthermore, he felt strongly that workers should be trained in ways to remain in the Safe Zone, ways to recover from the Hazard Zone back into the Safe Zone, and also how to identify, avoid, and ultimately recover from the Loss of Control Zone. Figure 2.1 shows Rasmussen's three zones of risk. According to Rasmussen, workload and economic pressures can push the worker from the Safe Zone toward the Hazard Zone, and eventually toward the Loss of Control Zone.

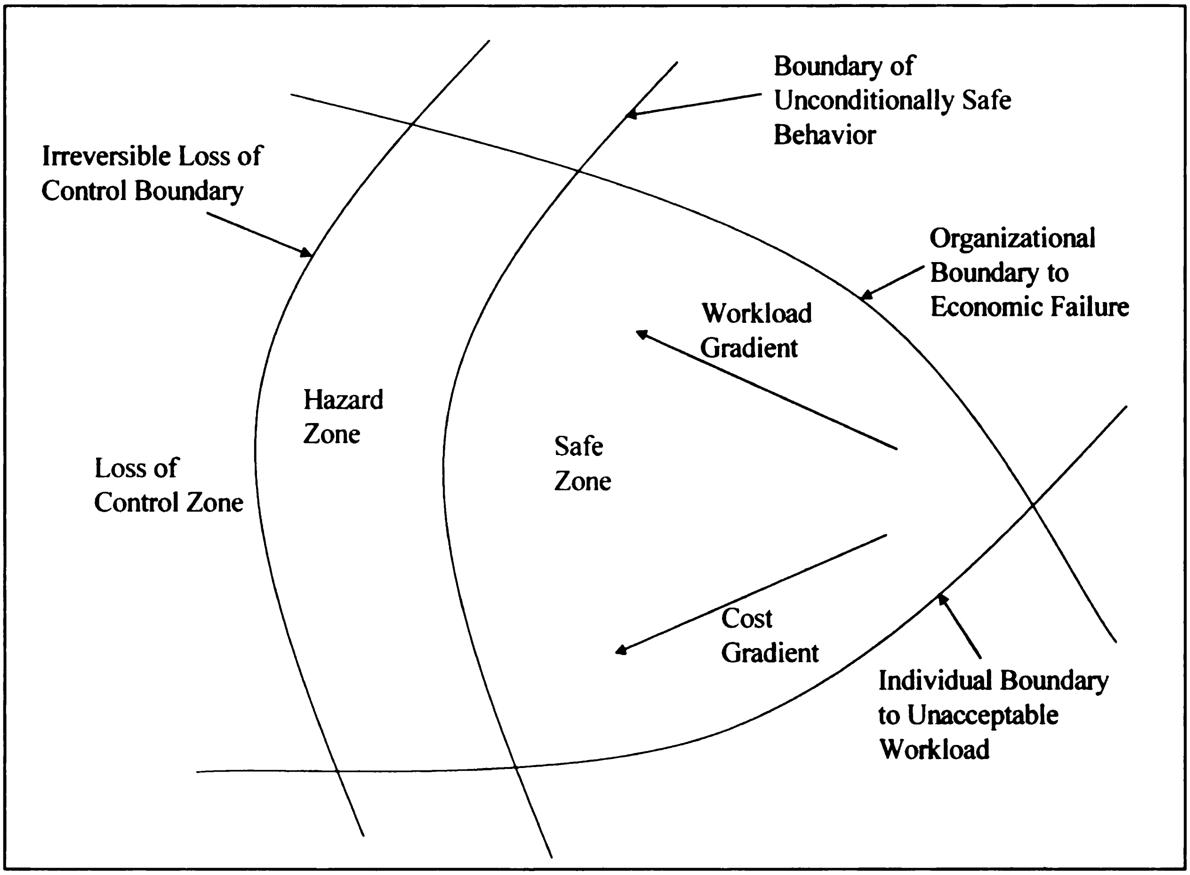


Figure 2.1 Three Zones of Risk (Howell et al., 2002)

Figure 2.2 further illustrates the factors that can push a worker into and beyond the Hazard Zone, and identifies the location of accidents. This figure shows that the pressure to move from one Zone to another can be both internal and external.

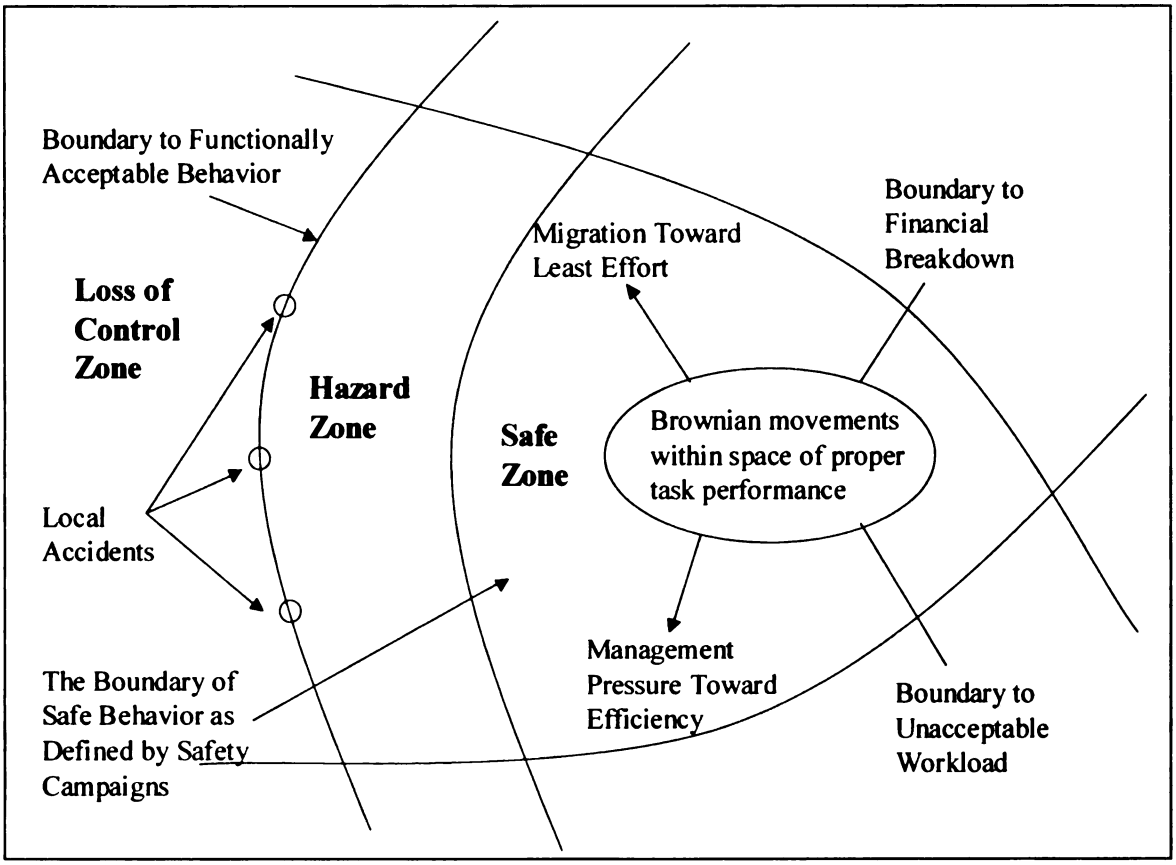


Figure 2.2 Migration of Work Toward Loss of Control (Howell et al., 2002)

Based on the work of Rasmussen (1997), Howell et al. (2002) proposed a new approach to construction safety. This model recognizes that many factors affect the behaviors of individuals where occupational safety is concerned. Howell et al. (2002) stressed the need to train workers to recognize hazardous situations, and suggested the following four questions as tools to aid this recognition.

1. Where are you? (In what zone?)
2. What is the risk or hazard you now face?
3. What can be done to prevent the release of the hazard?
4. What can be done to reduce harm should the hazard be released?

With Rasmussen's and Howell et al.'s emphasis on the worker's ability to identify the zones in mind, Patel (2003) employed a framework to assess how workers perceive safe and unsafe situations. He used Signal Detection Theory, a method of decision-making which is often used in manufacturing to detect defective products, to discern if the workers could correctly identify these conditions. Patel found that 40 out of 42 subjects had low to moderate sensitivity, suggesting that they might benefit from more safety training. Patel proposed a few possibilities for future research, including similar analysis of other populations, use of a larger population sample and the inclusion of other variables such as archival injury history.

2.2 Accident Causation in Construction

2.2.1 Systems Model of Construction Accident Causation (Mitropoulos et al. 2005)

Based on the assumption that the current approach to construction safety is grounded in a defensive strategy (barriers between workers and hazards), Mitropoulos et al. chose to investigate the work system factors that can contribute to hazardous situations and affect worker behavior. This research identified some major limitations of the traditional approach to safety; these limitations are as follows (Mitropoulus et al. 2005):

1. Reactive approach: Hazards should be avoided instead of managed or reacted to.
2. Conflict with production: Loss is still sustained, but it is loss of production, not loss of health or life.
3. Uncertainty limits the effectiveness of defenses: The possible hazards in the field of construction are innumerable, and it is not possible to plan for each and every one.

4. Limited view of accident causation: The current view of accident causation focuses on who is to blame for an accident, rather than interpreting safety as a question of safe or unsafe situation, and that decisions on the job are often made unconsciously and without an assessment of the possible hazard.
5. Limited learning: The traditional system of accident investigation focuses more on who is liable than on a dynamic understanding of accident occurrence.

2.2.2 Incident Causation Model for Improving Feedback of Safety Knowledge (Chua and Goh, 2004)

This scholarship addresses Safety Management Systems (SMS) on construction projects, and specifically, the need to learn from SMS failure. Chua and Goh propose the Modified Loss Causation Model (MLCM), which, if applied as a computer-based system and used universally, could provide a uniform platform for incident investigation, data storage and retrieval and future SMS planning. This model provides feedback in two distinct levels, the first of which is feedback to the SMS system that failed, and the second is feedback to the process through which future SMSs are created. This allows for continual improvement in the area of construction safety.

2.2.3 Corporate Culture (Molenaar et al., 2002)

Molenaar, Brown, Caile and Smith compared the corporate culture of three of the safest construction firms in the Denver area. The operant definition of 'corporate culture' used in this study was "a pattern of basic assumptions invented, discovered or developed by a given group as it learns to cope with its problems of external adaptation and internal integration that has worked well enough to be valid and to be taught to new members as the correct way to perceive, think and feel in relation to these problems" (Molenaar et al., 2002).

The goal of the research was to assess upper management, middle management and field personnel discrepancies with respect to company beliefs, values and behavior, and to see how those discrepancies related to safety behavior (Molenaar et al., 2002). The researchers developed a model, and created a survey based on the model to study several characteristics of the company culture. They found that the company with the best safety record of the three studied also had the most consistent safety culture, which was identified as having the fewest culture discrepancies between company levels.

2.3 Signal Detection Theory

Signal Detection Theory (SDT) is a method used to assess the decision-making strategy of a subject who must recognize and select a distinctly correct option. SDT has seen extensive use in the manufacturing sector to identify and remove defective products. SDT can be utilized to distinguish between two distinct 'states of the world' (Abdelhamid et al., 2003), noise and signal. In a manufacturing setting, if the 'state of the world' is signal (the product is defective), then the subject would chose either yes, the product is defective (hit), or no, the product is not defective (miss). Similarly, if the 'state of the world′ is noise, and the product is not defective, the response of the subject would either be yes, the product is defective (false alarm) or no, the product is not defective (correct rejection). Table 2.1 further illustrates this decision matrix.

Table 2.1 The Four Outcomes of Signal Detection Theory

		State of the World	
		SIGNAL	NOISE
Response	YES	HIT	FALSE ALARM
	NO	MISS	CORRECT REJECTION

Response bias, i.e., the tendency to give a certain response more often than another response across multiple random trials, plays a significant role in the use of SDT. Some subjects may tend to say yes more often than they say no, and consequently, have more false alarms. Conversely, if the subject says no more often than yes, s/he would tend to have fewer false alarms, but many misses. Each strategy has positives and negatives, depending on the task in question, but neither is ideal.

In its basic form, Signal Detection Theory makes a few fundamental assumptions. The first of which is that the value of d' (sensitivity) is not zero and is not negative. This is because it assumes that a worker can discriminate, and that their discrimination is not actively detrimental when compared to the ideal sensitivity. When observing a graphic representation, such as presented in Figure 2.3, SDT assumes that the Signal and Noise distributions never lie directly on top of each other, and that the Noise distribution is always to the left of the Signal distribution. Another basic assumption is that the variances of the distributions are uniform or at least similar. SDT allows for non-uniform variances and for the value of d' to be less than or equal to zero, but in these cases, either the ratio of areas or the c criterion must be used to calculate β.

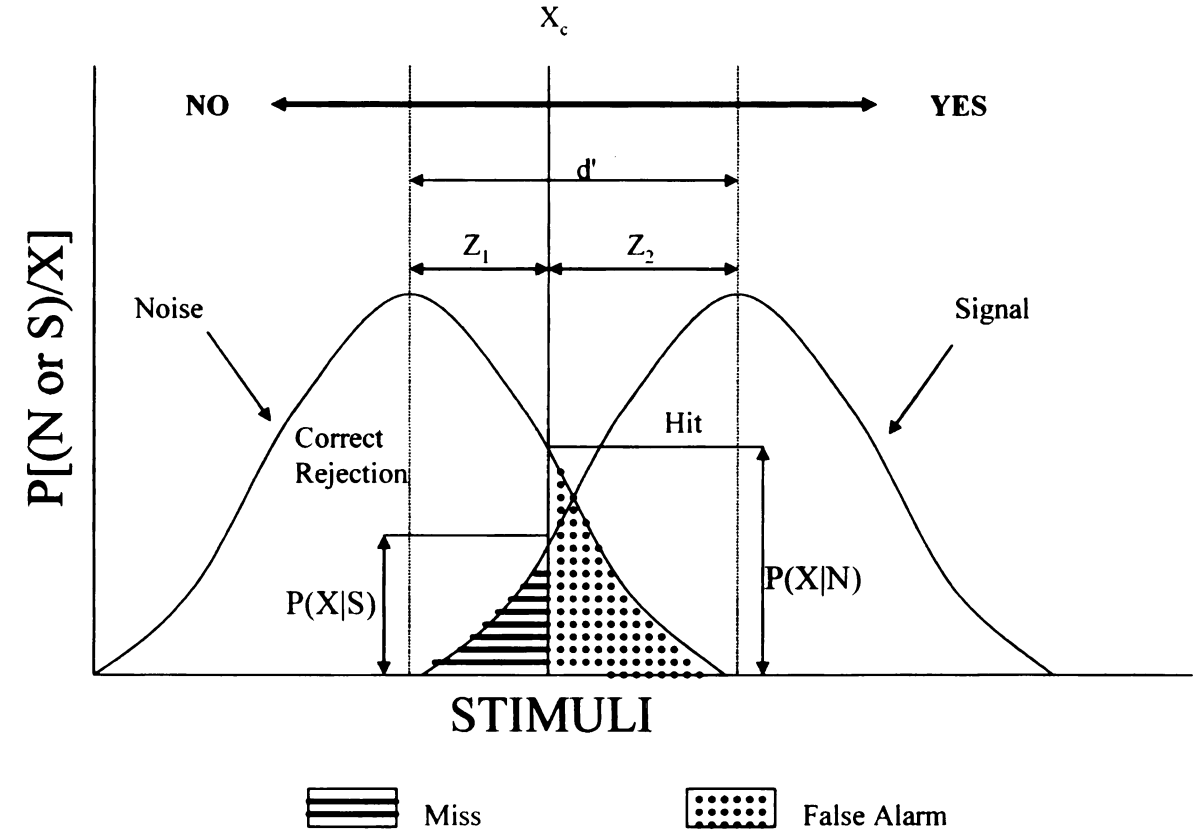


Figure 2.3 Distribution of Detection Theory (Wickens and Hollands, 2000)

As shown in Figure 2.3, X_c represents the point at which the subject makes a decision, and indicates the subject's response bias. The d′ value is the subject's sensitivity, or the separation between the mean of the signal and noise distributions. With respect to sensitivity, if the subject were completely unable to distinguish noise from signal, d′ would be 0. If the subject could infallibly distinguish noise from signal (perfect discrimination), then, in theory, d′ would be infinite. The value of d′ is calculated by adding Z_1 (the standard normal variable reflecting the possibility of a false alarm) and Z_2 (the standard normal variable reflecting the possibility of a hit). Both the values of Z_1 and

Z_2 can be found in standard statistical tables. Repeated trials indicate that average sensitivity is reflected by a d′ value equal to one (Wickens and Hollands, 2000).

$$d' = Z_1 + Z_2 \tag{2.1}$$

For this study, the ideal value of d′ was 4.6, if the worker were to have 11 hits and 7 correct rejections, and the absolute worst situation was 11 misses and 7 false alarms, resulting in a d′ value of – 4.6. The following table shows the range for low, moderate and high sensitivity.

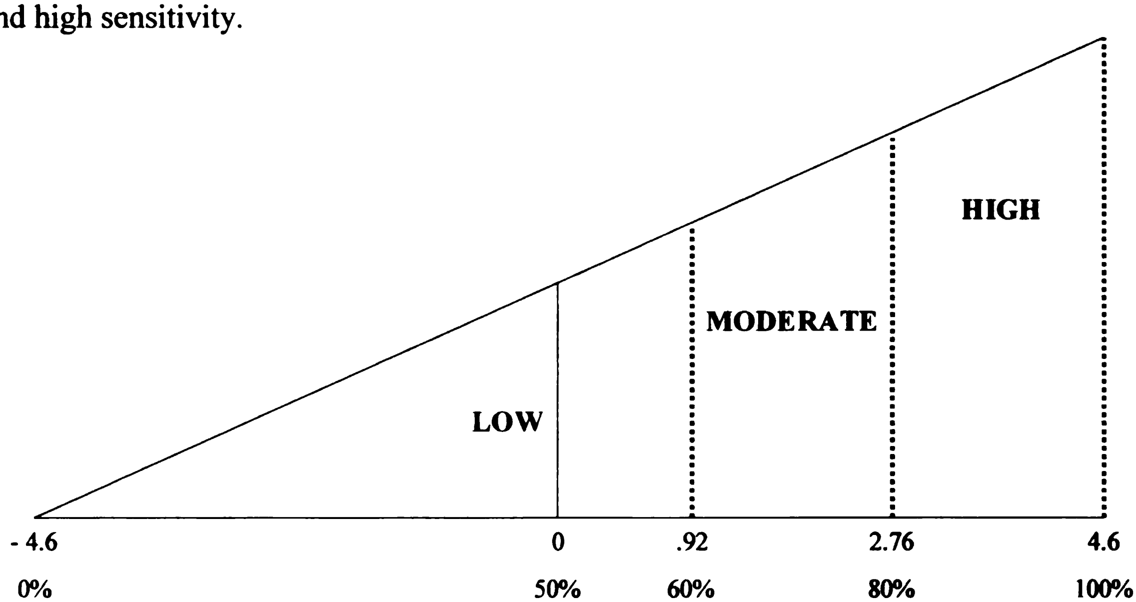


Figure 2.4 Sensitivity Ranges for d′ (Adapted from Patel, 2003)

The response strategy of an observer, whether they tend to say yes more often than no, or vice versa, is represented by a value termed β. The value of β depends on the specific location of X_c for a specific subject. This value of β is denoted as $\beta_{current}$ and represents the decision criterion of the subject. At a given location of X_c, $\beta_{current}$ is the ratio of P(X|S) to P(X|N), where P(X|S) represents the probability that X_c will be in a particular location given signal and P(X|N) represents the probability that X_c will be in a particular location given noise. Equation 2.1 shows the calculation of $\beta_{current}$ under the assumption that the variances of the noise distribution and the signal distribution are the same and/or similar, and that d' is greater than zero. (Wickens and Hollands, 2000).

$$\beta_{current} = P(X|S)/P(X|N) \tag{2.2}$$

Values of $\beta_{current}$ relate to the number of misses and false alarms, such that a high $\beta_{current}$ value indicates a high number of misses, and a low $\beta_{current}$ indicates more false alarms. Typically, $\beta_{current}$ is considered neutral when its value is equal to 1. Hence, a $\beta_{current}$ greater than one(1) would indicate more misses than false alarms, and a $\beta_{current}$ less than one would indicate more false alarms than misses. In construction, misses are more dangerous than false alarms, and a strategy that includes more misses than false alarms will be referred to as 'risky' for this research. Likewise, a strategy that includes more false alarms than misses will be termed 'conservative', though the traditional SDT literature (Wickens and Hollands, 2000) uses the reverse of this terminology. $\beta_{current}$ can also be used to characterize the strategy or bias of an individual subject by comparison to β_{opt}, which is where β should be, given the situation the observer is under. β_{opt} is the ratio of the probability of noise P(N) to the probability of signal P(S), the calculation for which is shown in equation 2.2 (Wickens and Hollands, 2000).

$$\beta_{opt} = P(N)/P(S) \tag{2.3}$$

If the value of $\beta_{current}$ is greater than the value of β_{opt}, then the strategy of the subject is more risky (X_c is farther to the right) because the subject tends to say no more often than yes and the result is a high number of misses. If the value of $\beta_{current}$ is less than the value of β_{opt}, then the strategy of the subject is more conservative and X_c is positioned farther to the left. This conservative strategy results in fewer misses and more false alarms. Macmillan and Creelman (1991) suggest the use of the c criterion, included as equation 2.3, to mitigate the effect of a very small or negative d′ on the $\beta_{current}$ value, as well as the effect of non-uniform variances. It is also suggested by Macmillan and Creelman (1991) that the ratio of areas could be used as an effective measure of $\beta_{current}$.

$$c = -0.5[z(H) + z(FA)] \tag{2.4}$$

The following example illustrates the use of SDT. This example is taken from Patel's 2003 thesis, and the SDT portion of this thesis research will closely parallel Patel's work.

Example:

A manufacturer produces DC motors using a process that has a 5% defective rate. After receiving an increasing number of customer complaints, the manufacturer begins to utilize an inspection system that detects 80% of the defective motors, but falsely rejects good motors at a rate of 1%. What is the sensitivity of this inspection system?

Solution:

Table 2.1 can now be reconfigured, as shown below in Table 2.2, to reflect this example.

Table 2.2 Example Probabilities (Patel, 2003)

		State of the World	
		SIGNAL (Defective product)	NOISE (Good product)
Response (Is the motor defective?)	YES	HIT = 80%	FALSE ALARM = 1%
	NO	MISS = 20%	CORRECT REJECTION = 99%

P(Noise) = P(Product is not defective) = .95 (given)

P(Signal) = P(Product is defective) = .05 (given)

P(Hit) = .80 (given)

P(Miss) = 1-P(Hit) = .20

P(False Alarm) = .01 (given)

P(Correct Rejection) = .99

SDT may be used as follows to determine the sensitivity and strategy of the inspection process. To begin calculations concerning d′ (sensitivity) the standard normal values of Z_1 and Z_2 must be obtained. These can be obtained from standard statistical tables. Using the probabilities of a false alarm and a miss, the Z values are as follows.

$Z_1 = 2.326$

$Z_2 = .842$

From Figure 2.3, $d' = Z_1 + Z_2$, therefore, $d' = 2.326 + .842$, $d' = 3.168$

As previously mentioned, average d′ = 1, hence, the value of 3.168 = d′ indicates that the subject has a high sensitivity.

Looking back to equations 2.1 and 2.2, the calculation for $\beta_{current}$ requires the determination of P(X|S) and P(X|N). However, according to Figure 2.2:

P(X|S) can be defined as the ordinate corresponding to Z_2, and

P(X|N) can likewise be defined as the ordinate corresponding to Z_1

Using the table included in Appendix E:

P(X|S) [the ordinate corresponding to Z_2] = .28

P(X|N) [the ordinate corresponding to Z_1] = .027

Therefore, using Equation 2.1:

$\beta_{current} = .28/.027 = 10.37$

β_{opt} must be calculated to make a comparison to $\beta_{current}$, and this can be done using Equation 2.2 as follows:

$\beta_{opt} = .95/.05 = 19$

$\beta_{current}$ is less than β_{opt}, indicating that the inspection process is risky (i.e. less misses and more false alarms) according to standard use of the term in SDT literature. The X_c of the process is positioned farther to the left. Consequently, the application of SDT to the example of DC motor manufacturing has come to these conclusions: the process is more sensitive than average to the difference between signal and noise, and thus, has a risky strategy (in manufacturing), tending to indicate no more often than yes (each trial is probabilistically independent of other trials) and resulting in more misses.

The above example demonstrates the use of SDT in assessing the ability of a process to discriminate between two distinct 'states of the world'. The specific 'state of the world' could be anything, such as "is the water wet or not", "is the wine red or not", and "is a construction situation safe or not".

It seems logical that SDT could be used to assess workers' awareness of the safety situations surrounding them in occupational settings, as well as the general strategies they use when deciding if a situation is safe or not. The long-term use of such a tool could prove useful as well: the same survey could be used initially to determine how sensitive the workers currently are to jobsite situations and whether they could benefit from further training. The strategies the workers employ can also indicate the type of training that may be appropriate, and also suggest, to an extent, the possible learning and environment type which should be used for each worker. The second use of SDT safety survey results can be augmented by partnering it with the use of personality assessment tools, a discussion of which is included in the next section. Furthermore, SDT could be used as a post-test after trainings, both to indicate the effectiveness of the training, and, longitudinally, the knowledge retention of the worker at certain intervals following the training. This last assessment could be indicative of appropriate training frequency.

2.4 The Use of SDT in Construction

Patel (2003) utilized Signal Detection Theory to assess the occupational safety competencies of 42 ironworkers. He conducted a survey based on standards for fall protection containing hypothetical situations where the worker was asked to respond that the situation was 'safe', 'unsafe' or 'I don't know'. It was found that approximately "95% of the iron workers surveyed had a low to moderate sensitivity toward unsafe conditions"

(Patel, 2003). He also found that about half of the iron workers surveyed had more misses than false alarms, which was considered a 'risky' decision making strategy. Where age and years on the job were concerned, Patel's regression analysis indicated that sensitivity was not linearly correlated to age, and a moderate dependency between years on the job and sensitivity was found, although no strong linear correlation between the two was present.

2.5 The Five Factor Model

Borne on the shoulders of a German researcher named Baumgarten, Allport and Odbert bought themselves a dictionary. In 1933, Baumgarten had released the fruits of many years' labor in the form an extensive list of descriptive German words that could be construed to reflect the nebulous concept of 'Persönlichkeit': personality.

Allport and Odbert poured over an unabridged English dictionary, seeking terms that "distinguish the behavior of one human being from that of another" (Allport and Odbert 1936). In the end, they collected more than 18,000 words. In an attempt to organize their list, Allport and Odbert came up with four categories. They defined the first category as "generalized and personalized determining tendencies - consistent and stable modes of an individual's adjustment to his environment" (Allport and Odbert, 1936), such as sociable, aggressive and fearful. The second category was temporary states, activities and moods, such as afraid, rejoicing and elated. Category three consisted of "highly evaluative syntax and judgments of personal conduct" (Allport and Odbert, 1936), such as excellent, worthy, average, irritating. The fourth category was created to encompass all the heretofore-uncategorized terms, containing physical descriptions, capabilities, talents; basically everything that could not easily be included in one of the previous categories.

Norman (1967) took the terms collected by Allport and Odbert and re-categorized them into seven groups: "biophysical traits, temporary states, activities, social roles, social effects, evaluative terms, anatomical terms and physical terms". In the process, he eliminated ambiguous or obscure terms that he felt were not useful in describing personality. Norman stated that a person could be described in a variety of ways: enduring traits (irascibility), internal states (gleeful), physical traits (tall), activities (jumping), effects on others (comforting), roles they play (parent) and the social evaluation of their conduct (unacceptable).

Up to this point, the lexicon had been assigned to categories that the researchers were assuming were mutually exclusive, but some researchers felt that the boundaries between the categories were fuzzy, and that many of the descriptors could fit into more than one category (Allen and Potkay, 1981). In a further effort to clarify the categories for personality terms and develop a working taxonomy, Cattel (as cited in Pervis and Johns, 1999), took a subset of the Allport/Odbert list, and began to develop his multidimensional model of personality structure. Cattel eliminated nearly 99% of the subset with which he began, and narrowed the field to a mere 35 variables. Pervis and Johns (1999) indicate that Cattel's decision to eliminate so many of the original terms may have been because of the data analytic capabilities contemporary to Cattel's research: factor analysis of variable sets containing a large number of variables was "prohibitively costly and complex" (Pervis and Johns, 1999). In 1970, Cattel and colleagues released a 16 Personality Factor Questionnaire (16PF), and this quickly became not only the object of much criticism, but also a readily available basis for further research concerning viable, valid and reliable personality inventories and questionnaires.

One important direction for research stemming from the 16 factor model was the inclination toward models with fewer, broader categories. One of the most accepted and widely used personality factor models is the Five Factor Model. Fiske (1949), Tupes and Christal (1961), Norman (1963), Borgata (1964), Digman and Takemoto-Chock (1981), and various others were intimately involved in the creation of the Five Factor structure, as well as the independent reproduction of the structure based on Cattel's categories. Though there is some argument surrounding the actual names of the factors, such as Extraversion sometimes referred to as Surgency, and Openness sometimes labeled Intellect, the facets that the factors encompass are generally agreed upon by the experts in the field. The Five Factors are as follows (each factor is succeeded by a few of its key facets):

1. Extraversion (or Surgency): talkative, assertive, energetic
2. Agreeableness: good-natured, cooperative, trustful
3. Conscientiousness: orderly, responsible, dependable
4. Emotional Stability (vs. Neuroticism): calm, not prone to depression, not self-conscious. [When Emotional Stability is reported as Neuroticism, any correlation to this trait simply changes signs]
5. Openness (or Intellect): imaginative, independent-minded, receptive to new things

In 1981, Goldberg coined the phrase "The Big Five", intending to reflect the broad, encompassing nature of the factors themselves (Pervis and Johns, 1999). Goldberg felt that the five traits represented personality on a global scale, the "broadest level of abstraction" with each factor enveloping a large number of distinct and specific, though related, personality characteristics (Pervis and Johns, 1999).

From this foundation, many inventories and questionnaires were developed. Of these, there are three questionnaire types with appropriate validity, reliability and acceptability to other researchers, which were considered for the personality assessment segment of the proposed research. They are as follows:

1. The NEO FFI: Neuroticism, Extraversion and Openness Five Factor Inventory. In general, this is the most commonly used of the three in a traditional questionnaire setting. Originally published by Costa and McCrae in 1992.
2. The TDA: Trait Descriptive Adjectives. This inventory is a list of single adjectives that the survey responder indicates whether they believe each term accurately describes themselves. Originally published by Goldberg in 1992.
3. The BFI: Big Five Inventory. This inventory is laid out in short phrases, not the full sentence structure of the NEO FFI, but longer and somewhat less ambiguous than the single descriptors of the TDA. Originally published by John, Donahue and Kettle in 1991.

The third form of the Five Factor Model was employed to assess the personality segment of the research reported in this thesis. This is discussed further in Chapter 3.

2.6 People-Based Safety (Geller and Weigand, 2006)

E. Scott Geller, the Director of the Center for Applied Behavior Systems at Virginia Tech in Blacksburg VA, was kind enough to grant the author of this thesis access to his most recent scholarship concerning the relationship between occupational safety and contemporary personality constructs, such as the Big Five. Dr. Geller has indicated that though nothing definitive has been found in this area, much more research is needed, warranted and encouraged. This paper is awaiting publication, and the information given here is from the final draft version of the article, which was kindly supplied by Dr. Geller.

In their article, Geller and Wiegand (2006) indicate the importance of three distinct variables, and emphasize that these variables are interactive, dynamic and reciprocal. The three domains identified by Geller and Wiegand are:

1. Environment: tools, equipment, climate of the workplace
2. Person: employee attitudes, beliefs, and personalities
3. Behavior: safe and at-risk work practices, as well as the willingness of another to intervene for a coworker's safety

Geller and Wiegand also recognize that situations and worker personalities are interactive, an important basis for this research. The article states: "to achieve and maintain an injury free workplace, employees need to address each of these domains daily during the development, implementation, and evaluation of intervention strategies to remove environmental hazards, decrease at-risk behaviors, increase safe behaviors, and provide more user friendly or ergonomically sound work environments." (Geller and Weigand, 2006).

Geller and Weigand cite numerous studies which have evidenced that personality factors influence safety-related behavior, many of which are also cited by Dr. Doug Cellar and colleagues (2001), whose work is discussed in the next section. It seems that the initial push to discover this relationship was in an attempt to define the injury-prone personality. The methods used to this end were multiple and quite varied, and most of the methods contained serious flaws, leading to inconsistent and ambiguous results (Hadden, Suchman, & Klein, 1964; McKenna, 1983; Shaw & Sichel, 1971). Geller and Weigand indicate that these flaws led to a significant amount of confusion about the subject, and a low general opinion concerning the worthiness of the research. They indicate, however, that the subject pops up about every ten or twelve years in the related literature, and many contemporary researchers have continued to identify past failings and miscommunications while calling for further study.

Geller and Weigand also ascertained that past safety researchers have focused on the readily observable and reliably measured variables of environment and behavior factors. It is important to note that these styles of study and subsequent management strategies have not failed, and are the foundations of personality/safety research. In a sense, these types of studies have pushed the American (and global) realm of occupational safety systems to the current state. However, in light of the statistics reported by the U.S. Bureau of Labor Statistics (see Figure 1.1) it seems apparent that the number of occupational fatalities has reached a plateau, and has seen the first increase in almost eleven years. This trend points to the fact that although the safety developments of the past been successful, there is room and need for improvement. Geller and Weigand term the concept "Low Hanging Fruit," saying that past research in terms of environment and behavior factors has been successful, and should, by all means, be continued, but should not be taken as the bottom line of safety research. The two researchers believe that one path for future safety research lies in the realm of personality, and suggest the Five Factor Model as a most appropriate tool.

The article includes a discussion of personality traits themselves, and a detailed discussion of the Big Five and the Five Factor Model. This information was covered in the preceding section (2.5), and need not be repeated here.

Geller and Weigand (2006) also indicate that empirical research concerning specific relationships between the Big Five and safety-related behavior is exceptionally rare, and that they could only find one article that addressed these issues. The article is "The Five Factor Model and Safety in the Workplace" (Cellar et al, 2001), which is discussed in detail in the following section (2.7).

Personality trait researchers agree that traits are essentially immutable; people are born with some degree of propensity toward certain personality characteristics (Ones and Viswesvaran, 2002). Geller reiterates his theory that the environment, person and behavior all play interactive and codependent roles in the expression of traits, and the manifestation of traits can be manipulated through environmental conditions, behavior intervention, and interpersonal dialogue.

The final statement of Geller and Weigand's article is as follows, and requires no further explanation.

> *"The authors hope this article will serve two important functions: 1) to increase awareness and understanding of the role personality can play in both injury proneness and injury prevention, and 2) to stimulate the systematic, empirical study of relationships between personality predispositions and voluntary participation in efforts to prevent unintentional injury."*

2.7 The Five Factor Model and Safety in the Workplace (Cellar et al., 2001)

In this study, Cellar and his colleagues administered the Revised NEO Personality Inventory (NEO PI-R) to 202 undergraduate students. They also had the students complete a self-report measure of personal workplace accident involvement histories. In Cellar's own words, "there have been few published studies that have examined the relationships between personality and safety" and fewer still that have involved the Five Factor Model as the personality perspective (Cellar et al., 2001).

Based on other research, Cellar et al. (2001) felt that a more encompassing and coherent representation of the subject could be extrapolated by focusing on safety through the perspective of the Five Factor Model.

A few statistics on the population surveyed in this study are as follows:

- Average age: 20.93 years, standard deviation: ± 4.96 years
- Ethnic background: 60.4% Caucasian, 13.4% Hispanic, 12.4% African American, 9.4% Asian American, 1.5% Native American, and 3% Other
- 69.3% held a job at the time of the study, though all participants had been employed at some time
- The tenure of employment ranged from one to 25 years, averaging 4.9 years, standard deviation ± 4.1 years

The version of the NEO PI-R that Cellar used consisted of 240 questions, judged by the responder on a Likert scale of 1 – 5, with 1 indicating 'strongly disagree' and 5 being 'strongly agree'. The respondents were asked to use this scale in rating the accuracy with which the items in the NEO PI-R described the respondent personally. Each participant also completed a personal safety behavior questionnaire, adapted from a prior study by Arthur and Graziano in 1996 that assessed driving accidents. The NEO PI-R creators, Costa and McCrae, reported their reliability (consistency with prior results) levels as: Neuroticism = .92; Extraversion = .89; Openness = .87; Agreeableness = .86; Conscientiousness = .90. These reliability levels from Cellar's study were in line with Costa and McCrae's (Neuroticism = .90; Extraversion = .87; Openness = .89; Agreeableness = .87; Conscientiousness = .90).

To complete the survey concerning workplace accidents, the participants were asked to supply the number of workplace accidents where they were personally injured, and categorize them as either 'at fault,' where the participant was at least partially responsible for the occurrence of the accident, or 'not at fault,' where the participant was not at all responsible for the occurrence of the accident. Though the participant must have been personally injured for the occurrence to qualify as an accident, the injury did not have to be significant, reported, or even reportable.

The participants were also asked to provide demographic information, including age, gender, year in school, GPA, ethnic identification, and employment status.

The analyses of the data in this study included the examination of possible relationships between each of the five factors, 'at fault' accidents, 'not at fault' accidents, and the total number of accidents. In an effort to measure the ability of each factor to predict accidents, namely, whether a particular participant might become involved in an accident, additional regression analyses were performed. Cellar's findings were as follows:

- Conscientiousness was found to have a statistically significant correlation to both 'at fault' ($r = -.16, p < .05$) and 'not at fault' ($r = -.14, p < .05$) accidents.

- Agreeableness was found to have a significant correlation to the total number of accidents (the sum of 'at fault' and 'not at fault' accidents) ($r = -.13, p < .05$).
- When stepwise linear regression was performed, Conscientiousness alone proved to be a good predictor of the number of 'at fault' accidents $F(1,201) = 3.94, p < .05$ ($R^2 = .019$) as well as the total number of 'at fault' and 'not at fault' accidents $F(1,201) = 5.02, p < .05$ ($R^2 = .024$).
- When Agreeableness was included in the model to predict total work accidents, a ΔR^2 of .009 was found. The model also remained a statistically significant predictor of total workplace accidents $F(2,201) = 3.93$, $p < .05$ ($R^2 = .033$).

Based on these results, Cellar et al. concluded that Agreeableness alone did not account for much incremental variance beyond that found when Agreeableness and Conscientiousness were taken together. The article states that it should come as no surprise that so much common variance was found between Agreeableness and Conscientiousness, considering that the two factors themselves are highly related.

On the whole, Cellar et al. felt that their findings reflected a strong relationship between personality factors and safe work practices and behaviors. They concede that their sample possessed potentially limited work experience, as the mean age of the participants was approximately twenty years and all were enrolled in at least one university course. The article postulates that his findings concerning the Conscientiousness and Agreeableness factors would likely be increased in strength when using an older adult population. Cellar et al. go on to say, "Through the extension of safety research to include the Five Factor Model of personality, it is evident that established personality inventories might be useful for predicting work-related accident behavior by identifying broad behavioral patterns related to safety." They indicate that the identification of these patterns will assist in the development of training programs that focus on altering certain behaviors, rather than trying to change the person (i.e., the individual's personality). It is also mentioned in the Cellar et al. paper that the use of future safety/personality studies could lead to new selection practices, allowing for employee selection based on the likelihood that the prospective employee will behave safely in a work environment, and that using the results of the same types of studies could lead to the development of more effective training programs to minimize the total number of workplace accidents.

2.8 The MMPI and the MBTI

It should be noted that two very influential personality surveys have achieved certain notoriety, but have had no mention in this thesis thus far. The first is the Minnesota Multiphasic Personality Inventory, and the second is The Myers-Briggs Type Indicator.

In the 1930's, a psychologist and a psychiatrist joined forces at the University of Minnesota to develop the Minnesota Multiphasic Personality Inventory (MMPI). The MMPI is the most frequently used clinical test, and is employed often in the legal system. It is well researched and highly reliable, but it is very long, and very difficult to score. It is also vulnerable to faking, because the intent of some items is very obvious (Karp & Karp, 2000). The MMPI is a very in-depth analysis of an individual's personality, and contains 8 clinical scales and 15 content scales, all of which have individual scoring strategies. Multiple versions of the MMPI are currently used, including those focusing on adults, teens and children, and other differentiations. The MMPI has been in use for more than 50 years, and has been subject to criticism that some of the items are "out of date, sexist, awkward, or ambiguous," additionally, "two items which contained religious content specific to Christianity were found to be offensive to other religious sectors" (Karp & Karp, 2000). These criticisms aside, the MMPI has seen tremendous use in the academic and clinical environments, and is considered to be a staple of personality research (Karp & Karp, 2000).

The Myers-Briggs Type Indicator (MBTI) is another well know personality assessment tool. This is a model of personality development, and the four gradient categories were termed 'preferences' by the MBTI creators, Isabel Briggs Myers and her mother, Katharine Briggs (Personality Pathways, 2005). They began their own adjustment of Jung's model in the early 1940's, and Myers-Briggs has been present in personality lexicon ever since. The MBTI preferences are not traits, though they do correlate to certain traits, and have been criticized by fellow psychologists as "too anti-Freudian" (Pervin & Johns, 1992) to apply to the general population. The MBTI is based on the work and theories of Dr. Carl Gustav Jung, a contemporary of Sigmund Freud and a prominent champion and defender of Gestalt personality theory. The Myers-Briggs Type Indicator has often been used as a personality assessment tool to aid in many work situations, most notably, High Performance Work Systems. In this instance Myers-Briggs was used as a measure to better allow members of a work team to mesh together as a single entity for certain job purposes (Personality Pathways, 2005).

Though these two measures were not discussed as a part of this research, it would be remiss to omit them completely from mention. These tests were both reviewed and passed over for possible use as the personality assessment tool for this particular study for various reasons: 1. The length of each respective questionnaire, 2. The depth to which the results are indicated (multiple subcategories in the MMPI and gradient scales in the MBTI), 3. The validity and reliability associated with each, and 4. The knowledge and training required to accurately score the questionnaires.

2.9 Chapter Two Recap

This chapter presented a brief survey of the existing research concerning occupational injuries and fatalities. It discussed the past safety research concerning accident causation with specific emphasis on the work of Rasmussen and Howell et al., as well as the hybridized research of Geller & Weigand (2006) and Cellar et al. (2001). This research indicates that, though great strides have been made in the endeavor to minimize occupational injuries and fatalities, the quest is far from over. Personality research and accident causation research are both well-developed fields, however, they are not often used in conjunction. This chapter also discusses the traditional use of Signal Detection Theory, and how it is used to assess subject sensitivity and risk assessment (strategy). Prior use of SDT in assessing sensitivity and strategy in construction workers was briefly illustrated and further clarification of this subject will be presented in the following chapter. This sample of the existing body of research on both subjects, independently and jointly, suggests that further investigation of the relationship between personality and safety is not only warranted, but necessary.

Chapter 3
METHODOLOGY

3. METHODOLOGY

Chapter one of this thesis offered a brief overview of prior research in the area of accident prevention, and posited personality psychology as a prospective area for future research into the causes of construction accidents. It also included the motivation, goals, and objectives of this research. The second chapter gave background information on Signal Detection Theory and discussed prior applicable use of SDT in the construction industry. Chapter two also included historical information on the Big Five and the Five Factor Model, as well as the research application of personality in the arena of occupational safety. Chapter three presents the methods proposed to achieve the goals and objectives stated in Chapter one.

As stated in Chapter one, the main goal of this research is to enhance the understanding of the factors that influence construction workers' ability to identify hazards. The following sections break down the plan of action to attain this goal by addressing each objective in turn.

3.1 Objective One

Develop a conceptual model to express the relationship between personality traits, situations and the hazard recognition of the construction worker.

Proposed Method

Throughout the development of this research, multiple prior studies involving accident causation and personality, both independently and jointly, were reviewed. These prior research efforts have offered many models, and one model in particular lends itself quite well to the proposed research. The model is an amalgamation of prior models, and was developed by Sanders and Shaw and presented as Figure 1.2, in the form adapted by Sanders and McCormick. The model developed to satisfy Objective One is in the same spirit as the Sanders and Shaw model, though it was created with the specific intent to illustrate the hypothetical connection between personality and situational awareness. Discussion of the model and the model itself are included in Chapter 4.

3.2 Objective Two

Investigate the relationship between personality traits and the hazard recognition level of the construction worker. This objective also involved an investigation of the relationship of personality traits to the decision-making strategy of the worker. This objective was twofold, and was addressed in appropriate steps, as follows.

3.2.1 Objective Two Part A

Develop and conduct a survey using Signal Detection Theory (SDT) to assess worker safety awarenesses.

Proposed Method

At this point, it is appropriate to mention that if this objective had not been previously executed in a similar fashion, it would be necessary to develop a technique to assess the sensitivity and risk orientation of construction workers to unsafe conditions. However, this research closely follows the methods used in Patel (2003), and Narang (2006). The discussion that follows is a summary of this method, the purpose of which is to lay a foundation for the above stated Objective Two Part A.

Patel (2003) conducted an assessment of construction worker sensitivity and risk orientation using a modified version of Signal Detection Theory. In section 2.3, an example concerning defective DC motor detection was given, and parallels were drawn to the possible use of SDT in terms of construction safety. Patel used the terms 'unsafe condition' and 'safe condition' to correspond with the SDT 'states of the world,' signal and noise, respectively. A construction worker is faced with a hypothetical situation, and must respond whether he/she believes the situation presented is either safe or unsafe. For the purposes of the research conducted in the current study, the workers were asked to respond whether they believe a situation is safe, unsafe or they are not sure. The matrix presented in Table 3.1 reflects the following responses and is represented in Table 3.1:

- **Hit**: situation is unsafe; worker answers "Unsafe"
- **Miss**: situation is unsafe; worker answers "Safe"
- **Miss**: situation is unsafe; worker answers "I am not sure"
- **False alarm**: situation is safe; worker answers "Unsafe"
- **False alarm**: situation is safe; worker answers "I am not sure"
- **Correct rejection**: situation is safe; worker answers "Safe"

Table 3.1 SDT Matrix for Detection of Unsafe Conditions in Construction (Adapted from Patel, 2003)

		State of the World	
		SIGNAL (UNSAFE condition)	NOISE (SAFE condition)
Response (Is the condition unsafe?)	YES	HIT	FALSE ALARM
	NO	MISS	CORRECT REJECTION

As was discussed in chapter two, the SDT parameters of d′ and $\beta_{current}$ can be respectively used to assess subject sensitivity and risk assessment/response (strategy). Using the adjusted SDT matrix in Table 3.1, d′ and $\beta_{current}$ can be used to assess the same characteristics of construction workers. As in the example in chapter two, high values of d′ represent a significant ability to discriminate between safe and unsafe conditions, and low values indicate a low ability to do so. The response bias (strategy) would normally be indicated in the same way as in the chapter two example: the value of $\beta_{current}$ compared to the value of β_{opt} would indicate the worker's strategy. However, a peculiarity in the $\beta_{current}$ versus β_{opt} method was discovered, and will be discussed in greater detail at the end of this section.

In Patel's thesis, he indicated that the usual SDT application concerning strategy would consider a worker with fewer false alarms than misses to employ a 'risky strategy.' He states, "In construction, the cost of a miss could be a fatality or serious injury." The author of this thesis is in complete agreement with Patel, and, as discussed in section 2.1, addressed the situation by terming the strategies as follows: the strategy in which the worker has more false alarms will be 'conservative', and where more misses are present, the strategy will be referred to as 'risky.' Additional discourse will be supplied when appropriate to avoid semantic obfuscation.

In the current thesis, the sensitivity and strategy of construction workers has been assessed using a self-report survey, because a live, real time study would not be feasible for many reasons. The survey posed hypothetical situations to the worker and requested one of three responses: "Safe", "Unsafe", or "I am not sure." The corresponding SDT assignments are shown in Table 3.1. The survey was modified from the one used by

Narang (2006), in that the portrayed situations were created using OSHA guidelines, and each situation was specifically safe or unsafe according to OSHA. The survey is comprised of 18 situations. Sample survey questions are as follows, and the survey in its entirety is included as Appendix A:

- A crawler crane lifting steel columns, located at 30 feet from a 600 kV power line.
- When climbing a portable ladder to access an upper landing surface, the side rail extends 3.5 feet above the upper landing surface.
- While erecting steel beams using multiple lift rigging procedure, the steel members are rigged at 6 feet apart.

The worker responses, hit, miss, false alarm, and correct rejection were converted to probabilities to determine the sensitivity and risk orientation of the worker. The following example is used to illustrate the SDT analysis, and is performed on the data obtained from one of the workers who participated in the survey.

Table 3.2 Sample Survey Responses

		State of the World	
		SIGNAL (UNSAFE condition)	NOISE (SAFE condition)
Response (Is the condition unsafe?)	YES	HIT = 8	FALSE ALARM = 6
	NO	MISS = 3	CORRECT REJECTION = 1

The following probabilities can be applied:

P(Noise) = P(Safe condition) = 7/18 =39%

P(Signal) = P(Unsafe condition) = 11/18 = 61%

P(Hit) = 8/11 = 73%

P(Miss) = 1-P(Hit) = 3/11 = 27%

P(False Alarm) = 6/7 = 86%

P(Correct Rejection) = 1-P(False Alarm) = 1/7 = 14%

As outlined in section 2.3, d′ (sensitivity) can be calculated as follows

$Z_1 = -1.08$ and $Z_2 = .61$

Therefore, $d' = -1.08 + .61 = -.47$

This value of d′ indicates that the worker has a low, in fact, negative, ability to distinguish noise from signal; in other words, the worker's sensitivity is actually worse than not being able to distinguish noise from signal at all. This means that the basic SDT equations for β cannot be used, because d′ is negative. Referring again to section 2.3, the course of action for this problem is to use the ratio of areas to produce the values of β. For the sake of clarification, the β values in this research have been calculated using both the corresponding ordinate method and the ratio of areas, and there were no discrepancies in β values were found between the two methods. The ratio of the areas refers to the areas under the curve representing miss and false alarm proportions. When using the ratio of areas, the probability of a miss is divided by that of a false alarm.

Corresponding Ordinate Method for β

Ordinate corresponding to $Z_2 = .331$

Ordinate corresponding to $Z_1 = .223$

$\beta_{current} = .331/.223 = 1.484$

β_{opt} = P(Noise)/P(Signal) = .39/.61 =.639

$\beta_{current}$ is more than β_{opt}, which would make this a risky strategy. However, when examined strictly by the definition of risky strategy, where more misses and fewer false alarms are present, then it is safe to say that the $\beta_{current}$ versus β_{opt} comparison is not correct, and that the procedure that should be used is indeed the ratio of areas. This is because the worker had six false alarms and three misses, making him truly conservative. When the ratio of areas is used, the point of comparison is one (1), because the β value will be one when the pure count and probability of a false alarm is equal to that of miss, with values greater than one indicating a risky strategy, and vice versa.

This particular idiosyncrasy of SDT was discovered during a pilot study for this research. The survey that is included as Appendix A was given to three graduate students in the Construction Management Program at Michigan State University to provide preliminary data to the researcher. During the statistical analysis of the data from this pilot study, it was found that the standard practices used to assign values for β were creating a false assignment of strategy that did not match the pure counts of false alarms and misses. This led to further research and discussion, and resulted in the discovery of the method that has been used to analyze the actual data from the ironworkers in this study.

3.2.2 Objective Two Part B

Conduct a version of the Five Factor Model (FFM) personality test with the same population as surveyed in Objective Two Part A.

Proposed Method

As mentioned in section 2.3, the method selected to measure the personality segment of this research was the Big Five Inventory (BFI), an established questionnaire format of the Five Factor Model. The reasons for the use of this model quite simple: the validity and reliability is effectively identical for the TDA, the NEO FFI and the BFI. However, the BFI uses a format that is more conducive to the study at hand, because it is not time consuming and is relatively unambiguous, hence able to minimize confusion or apathy on the part of the responder.

The personality questions that appear on the survey were selected from the 100 available on the International Personality Item Pool (IPIP, 2005) website. An equal number of questions for each factor were included in the survey, which consisted of 30 items. It is appropriate to mention that some items in the BFI are scored in reverse because the question is presented as a negative, and reversing the score is much less confusing to the responder than asking the responder to reverse the location of 'strongly agree' and 'strongly disagree' in the Likert scale. The following list contains examples of BFI survey questions, and the personality section, which comprises the second half of the actual survey that was given to the ironworkers in included in Appendix A.

- I am the life of the party
- I feel little concern for others
- I am always prepared
- I get stressed out easily
- I have a rich vocabulary

As mentioned above, certain items are reverse scored because of negativity: essentially the responder is asked how well each question applies to themselves, and occasionally a question is asked that is the reverse of the factor being measured. For example, the question is "I have little to say" or "I don't talk a lot" and the response is "Very Accurate." In this case the responder shows very little of the factor being measured, which is Extraversion, and would receive a score of one for that answer to either question. Similarly, if the question is "I feel little concern for others" and the answer is "Very Accurate" then the score is one, because the questions measures Agreeableness. A person who says that feeling little concern for others is an accurate description of themselves is probably not very agreeable.

The decision was made concerning this survey to drop the number of questions from the usual 50 or 100 to thirty for several reasons. The first is that no validity is lost even when the test has only 10 questions, or two per factor, (IPIP, 2005). Additionally, though the safety portion of the survey is only 18 questions, it represents nine pages of the entire survey. According to the IPIP information (2005) the need for 50 or more questions is arbitrary in terms of validity and reliability of the survey, and participant fatigue and apathy are increasing factors, respective to the length (real or perceived) of the survey as a whole.

Similar to the scale used to assign groups via the range of sensitivities for SDT, the following table can be constructed to categorize the Five Factor results.

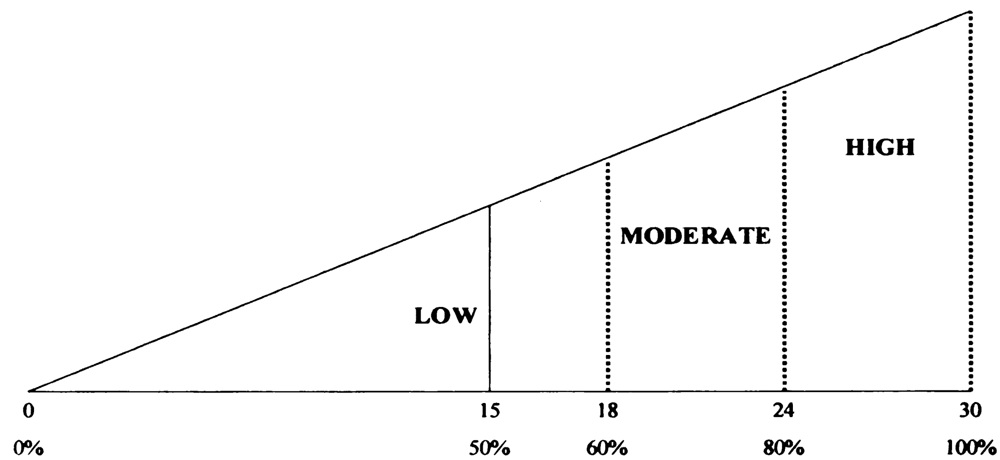


Figure 3.1 Ranges for the Five Factors

3.3 Additional Demographic Data

In addition to the data collected via SDT and BFI, certain demographic information, including age, gender, years of experience and prior accident occurrence (accidents on the job resulting in hospital visits or emergency medical care) were included in separate analyses to both the SDT and the FFM results. These factors were regressed against the SDT and FFM measures, and the results of those analyses are discussed in chapters four and five. It should be noted that though there was no restriction on gender (or any other variable), all of the participants in the survey were male.

3.4 Methodology Summary

This chapter outlined the procedures that were used to conduct this research, and presented the modifications made to the survey tools. It discussed the changes in the analysis of the SDT measure of β, due to the presence of negative d' values. This change was further indicated by a pilot study done on three Master's students at Michigan State

University before the survey was given to the ironworkers consulted in this study. A complete statistical analysis was performed on the results of the pilot study, and the limitations of using $\beta_{current}$ and β_{opt} became apparent. The decision was then made to use the ratio of areas method suggested by Macmillan and Creelman (1991).

The reverse scoring for 'negative' questions in the personality section of the survey was discussed, as was the decision to reduce the number of questions in this section. This chapter also indicated that certain demographic information was collected and regressed in the analysis.

Chapter 4

SURVEY RESULTS AND DATA ANALYSIS

4. Survey Results and Data Analysis

This chapter presents the survey data and its analysis according to the procedure outlined in the previous chapter. As explained in chapter one, construction is an inherently hazardous occupation, and this research was intended to broaden the scope of previuos safety research by examining the relationship between personality factors and hazardous situation recognition data as measured by Signal Detection Theory methods.

4.1 Objective One: The Model

As stated in chapter three, objective one was to develop a conceptual model to express the relationship between personality traits, jobsite situations and the hazard recognition of the construction worker. Figures 4.1 and 4.2 illustrate the model, with Figure 4.1 representing the basic model, and Figure 4.2 demonstrating a higher degree of detail.

While pursuing a degree in psychology some years ago, the author of this thesis was enrolled in several educational psychology classes. These classes were specific to the education of students (children and adults) with mental illness and disabilities. The idea of the 'ABCs of Behavior' has been a long-standing tenet of behavioral psychology, upon which special education psychology classes rely heavily. This idea helps a person to understand his/her own behavior, as well as to provide insight into the behavior of others. The common sense version of this Antecedent – Behavior –Consequence theory is that everyone does what they do for a reason, and people do not do something if they get nothing from it. It must be kept in mind, however, that the 'something' a person gets from an action may not be something positive, but could be the removal of something negative. In certain cases, it can be said that negative attention is more desirable to the subject than no attention at all, if attention in general was the goal of the behavior. The basic model developed for this thesis and the fulfillment of Objective One is as follows.

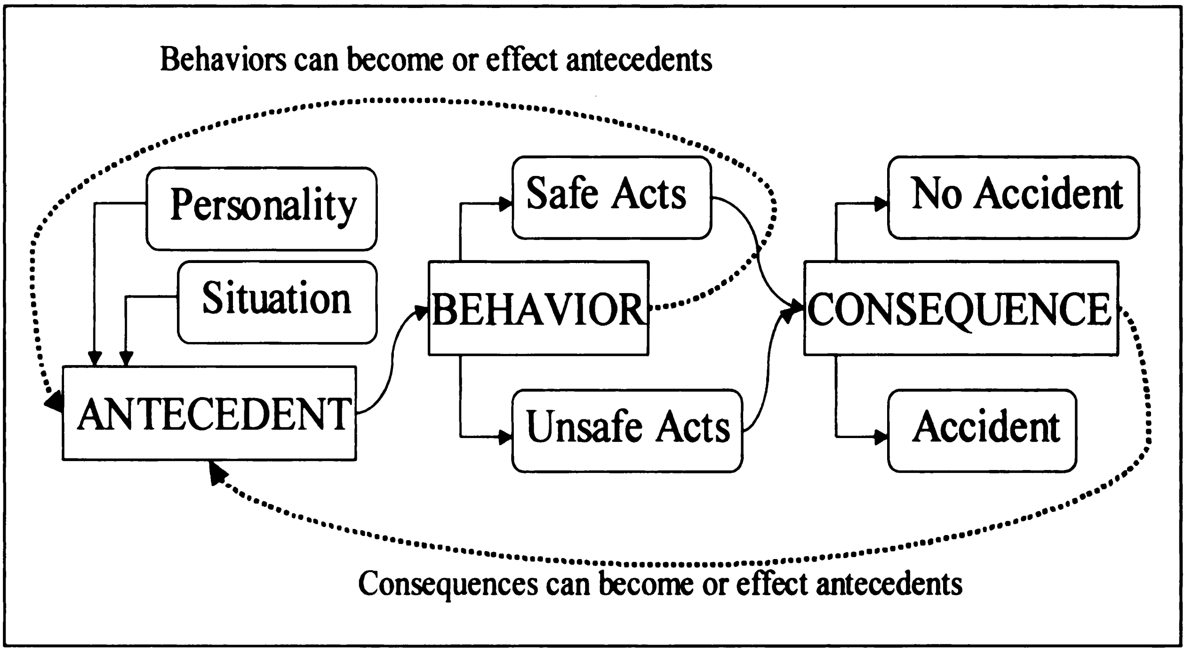


Figure 4.1 The ABCs of Accidents

Essentially, the model suggests that action (behavior) is preceded by a reason for that action (antecedent), and once the action is carried out, it is followed by one or many outcomes (consequences). For example: two children at day care would like to play with the same truck. Child A has the truck, and Child B desires it. Child B now has a reason or antecedent for his behavior: he wants the toy. His behavior, stemming from this antecedent, will have consequences. The action Child B opts for could be to simply take the truck from the other child. As any parent knows, most children of day care age (and older) do not consider the consequences of their action before they do something. In this case, the consequence might be that Child A cries when Child B takes the truck, and maybe an adult would come take the truck back from Child B.

At this point the consequence becomes an antecedent, and Child B now can choose to act in a variety of ways. Child B can cry, try to reclaim the truck, move on to other toys, etc. Each level, each behavior, is an ever-blossoming, multi-petaled flower that continues to grow and change. It is assumed and expected that the consequences of actions will teach a lesson, and they do, but it may not always be the lesson that was intended. For instance, Child B may choose to scream and cry when an adult takes from him the truck he took from Child A, and the adult may give Child B a piece of candy. This essentially becomes positive reinforcement for the child to scream and cry, because the message that he received was "When I cry I get candy" as opposed to, "I should not take someone else's toys." Admittedly, this example is elementary at best, but it should help to clarify the complex interaction of the ABCs.

The ABCs of accidents work in essentially the same way as the example with the children did, with one small change. The costs are much higher when an accident occurs. Ideally, a worker in a potentially hazardous occupation should be aware of and able to identify any possible hazards that may arise. However, this is not a perfect world, and accidents are thus named because they are not expected, and generally were not foreseen. It seems logical that a worker who looks ahead to possible consequences may be better prepared for an accident, and/or better able to avoid one.

The expanded ABCs of accidents begin to explain the details of this research, in that it expands upon the set of antecedents that are specifically at issue in this thesis. As noted in the example with the children and their toy, consequences can become antecedents, but it is important to also note that antecedents can and do work together, and effect each other. In Figure 4.2, the two main antecedents that are being investigated are personality and situation, and the bold bubble contains many examples of things that can effect personality, or situation, or both. It is essential to understand that the defining factor in this research is the worker: i.e. the measurements of personality and safety were taken specifically through the filter of perception, namely that of the worker. Various limitations inherent to this type of research make it incredibly difficult and unreliable, and in some cases unethical, to measure personality and/or hazard recognition in real-time, real-life studies. In light of this, the entire data set for this research was obtained through self-report surveys.

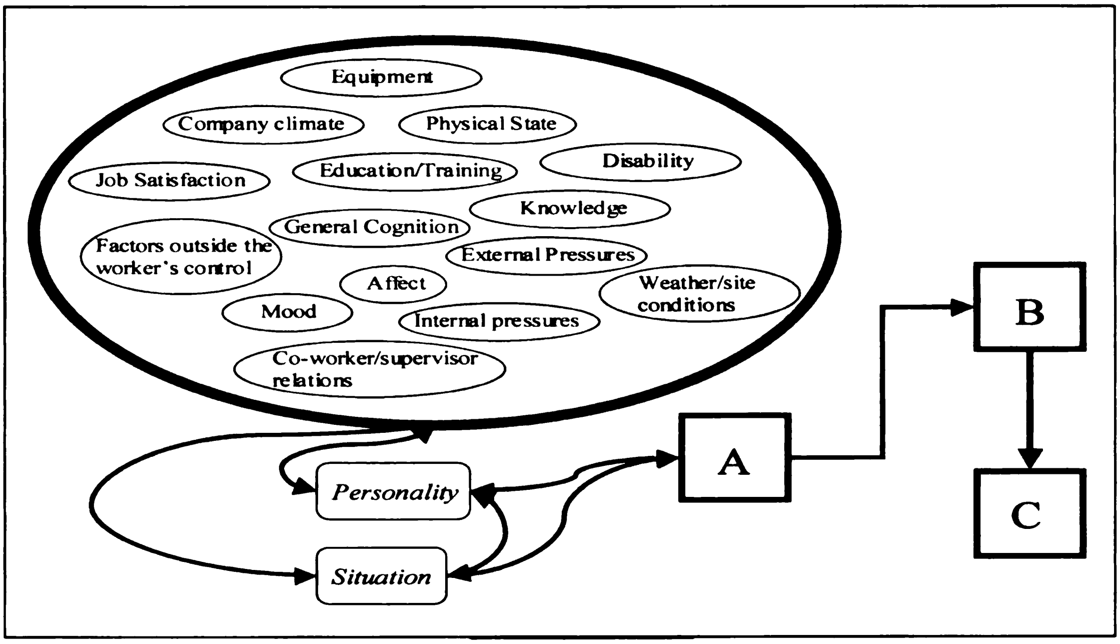


Figure 4.2 The Expanded ABCs of Accidents

4.2 Data Collection

Thirty workers participated in the study by completing the developed survey, and no questions were left unanswered. The sample size was reasonably large to allow the use of the normal distribution to analyze the data. No restriction on age, gender, years of experience, or any other criteria was imposed on the ironworkers who volunteered to complete the survey. The aggregate survey is included as Appendix A. All workers who participated in the survey did so voluntarily, and were not compensated or coerced in any way. Each ironworker had received some form of safety training from their respective companies, and it was reasonable to expect that the situations hypothesized in the survey were within their scope of experience and training. The average age of the workers who participated was 43 years and the average years of experience was 21.

The safety section of the survey addressed situations in which the worker must identify whether the situation was safe or unsafe. The survey was adapted from the one developed and implemented by Narang (2006), and presented 18 situations that an ironworker would encounter during steel erection. The 18 safety questions were comprised of absolutely safe conditions, absolutely unsafe conditions which presented a significant personal risk, and situations that were considered to be unsafe by OHSA standards, but carried a slightly lower personal risk. The workers were asked to choose one of three responses during the SDT safety section, "Safe", "Unsafe" or "I am not sure." The SDT coded responses (hit, miss, false alarm and correct rejection) are included in Appendix B.

Figures 4.3 and 4.4 show the number of miss and false alarm responses to each question. A miss occurs when the worker responds to an unsafe situation with a "Safe" or "I am not sure" answer. A false alarm occurs when the worker responds to a safe situation with an "Unsafe" or "I am not sure" answer. The two questions with the most misses and the most false alarms, as well as the two questions with the least misses and the least false alarms discussed below.

<u>Question #7:</u> *Bolting steel members in place on the 3^{rd} floor, when the temporary bracing is <u>not</u> in place on the lower floors.* 15 misses. Half of the ironworkers scored misses on this question. This number of misses could mean that the situation is ambiguous or unclear in some way, or that the workers do not consider the risk to be significant. The workers may also simply not know if this is safe.

<u>Question #3:</u> *While erecting steel beams using a multiple lift rigging procedure, the steel members are rigged 6 feet apart.* 14 misses. This question could represent an intermittent risk, in that OSHA says it is not safe, but a worker may have to be six feet tall or taller to even consider this a risk.

<u>Question #9:</u> *An opening of 16 inches by 10 inches is left uncovered next to a column. The concrete planks (precast) are bearing (sitting) on the beam that connects to this column.* 27 false alarms. OSHA does not consider this to be a violation, though the workers surveyed in this thesis overwhelmingly felt that this was not safe. This could point to a possible need for revision in the OSHA standards.

<u>Question #15:</u> *Ironworker climbs on the steel beam, when it is held by the crane (tied with a choker), to bolt it in place.* 21 false alarms. This is not an OSHA violation, though 70% of the ironworkers surveyed felt that this was not safe. Again, possible revisions may be indicated.

<u>Question #13:</u> *Removing the fall protection while transferring from a beam to the hoisting crane.* 0 misses. Every single ironworker in this study recognized this as an unsafe situation. In the author's opinion, this is the most obvious unsafe situation in the survey, and it is encouraging to know that the ironworkers surveyed were all aware of the risk involved.

<u>Question #14:</u> *A column is bolted in place with 3 anchor rods while beams are being connected on the 2^{nd} floor.* 1 miss. As was question #13, this was an obviously unsafe condition, and the ironworkers overwhelmingly recognized this.

<u>Question #2:</u> *When climbing a portable ladder to access an upper landing surface, the side rail extends 3.5 feet above the upper landing surface.* 6 false alarms. It is possible that those who scored false alarms on this question simply were not aware of the OSHA requirement for ladder overlap, but it is interesting to note that those who said this was not safe were among the most conservative strategists in the sample.

<u>Question #11:</u> *Operating a forklift on the 4^{th} floor when all perimeter cabling is in place and precast concrete panels are being placed on the 6^{th} floor.* 7 false alarms. As was the case with question #2, the workers who scored false alarms on this question were much more conservative than those who did not. This may also be a somewhat ambiguous question: there is not mention of what activity might be underway on the 5^{th} floor of the building.

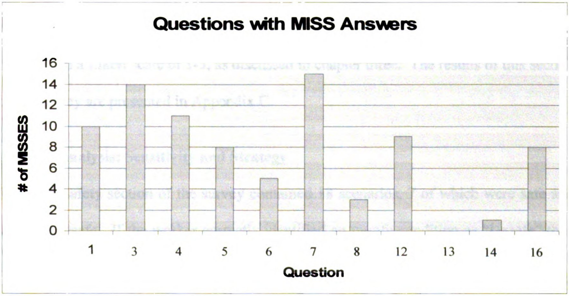


Figure 4.3 Unsafe Situation with "Safe" or "I am not sure" Responses

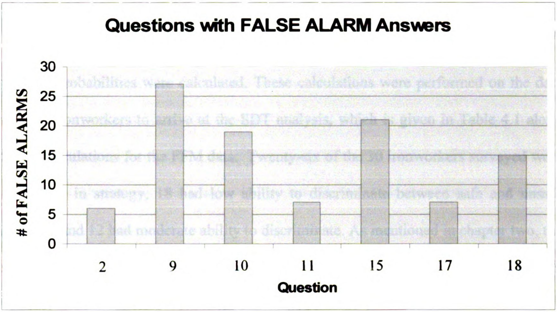


Figure 4.4 Safe Situation with "Unsafe" or "I am not sure" Responses

The personality section of the survey consisted of 30 questions that are further broken down into five categories. Each category, Extraversion (EX), Agreeableness (A), Conscientiousness (C), Emotional Stability (ES) and Openness (O) was represented by six questions, and the total possible score for each category was 30, with values for each question on a Likert scale of 1-5, as discussed in chapter three. The results of this section of the survey are presented in Appendix C.

4.3 SDT Analysis: Sensitivity and Strategy

The SDT safety section of the survey contained 18 scenarios, 7 of which were safe and 11 were unsafe. If the worker correctly identified an unsafe condition as "Unsafe" then the SDT representation was a hit (H). If the worker identified the unsafe situation as "Safe" or "I am not sure" then the response was coded as a miss (M). If the situation was safe and the worker correctly identified it as such, then the response was denoted as a correct rejection (CR). A false alarm (FA) resulted when the situation was safe and the worker identified it as "Unsafe" or "I am not sure."

After the SDT status of the response was assigned (H, M, CR, FA), then the respective probabilities were calculated. These calculations were performed on the data for all 30 ironworkers to arrive at the SDT analysis, which is given in Table 4.1 along with the calculations for the FFM data. Twenty-six of the 30 ironworkers surveyed were conservative in strategy, 18 had low ability to discriminate between safe and unsafe conditions, and 12 had moderate ability to discriminate. As mentioned in chapter two, the ideal value of d' for this study was 4.6, if the worker were to have 11 hits and 7 correct rejections, and the absolute worst situation was 11 misses and 7 false alarms, resulting in a d' value of – 4.6. A d' value of 0, halfway between the ideal (best) value of 4.6 and the worst value of – 4.6, is 50%. As illustrated in Figure 2.4, d' values between – 4.6 and 0.92 (60%) are classified as low, values between 0.92 and 2.76 (80%) are moderate, and values greater than 2.76 are high sensitivity. In terms of β (strategy), values below one are considered to be conservative, values above one are risky, with one representing an absolutely neutral strategy, where the number of misses and false alarms are equal. The average sensitivity (d') was 0.71 with a standard deviation of $\pm$ 0.57 and the average strategy (β) was 0.68 with a standard deviation of $\pm$ 0.61.

4.4 FFM Analysis

As previously discussed, the FFM data was collected in the second section of the survey by means of 30 questions to which the participant responded according to a choices ranging from "Very Accurate" to "Very Inaccurate". The complete data set for all 30 ironworkers is shown in Table 4.1, containing the SDT and FFM measures as well as the collected demographic and historical data.

The scoring was performed according to a Likert scale of 1-5, 1 being "Very Accurate" for questions that were not posed in the negative sense, and 5 being "Very Accurate" for those questions that were posed in the negative sense. After the surveys were scored the total score for each category was tallied. The total possible score for any category was 30, because there were 6 questions for each category and the maximum score for each question was 5.

Table 4.1 Summary of Data

Worker	Age	Exp.	Acc.	EX	A	C	ES	O	d′	β	Strategy b	Sensitivity d
1	42	20	0	23	26	25	18	24	1.16	0.16	Conservative	Moderate
2	26	2	0	19	28	27	18	26	0.53	0.84	Conservative	Low
3	52	30	1	20	20	24	24	19	0.91	1.24	Risky	Low
4	37	20	0	19	22	20	22	29	1.52	0.21	Conservative	Moderate
5	49	30	0	20	20	24	24	19	1.17	0.93	Conservative	Moderate
6	50	31	0	9	24	22	19	16	1.16	0.16	Conservative	Moderate
7	24	2	0	25	30	26	20	21	0.79	0.63	Conservative	Low
8	48	25	0	15	21	18	17	18	1.16	0.16	Conservative	Moderate
9	48	20	0	15	22	23	28	17	0.53	0.84	Conservative	Low
10	49	32	0	15	21	22	18	21	-0.47	0.31	Conservative	Low
11	33	11	0	19	22	25	21	21	1.17	0.93	Conservative	Moderate
12	48	29	0	15	18	16	17	12	0.44	0.47	Conservative	Low
13	42	14	0	13	11	15	18	18	-0.95	0.52	Conservative	Low
14	28	8	0	19	22	18	19	27	1.21	3.21	Risky	Moderate
15	49	29	0	21	24	21	19	22	0.79	0.13	Conservative	Low
16	50	28	1	21	22	27	21	20	1.17	0.93	Conservative	Moderate
17	47	29	1	23	23	25	23	26	1.16	0.16	Conservative	Moderate
18	39	18	0	20	19	21	18	16	0.68	1.55	Risky	Low
19	42	19	0	23	26	25	18	23	1.52	0.21	Conservative	Moderate
20	26	5	0	20	27	27	18	26	0.00	1.33	Risky	Low
21	43	20	0	21	21	25	14	20	0.06	0.38	Conservative	Low
22	49	21	0	15	21	18	17	18	0.74	0.32	Conservative	Low
23	52	33	1	15	21	22	18	21	0.06	0.38	Conservative	Low
24	44	21	0	21	21	25	14	20	0.44	0.47	Conservative	Low
25	43	20	0	23	26	27	18	23	1.09	0.42	Conservative	Moderate
26	52	30	1	20	20	25	24	18	0.53	0.84	Conservative	Low
27	48	20	0	16	23	24	27	16	0.53	0.84	Conservative	Low
28	31	11	0	18	23	24	22	22	0.79	0.63	Conservative	Low
29	52	30	1	21	19	23	25	18	1.17	0.93	Conservative	Moderate
30	49	29	0	22	25	22	20	23	0.36	0.25	Conservative	Low
avg.	43	21	0.2	19	22	23	20	21	0.71	0.68	Conservative	Low

The average score and standard deviations for the FFM factors were as follows:

Extraversion: sample mean: 18.87, sample standard deviation: ± 3.60

Agreeableness, sample mean: 22.27, sample standard deviation: ± 3.54

Conscientiousness, sample mean: 22.87, sample standard deviation: ± 3.29

Emotional Stability, sample mean: 19.97, sample standard deviation: ± 3.44

Openness, sample mean: 20.67, sample standard deviation: ± 3.82

According to Figure 3.1, the high range for all five factors is 80% or more (a score of 24 or higher), the moderate range is 60% to 80% (a score of 18-23), and the low range is anything below 60% (18 or less); the sample average for all five personality factors fell in the moderate range.

4.5 Regression Analysis

Regression analysis was performed to determine the relationship between the workers' safety knowledge and their personalities. Regressions were performed individually to compare age, years of experience, and number of accidents to sensitivity and strategy. Regressions were also individually performed to compare the FFM measures to the SDT measures. The R^2 and p-values for each regression model constructed are recorded in Table 4.2, and the entire regression and scatter plots for each regression are included as Appendix D.

Table 4.2 Regression R, R^2 and p-values

variables	R	R^2 (%)	P_value
d′ and Age	0.316	0.1	0.884
d′ and Exp	0.447	0.2	0.797
d′ and Acc	1.095	1.2	0.057
d′ and EX	3.507	12.3	0.572
d′ and A	3.847	14.8	0.036
d′ and C	2.280	5.2	0.226
d′ and ES	2.665	7.1	0.155
d′ and O	2.280	5.2	0.226
ß and Age	3.962	15.7	0.030
ß and Exp	3.834	14.7	0.036
ß and Acc	0.548	0.3	0.770
ß and EX	0.775	0.6	0.692
ß and A	0.894	0.8	0.692
ß and C	0.447	0.2	0.826
ß and ES	1.817	3.3	0.340
ß and O	1.095	1.2	0.558

As indicated in Table 4.2, the only variable combinations that had a p-value less than .05 were d′ and Agreeableness, β and Age and β and Experience. The R^2 values for these items are low, but the fact that the p-value is less than α indicates that the finding itself is significant, and there is a linear association between the two.

4.6 Grouped Analysis (SDT)

Considering the low levels of correlation and high p-values resulting from the regression analysis, further analysis was conducted. The workers were split into groups according to their strategy, risky v. conservative, and also according to their level of sensitivity: i.e., low, moderate or high. This further analysis was attempted to determine whether any patterns or trends existed within particular sub-groups.

Table 4.3 shows the results of this grouped analysis. The table shows the average age, experience, accidents, Extraversion, Agreeableness, Conscientiousness, Emotional Stability, Openness and d′ (sensitivity), in relation to β (strategy).

As shown below in Table 4.3, no difference between either strategy group and the average of the 30 workers as a whole was greater than the respective standard deviation for that variable. For example, the difference between the risky group and the average of all workers for the variable Openness was 1.39; still within the standard deviation for the entire sample, which was 3.82. This is further illustrated in Figures 4.5 and 4.6.

Likewise, the difference between the conservative group and the risky group across all variables was less than the standard deviation for the respective variables. The average for the risky group was lower than the average for the conservative group on all variables with the exception of accidents, Extraversion and Openness. In other words, the risky group was on average, younger, less experienced, less agreeable, less conscientious, less stable emotionally, and had a lower sensitivity. However, the differences in the averages for all variables between the two groups were too miniscule to be considered definitive in any way.

Table 4.3 Average Variable Value Differences by Strategy Groups

β	Age	Exp.	Acc.	EX	A	C	ES	O	d′
avg all	43.07	21.23	0.20	18.87	22.27	22.87	19.97	20.67	0.71
avg risky	36.25	15.25	0.25	19.75	22.00	19.75	19.75	22.00	0.70
avg cons	44.12	22.15	0.19	18.73	22.31	22.92	20.00	20.46	0.72
diff risky	6.82	5.98	0.05	0.88	0.27	3.12	0.22	1.33	0.01
diff cons	1.05	0.92	0.01	0.14	0.04	0.06	0.03	0.21	0.01
risky - cons	-7.87	-6.90	0.06	1.02	-0.31	-3.17	-0.25	1.54	-0.02
st. dev all	8.67	9.14	0.41	3.60	3.54	3.29	3.44	3.82	0.57

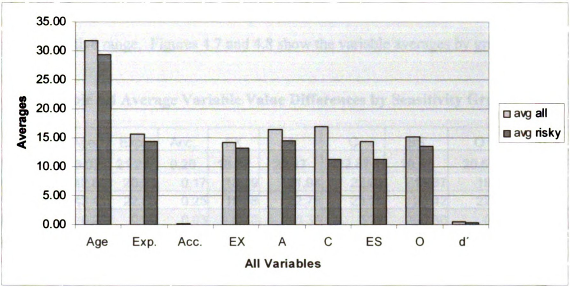


Figure 4.5 Risky Group Averages Compared to Overall Averages (β)

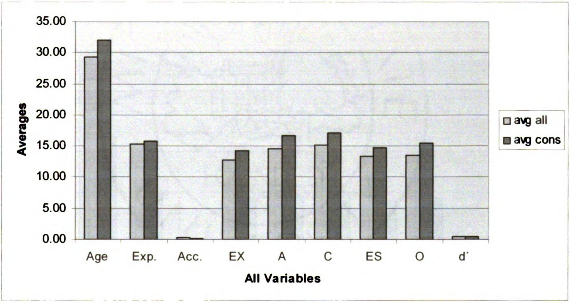


Figure 4.6 Conservative Group Averages Compared to Overall Averages (β)

The same type of breakdown by groups was performed with respect to sensitivity, and as in Table 4.3, Table 4.4 shows the average age, experience, accidents, Extraversion, Agreeableness, Conscientiousness, Emotional Stability, Openness and β (strategy), but related them to the sensitivity groups of low and moderate, as there were no results in the highly sensitive range. Figures 4.7 and 4.8 show the variable averages by group.

Table 4.4 Average Variable Value Differences by Sensitivity Groups

d′	Age	Exp.	Acc.	EX	A	C	ES	O	β
Avg all	43.07	21.23	0.20	18.87	22.27	22.87	19.97	20.67	0.68
Avg low	42.83	20.33	0.17	18.39	21.94	22.61	19.67	19.78	0.66
Avg mod	43.42	22.58	0.25	19.58	22.75	23.25	20.42	22.00	0.70
diff low	0.23	0.90	0.03	0.48	0.32	0.26	0.30	0.89	0.01
diff mod	0.35	1.35	0.05	0.72	0.81	0.38	0.45	1.33	0.02
Low-mod	-0.58	-2.25	-0.08	-1.19	-0.81	-0.64	-0.75	-2.22	-0.04
st. dev all	8.67	9.14	0.41	3.60	3.54	3.29	3.44	3.82	0.61

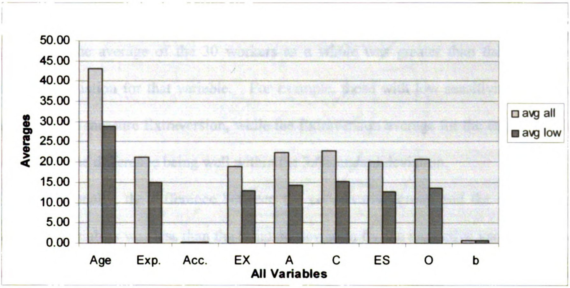


Figure 4.7 Risky Group Averages Compared to Overall Averages (d′)

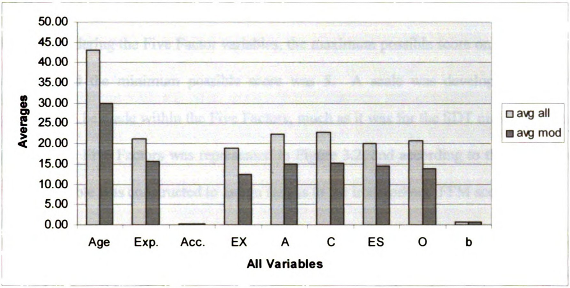


Figure 4.8 Conservative Group Averages Compared to Overall Averages (d′)

Similar to the results of grouping by strategy, no difference between either sensitivity group and the average of the 30 workers as a whole was greater than the respective standard deviation for that variable. For example, those with low sensitivity averaged 18.39 for the measure Extraversion, while the Extraversion average for the entire sample was 18.87, the difference being well within the 3.6 standard deviation.

Additionally, the difference between the conservative group and the risky group across all variables was less than the standard deviation for the respective variables. The average for the low sensitivity group was less than the average for the moderate sensitivity group on all variables. The average for the low sensitivity group was also less than the average of the 30 workers as a whole for all variables. Again, as was the case when grouped by strategy, the differences in the averages for all variables between the two groups were too miniscule to be considered definitive in any way.

4.7 Grouped Analysis (FFM)

When considering the Five Factor variables, the maximum possible score on any variable was 30, and the minimum possible score was 5. A scale was developed to allow groupings to be made within the Five Factors, much as it was for the SDT measures. The scale for the Five Factors was represented in Figure 3.2, and according to this scale, the following table was constructed to assign ranges to the ironworkers' FFM scores.

Table 4.5 Five Factor Ranges

	Actual Score							Range				
Worker	EX	A	C	ES	O	d′	β	EX	A	C	ES	O
1	23	26	25	18	24	1.16	0.16	Moderate	High	High	Low	Moderate
2	19	28	27	18	26	0.53	0.84	Moderate	High	High	Low	High
3	20	20	24	24	19	0.91	1.24	Moderate	Moderate	Moderate	Moderate	Moderate
4	19	22	20	22	29	1.52	0.21	Moderate	Moderate	Moderate	Moderate	High
5	20	20	24	24	19	1.17	0.93	Moderate	Moderate	Moderate	Moderate	Moderate
6	9	24	22	19	16	1.16	0.16	Low	Moderate	Moderate	Moderate	Low
7	25	30	26	20	21	0.79	0.63	High	High	High	Moderate	Moderate
8	15	21	18	17	18	1.16	0.16	Low	Moderate	Low	Low	Low
9	15	22	23	28	17	0.53	0.84	Low	Moderate	Moderate	High	Low
10	15	21	22	18	21	-0.47	0.31	Low	Moderate	Moderate	Low	Moderate
11	19	22	25	21	21	1.17	0.93	Moderate	Moderate	High	Moderate	Moderate
12	15	18	16	17	12	0.44	0.47	Low	Low	Low	Low	Low
13	13	11	15	18	18	-0.95	0.52	Low	Low	Low	Low	Low
14	19	22	18	19	27	1.21	3.21	Moderate	Moderate	Low	Moderate	High
15	21	24	21	19	22	0.79	0.13	Moderate	Moderate	Moderate	Moderate	Moderate
16	21	22	27	21	20	1.17	0.93	Moderate	Moderate	High	Moderate	Moderate
17	23	23	25	23	26	1.16	0.16	Moderate	Moderate	High	Moderate	High
18	20	19	21	18	16	0.68	1.55	Moderate	Moderate	Moderate	Low	Low
19	23	26	25	18	23	1.52	0.21	Moderate	High	High	Low	Moderate
20	20	27	27	18	26	0.00	1.33	Moderate	High	High	Low	High
21	21	21	25	14	20	0.06	0.38	Moderate	Moderate	High	Low	Moderate
22	15	21	18	17	18	0.74	0.32	Low	Moderate	Low	Low	Low
23	15	21	22	18	21	0.06	0.38	Low	Moderate	Moderate	Low	Moderate
24	21	21	25	14	20	0.44	0.47	Moderate	Moderate	High	Low	Moderate
25	23	26	27	18	23	1.09	0.42	Moderate	High	High	Low	Moderate
26	20	20	25	24	18	0.53	0.84	Moderate	Moderate	High	Moderate	Low
27	16	23	24	27	16	0.53	0.84	Low	Moderate	Moderate	High	Low
28	18	23	24	22	22	0.79	0.63	Low	Moderate	Moderate	Moderate	Moderate
29	21	19	23	25	18	1.17	0.93	Moderate	Moderate	Moderate	High	Low
30	22	25	22	20	23	0.36	0.25	Moderate	High	Moderate	Moderate	Moderate
avg. all	19	22	23	20	21							

(Figures in Appendix G show the distribution of low, moderate and high scores for each of the Five Factors.)

As was performed with the SDT results, group analysis was executed with the FFM results. The results are presented below in summary tables and figures, followed by a brief explanation.

Table 4.6 d′ and the Five Factors

	EX	A	C	ES	O
d′ avg all	0.71	0.71	0.71	0.71	0.71
d′ avg low	0.40	-0.26	0.52	0.46	0.60
d′ avg mod	0.88	0.78	0.71	0.98	0.76
d′ avg high	0.79	0.78	0.77	0.75	0.88
d′ diff low	0.31	0.97	0.20	0.25	0.11
d′ diff mod	0.16	0.07	0.01	0.26	0.05
d′ diff high	0.08	0.07	0.05	0.03	0.17
d′ low-high	-0.39	-1.04	-0.25	-0.28	-0.28
d′ st. dev. all	0.57	0.57	0.57	0.57	0.57

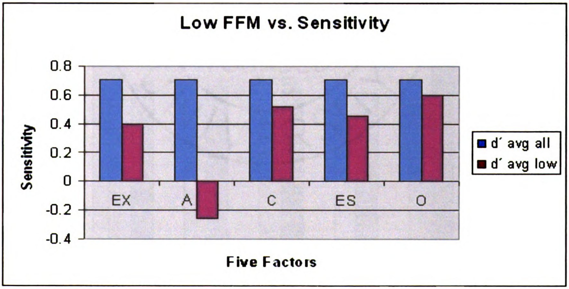


Figure 4.9 Low Five Factor Scores Compared to Sensitivity (d′)

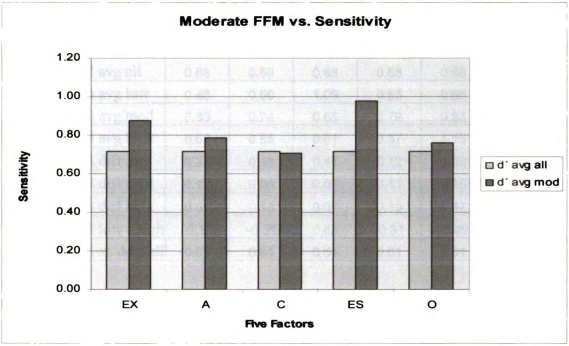


Figure 4.10 Moderate Five Factor Scores Compared to Sensitivity (d′)

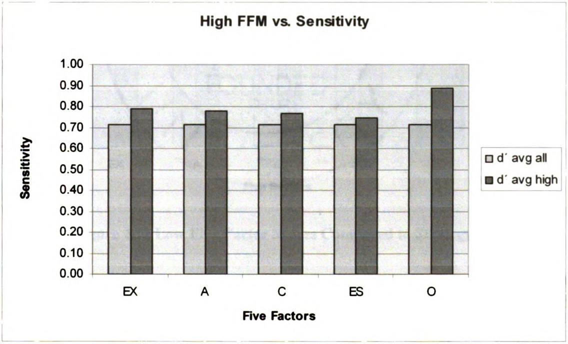


Figure 4.11 High Five Factor Scores Compared to Sensitivity (d′)

Table 4.7 β and the Five Factors

	EX	A	C	ES	O
β avg all	0.68	0.68	0.68	0.68	0.68
β avg low	0.46	0.50	1.09	0.55	0.66
β avg mod	0.80	0.74	0.65	0.79	0.53
β avg high	0.63	0.55	0.61	0.87	1.15
β diff low	0.22	0.18	0.41	0.12	0.02
β diff mod	0.12	0.06	0.03	0.11	0.15
β diff high	0.05	0.13	0.07	0.19	0.47
β low - high	-0.17	-0.05	0.48	-0.31	-0.49
β st. dev. all	0.61	0.61	0.61	0.61	0.61

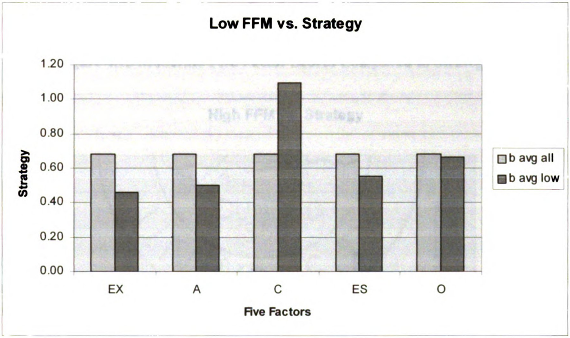


Figure 4.12 Low Five Factor Scores Compared to Strategy (β)

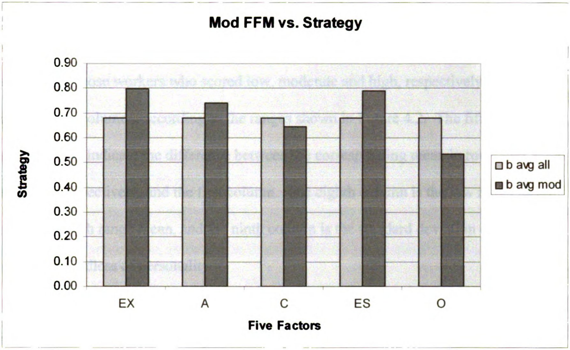


Figure 4.13 Moderate Five Factor Scores Compared to Strategy (β)

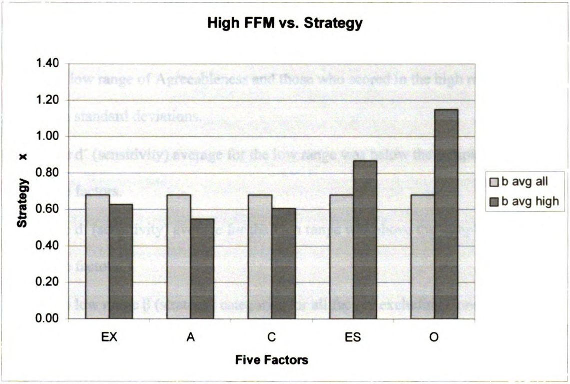


Figure 4.14 High Five Factor Scores Compared to Strategy (β)

For both Tables 4.6 and 4.7, the first row represents the average d′ or β for the entire sample, regardless of personality factor. The second, third and fourth rows are the average for those workers who scored low, moderate and high, respectively, on each factor in the columns, according to the ranges shown in Figure 4.2. The fifth, sixth and seventh rows indicate the difference between the corresponding mean in rows two, three and four, respectively, and the first column. The eighth column is the low range mean minus the high range mean, and the ninth column is the standard deviation of the entire sample, regardless of personality.

Many of the values are within one standard deviation of their respective means, but there are a few notable exceptions. These exceptions are as follows:

- The average d′ (sensitivity) of workers who scored less than 18 on Agreeableness is nearly two standard deviations below the sample mean.
- The difference between the mean d′ (sensitivity) of those workers who scored in the low range of Agreeableness and those who scored in the high range is almost two standard deviations.
- The d′ (sensitivity) average for the low range was below the sample mean for all five factors.
- The d′ (sensitivity) average for the high range was above the sample mean for all five factors.
- The low range β (strategy) categories for all factors excluding Conscientiousness were below the sample mean.
- The average β (strategy) of workers who scored in the low range of Conscientiousness was above the sample mean for β.

- The average β (strategy) of workers who scored in the high range of Openness was above the sample mean for β. (It is important to note that all differences in mean for β are within one standard deviation of the mean. Mean β: .68 and standard deviation β: ± .61.

4.8 Principle Component Analysis

A Principle Component Analysis (PCA) was conducted on the β and d′ values to examine their interaction, primarily to determine if the two variables are independent, as would be expected when using SDT. The PCA returned Eigen Values of 1.07 for d′ and .93 for β, with proportions of .535 and .465 respectively, indicating that d′ and β are indeed independent. The Eigen Vector Matrix is shown in Table 4.8.

Table 4.8 PCA Eigen Vector Matrix

	Prin1	Prin2
dprime	0.707107	0.707107
Beta	0.707107	-0.70711

4.9 Multiple Regressions

Multiple regressions were also performed on the data obtained from the survey. Two separate multiple regression were executed, one with d′ versus age, experience, accident count, Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Openness and the other with β versus the above mentioned variables. The complete details of both regressions are included in Appendix F.

4.9.1 d′ versus Age, Exp., Acc., EX, A, C, ES and O

The initial multiple regression of d′ versus age, experience, accidents, Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Openness returned the following regression equation:

$d' = - 1.45 - 0.0212\ Age + 0.0295\ Exp. + 0.041\ Acc. + 0.0514\ EX + 0.0820\ A - 0.0567\ C + 0.0526\ ES - 0.0051\ O$, *with* $R^2 = .35$, $R = .59$, *and* $p = .252$.

At this point, the variables with p-values greater than .05 were removed from the analysis, leaving experience, Extraversion, Agreeableness, Conscientiousness and Emotional Stability to compare to d′. These variables returned the following regression equation:

$d' = - 2.17 + 0.0129\ Exp. + 0.0540\ EX + 0.0847\ A - 0.0575\ C + 0.0510\ ES$ *with* $R^2 = .34$, $R = .59$, *and* $p = .06$.

A second reduction was made based on p-values, and the variables with p-values greater than .15 were removed from the analysis, leaving Extraversion, Agreeableness and Emotional Stability in the regression. These three regressed against d′ yielded the following regression equation:

$d' = - 1.88 + 0.0336\ EX + 0.0469\ A + 0.0456\ ES$ *with* $R^2 = .26$, $R = .50$, *and* $p = .048$.

It would appear that the second step regression equation is the most meaningful: though the p-value is lower for the third regression equation, the R^2 is not so significantly lower as to justify the decrease in the R and R^2 values. Also, the p-value was acceptable in the second step regression.

4.9.2 β versus Age, Exp., Acc., EX, A, C, ES and O

The initial multiple regression of β versus age, experience, accidents, Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Openness returned the following regression equation:

$\beta = 3.85 - 0.0566\,Age + 0.0026\,Exp. + 0.411\,Acc. + 0.0156\,EX - 0.0429\,A - 0.0299\,C + 0.0449\,ES - 0.0205\,O$, *with* $R^2 = .39$, $R = .62$, *and* $p = .171$.

The variables with p-values greater than .05 were removed from the analysis, leaving Age, Accidents, Agreeableness, and Emotional Stability to compare to β. These variables returned the following regression equation:

$\beta = 3.30 - 0.0502\,Age + 0.324\,Acc. - 0.0621\,A + 0.0430\,ES$, *with* $R^2 = .37$, $R = .61$, *and* $p = .017$.

A second reduction was made, and the variables with p-values greater than .15 were removed from the analysis, leaving Age and Agreeableness in the regression. These two regressed against β yielded the following regression equation:

$\beta = 3.67 - 0.0390\,Age - 0.0590\,A$, *with* $R^2 = .25$, $R = .50$, *and* $p = .021$.

As was the case with the multiple regressions for d′, it appears that the second step regression equation is the most meaningful: though the p-value is lower for the third regression equation, the R^2 is enough lower to justify the decrease in the R and R_2 values. The p-value was also acceptable in the second step regression.

4.10 Discussion

With regard to the comparison by groups, sections 4.6 and 4.7, a few trends within this sample can be asserted. Agreeableness, which was one of the factors with a significant p-value when regressed against d′(sensitivity), indicated a deviation from the sample mean. This was especially true for workers who scored in the low range of deviation, suggesting that low Agreeableness is positively related to low sensitivity. This is also true for those workers who scored low on all the five factors, though the trend is slightly weaker when all five factors are considered. Additionally, the trend of workers who scored high on all five factors scoring above average d′ reinforces this tenuous relationship.

When considering strategy, Conscientiousness seemed to be the trend-defining factor, though one worker had a very high β, and when this data point is removed, the strategy of those who scored low on Conscientiousness tends to be lower, in fact below one (conservative). Those workers who scored in the high range of Openness had a slightly higher than average β, indicating a slightly riskier strategy.

These trends indicate a few notable concepts. The first is that the more Agreeable a worker was, the more discrimination they showed. It is possible that the workers who are less Agreeable care less about what others thinks or feel, and do not take safety training to heart. It is also possible that the more Agreeable they are, the more willing they are to please someone else by following safety rules on a jobsite, or by actively trying to keep their work environment and work practices safe.

Concerning Openness, the same ideas can be postulated: perhaps the workers who scored high in Openness are more willing to look at a new way to do things on the job, instead of thinking that the old way is the only way, and no one should tell them how to do their job. Though these trends are inconclusive and can be applied only to this sample, these results merit further research into the relationship between safety awareness or hazard recognition and personality.

The multiple regressions yielded the most useful information, indicating that the variables with the strongest relationship to d′ were experience, Extraversion, Agreeableness, Conscientiousness and Emotional Stability when taken together. The following regression equation describes the relationship between these variables and d′:

$$d' = -2.17 + 0.0129\,Exp. + 0.0540\,EX + 0.0847\,A - 0.0575\,C + 0.0510\,ES \text{ with } R^2 = .34,\ R = .59, \text{ and } p = .06.$$

This essentially means that the variables of Experience, Extraversion, Agreeableness, Conscientiousness and Emotional Stability account for 59 % of the difference from the mean for the measure of d′(sensitivity) when taken together. With this regression result, the null hypothesis of Ho: $R^2 = 0$ (there is no relationship) can be rejected in favor of the alternative hypothesis Ha: $R^2 \neq 0$ (there is a relationship).

The multiple regressions also indicated that the variables with the strongest relationship to β were age, accidents, Agreeableness, and Emotional Stability when taken together. The following regression equation describes the relationship between these variables and β:

$\beta = 3.30 - 0.0502\,Age + 0.324\,Acc. - 0.0621\,A + 0.0430\,ES$, *with* $R^2 = .37$, $R = .61$, *and* $p = .017$.

In other words, this regression equation says that the variables of age, accidents, Agreeableness, and Emotional Stability account for 61% of the difference from the mean for the measure β (strategy) when taken together. With this regression result, the null hypothesis of Ho: $R^2 = 0$ (there is no relationship) can be rejected in favor of the alternative hypothesis Ha: $R^2 \neq 0$ (there is a relationship).

This research, like any investigation, has various inherent limitations, such as:

- Both survey tools rely on self-reported data, which has been hotly debated in the past (Winter et al., 1998 and Pervin and John, 1992). Personality traits are observable, but the issue of observer bias casts a significant shadow on this form of personality assessment. Safety behaviors could be directly observed, and though observer bias would also be a factor, the main issue here would be the obligation of the observer to intervene if s/he were to anticipate an accident.
- Only the traits that are represented by the Five Factors were measured. This may not be the most appropriate tool for assessment, and this is a topic for future investigation. Additionally, the various facets of the five factors may prove to be useful in this type of research.
- It is rarely the case where one isolated signal is the 'state of the world.' In any situation, a person is required to make a series of judgments and decisions that dictate the course of action that they ultimately choose. These split second decisions are often unconscious, and difficult to

measure. SDT distills the process of a decision down to a choice that is essentially yes or no, and allows for no other factors to be present in the particular situations that were included in the survey for this research. Fuzzy Signal Detection Theory attempts to address this difficulty.

- The bulk of the population that responded to the survey was from the local ironworkers union, and it is very possible that they represent a homogenous segment of the total population. The world is not a closed shop, and further research should look to diversify the sample population.
- There is an inherent difference in what people say they would do, and the actions they actually take. This could come to light as a defensive posture, where a worker knows that the situation is unsafe, and answers that it is so, but may choose not to act on that knowledge in real life situations. This is actually a form of response bias, where the participant may answer in the way they think they should, for whatever reason, and not in the way they truly feel. Some individuals may feel that the risk of injury or death is so minimal that they do not need to take safety precautions; for instance, few people follow the safety guidelines for using a lawn mower which include wearing long pants, boots, gloves and safety goggles. Of course, there are always the select few who choose to trim their hedges with a lawn mower. A partial solution may be to use Fuzzy SDT where each scenario has three questions, answered on a continuum ranging from "Very" to "Not at All" (Narang 2006):

    1. How safe is this situation?

2. How certain are you about your answer?
3. How comfortable would you be working in this situation?

- The sample size was very small: only 30 ironworkers were surveyed. Ideally, a large sample should be obtained. The survey was also administered only once, and should be subject to repetition.

4.11 Results and Analysis Summary

In this chapter, the survey data was analyzed using Signal Detection Theory, and the Five Factor Model, to determine the hazard sensitivity and strategy of the ironworkers, as well as their personalities. The results were further analyzed, using simple linear regression analysis, comparison by groups and multiple regressions.

The objectives stated in chapter one were achieved using the methodology outlined in chapter three and described in detail in this chapter. Chapter five discusses the results and contributions, and concludes with a discussion of the research limitations and suggestions for future research.

Chapter 5
SUMMARY AND CONCLUSION

5. Summary and Conclusions

5.1 Thesis Summary

The primary goal of this research was to enhance the understanding of the factors that influence the hazard identification of workers in construction situations. The chapters preceding this one presented the details of the background, concepts, existing literature, prior research, and approach that this scholarship followed as well as the methods by which the results were obtained and analyzed.

The first chapter outlined the problem area, and addressed the motivation for this research. Chapter one also presented the motivation and objectives. Chapter two discussed Accident Causation research, and introduced Signal Detection Theory and the Five Factor Model. The third chapter discussed the methods used to achieve the objectives of this research. Chapter four reported the data collected during the course of this study, and the respective analysis. This chapter addresses the research findings in further detail.

5.2 Conclusions

This thesis expanded on an approach to measure a worker's ability to distinguish between a safe condition and an unsafe condition on a jobsite. It also measured the worker's decision-making strategy. Furthermore, it compared the results of a five factor personality assessment to the results obtained concerning workers' discrimination and strategy.

Analysis of the survey data indicated that experience, Extraversion, Agreeableness, Conscientiousness and Emotional Stability were related to d′ when considered in a multiple regression relation ($R^2 = .34$, $R = .59$, and $p = .06$). Likewise, multiple regressions also indicated that the variables with the strongest relationship to β were, respectively, age, accidents, Agreeableness, and Emotional Stability ($R^2 = .37$, $R = .61$, and $p = .017$). For both measures d′ and β the null hypothesis of Ho: $R^2 = 0$ (there is no relationship) was rejected in favor of the alternative hypothesis Ha: $R^2 \neq 0$ (there is a relationship).

With this in mind, the average sensitivity of the workers was low, at 0.71 with a standard deviation of ± 0.57: 18 workers were below 0.92 and 12 were above. The average strategy of the workers was conservative: only four out of the 30 surveyed were risky ($\beta > 1$). The average strategy (β) of the 30 workers was 0.68, again with a large standard deviation of ± 0.61.

A distinct idiosyncrasy concerning the strategy calculation in Signal Detection Theory was experienced during the pilot for this study. The result of this irregularity was an inaccurate assignment of strategies: a worker with a conservative strategy could be classified as risky if his/her sensitivity was very poor. In other words, if the d′ value was less than zero, the $\beta_{current}$ calculations were incorrect. In fact, the d′ value could be zero, below zero, or a small positive value approaching zero. It seems that the closer the value gets to zero, the more distortion is present in the $\beta_{current}$ calculations. Investigation into existing SDT theory and research revealed solutions to this problem, one of which (the ratio of areas) was used in this study. According to the basics of Signal Detection, the theory assumes that subjects actually have the ability to discriminate, meaning that the value of d′ (sensitivity) is not zero and is not negative. SDT also assumes that the variances of the distributions are uniform or at least similar, and in this study, the variances were not only unknown, there was no reason to assume that they were similar at all.

As mentioned in the Discussion section of the previous chapter, the results from the grouping analysis shown in sections 4.6 and 4.7 indicate that the risky group was, on average, younger, less experienced, less agreeable, less conscientious, less stable emotionally, and had a lower sensitivity. The average for the low sensitivity group was less than the average for the moderate sensitivity group on all variables. Though the grouping analysis was useful to determine trends within certain ranges of sensitivity and strategy, the differences in the averages for all variables between the groups were too miniscule to be considered definitive.

In the author's opinion, the most useful information that resulted from this study was that the majority of the workers were conservative in terms of strategy, meaning that when they were unsure whether a situation was safe or not, they were more inclined to view a safe situation as unsafe, rather viewing an unsafe situation as safe. The second viewpoint, which epitomizes the risky strategy, is not desirable in a construction worker, as it could easily lead to more accidents on the job site because workers were assuming an unsafe situation to be safe. The author believes that it is more difficult to change whether a person cares about a situation i.e., will the worker treat an unsafe situation differently from a safe one, than it is to heighten the workers awareness of the dangers any given situation may present. To be unaware of a hazard is entirely different than how a person reacts to a hazard. To an extent, a conservative strategy can compensate somewhat for a lack of knowledge; if a worker tends to view the work environment as less safe, they may actually react to an unsafe situation in a very cautious manner, even if they do not specifically know that the situation is not safe. Some experts would say that erring on the side of caution is the route to take, and a worker with a conservative strategy is essentially doing just that. To the author, it is comforting to know that such a high number of workers in this study had a conservative strategy. However, it is somewhat alarming that the workers' average sensitivity was so low. This is a problem that can be more easily addressed through training; a worker who cannot discriminate between safe and unsafe situations can always benefit from simply being told that certain things are not safe. For example, question #3 in the attached survey shows a tree rigging of multiple steel members. The caption states that the members are rigged six feet apart; however, OSHA requires that the members be rigged seven feet apart. Technically, this situation is unsafe, though many workers may view it as safe, because a worker would have to be six feet tall to be struck by a member while standing on level with the member below. An answer of "Safe" to this question could be remedied through training.

The following section (5.3) makes various recommendations for future research which would relate to studies done in the spirit of this thesis; looking for the relationship between personality and safety awareness. However, it must be said that knowing what to do with the relationship once it is established equally important. Parallel research into adult learning styles, and training techniques based on learning styles and personalities has been and should continue to be investigated. Knowing the personality 'type' of the person who is to receive training can and often does effect the way trainings are organized and executed. Within this psychological research, possible variables include occupation, age, personality (of trainer and trainee), region of work, cultural background, marital status and years of experience, and all of the intricate relationships between the above variables. It is important to note that not all of the relationships between these variables are known, and the complex interactions between variables work in ways that have not even begun to be understood. Educational, Industrial/Organizational and various other psychological disciplines have studied training in general, as well as specific training aspects. The author's recommendation in this continued research is to work very closely with colleagues in other areas, as cooperation can often lead to quicker advances in research and understanding.

5.3 Recommendations for Future Research

As mentioned in chapter four, future research should consider using Fuzzy SDT with a third question, as well as a larger, more diverse population. This diversity should take into account geographic regions, union/non-union, gender, country of origin, and size of sample, among other aspects. Investigation into a way to observe workers in real-time, or to minimize the disparity between self-report and action, should be considered. Further research into locating the threshold of distortion concerning the standard calculation for strategy should also be considered.

It is possible that the Five Factor Model is not the ideal research tool for assessing personality. Other inventories and assessments should be considered as the psychological measure in relation to safety. This is not to say that FFM should be discarded; only that research into the appropriate tool should be as all-inclusive as possible.

This particular methodology may lend itself well to other trades within the construction industry, and other industries themselves. The survey that was used in this research was specific to ironworkers with a significant emphasis on fall hazards, and the development and use of similar surveys in the course of further research would certainly be a benefit to future understanding of accidents in general.

5.4 Contributions of this Research

As in any research, there always exists the possibility that there is no statistically significant correlation between two variables. Though a correlation was found, it is by no means a definitive result. With this in mind, this particular study attempted to fill a void in the research on the subject, and any lack of a significant correlation in this study would not and does not preclude the need for similar future research. This work has resulted in the following contributions:

- A statistically significant result indicating that a relationship does exist between the variables studied (age, experience, accidents, Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Openness) and the two Signal Detection Theory measures (d′ and β).
- A revisitation to a technique designed to determine the sensitivity and risk orientation of construction workers.
- A survey combining safety and personality assessment specific to the construction industry and ironworkers in particular.
- A platform from which to launch future research. The blind 'stab in the dark" has been made, and future research can easily learn from, build on and replicate this work.
- The introduction of a significant social science issue into a largely engineering field.

As the author of this thesis, I believe its greatest contribution is the fact that it was done, that this journey was taken. To my knowledge, it is the first research of its kind with respect to industry and topic, and will hopefully become but one of many studies and scholarship in this area.

"Success is a journey, not a destination. The doing is often more important than the outcome"

Arthur Ashe (1943 – 1993)

Appendix A
CONSENT LETTER AND SURVEY QUESTIONNAIRE

Participant Consent Form

OCCUPATIONAL SAFETY and PERSONALITY

Principal Investigator: **Tariq S. Abdelhamid, PhD**
Research Assistant: **Suzie von Bernuth**

The Construction Management Program at Michigan State University is conducting a research project to assess the occupational safety knowledge and personality of ironworkers. The research will help in improving the effectiveness of safety training programs. You are being asked to participate in this project in your capacity as a construction Ironworker.

As a participant in this research, you will be asked to complete an 18 question survey on occupational safety rules related to fall protection, as well as the 30 question personality survey.

Your assistance is voluntary and you may choose to terminate your involvement in this study at any time during this project. If you are uncomfortable answering any part of the survey, you may leave those sections unanswered. Your privacy will be protected to the maximum extent allowable by law. Neither you nor your company will be identified by name. The estimated time for the survey is 30-45 minutes. As a participant, you may request a copy of this consent letter for your records.

If you have any questions about this project, you may contact Dr. Tariq Abdelhamid, Construction Management Program, Michigan State University at (517) 432-6188, or Dr. Mohammad Najafi, Construction Management Program, Michigan State University at (517) 432-4937. If you have questions or concerns about your rights as a research participant, please feel free to contact Peter Vasilenko, Ph.D., Director of the Human Subject Protection Programs at Michigan State University: (517) 355-2180, fax: (517) 432-4503, email: irb@msu.edu, or regular mail: 202 Olds Hall, East Lansing, MI 48824.

I voluntarily agree to participate in this study.

Subject Name	*Occupation*	*Signature*	*Date*

Witness Name	*Occupation*	*Signature*	*Date*

IRB # 06-202
Category: Expedited
Approval Date: 3/27/2006
Expiration Date: 3/26/2007

SURVEY QUESTIONNAIRE

MSU Member: Suzie von Bernuth

MICHIGAN STATE UNIVERSITY

Occupational Safety and Personality Assessment

Date: ________________

Construction Industry Experience (In Years): ________________________________

Gender (Circle one): M F

Age: _______

Have you ever had a work related accident that required emergency medical care or a trip to the hospital? (Circle one) Y N

If yes, how many? ____________

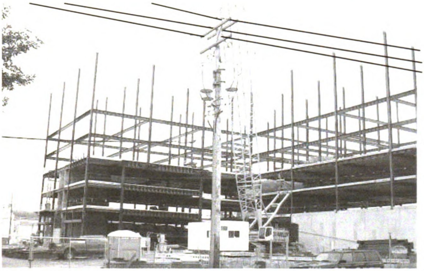
SAFETY QUESTIONS[1]

Please read the following scenarios and select your answer from the choices: "Safe," "Unsafe, or "I am not sure." Please circle only one answer per question. The pictures are intended as visual aids only, please answer the question using the written information given. Please disregard other possible hazards present in the picture if they are not specifically addressed in writing.

Please proceed to the questions on the next page.

There will be similar instructions at the beginning of the second segment of the survey.

1. A crawler crane lifting steel columns, located 30 feet from a 600 kV power line.

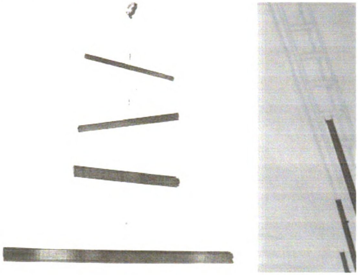


Is this situation (the distance between the crane and the power line)
A. Safe
B. Unsafe
C. I am not sure

2. When climbing a portable ladder to access an upper landing surface, the side rail extends 3.5 feet above the upper landing surface.

Is this situation (the height that the ladder's side rail extends above the landing surface)
A. Safe
B. Unsafe
C. I am not sure

3. While erecting steel beams using a multiple lift rigging procedure, the steel members are rigged 6 feet apart.

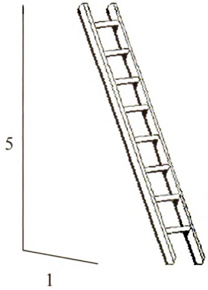


Is this situation (the distance between the rigged members)
A. Safe
B. Unsafe
C. I am not sure

4. Erecting 7th floor columns, when all the 5th floor planks (precast concrete panels) are <u>not</u> completely in place.

Is this situation (5th floor planking is incomplete during 7th floor column erection)
A. Safe
B. Unsafe
C. I am not sure

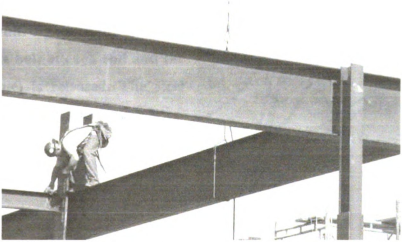
5. Climbing a portable ladder that is set 1 foot out for every 5 feet climb (as shown in figure).



Is this situation (the horizontal distance compared to the vertical distance)

A. Safe
B. Unsafe
C. I am not sure

6. An ironworker connecting 4th floor beams, with an unprotected edge with no decking in place on the lower floors while wearing a fall arrest harness that is <u>not</u> tied off.



Is this situation (the type of fall protection and the manner in which it is used)

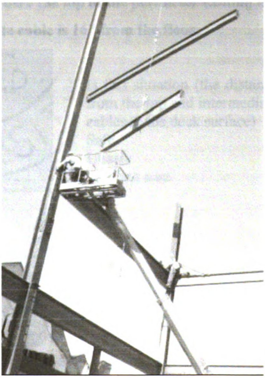
A. Safe
B. Unsafe
C. I am not sure

7. **Bolting steel members in place on the 3rd floor, when the temporary bracing is <u>not</u> in place on the lower floors.**

Is this situation (temporary bracing is not in place)

A. Safe
B. Unsafe
C. I am not sure

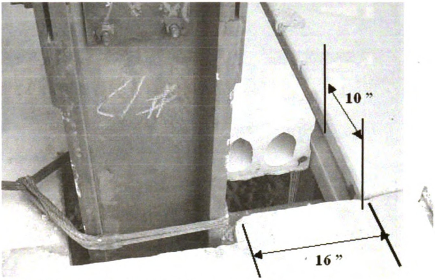
8. **A 40 ft. long beam being attached as a part of a multi-rig assembly is bolted with a single bolt at each end and the choker (cable) is released. The steel beam is detailed into place much later.**



Is this situation (# of bolts)

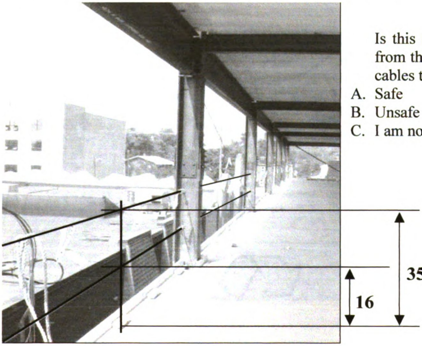
A. Safe
B. Unsafe
C. I am not sure

9. **An opening of 16 inches by 10 inches is left uncovered next to a column. The concrete planks (precast) are bearing (sitting) on the beam that connects to this column.**



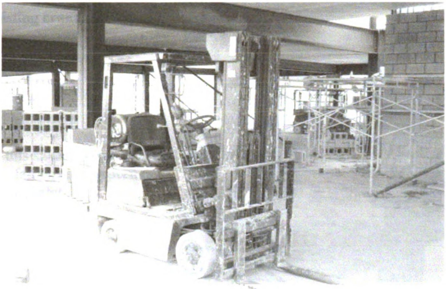
Is this situation (the hole is not covered)
A. Safe
B. Unsafe
C. I am not sure

10. **Working on the 3rd floor of a building where the top of the perimeter cabling is at 35" from the floor and the intermediate cable is 16" from the floor.**



Is this situation (the distance from the top and intermediate cables to the deck surface)
A. Safe
B. Unsafe
C. I am not sure

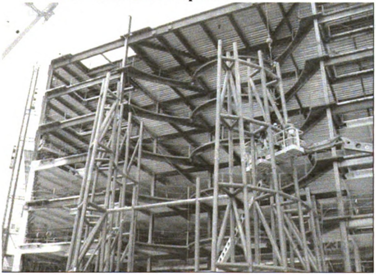
11. Operating a forklift on the 4th floor when all perimeter cabling is in place and precast concrete panels are being placed on the 6th floor.



Is this situation (fork on the 4th floor, cabling is up, and panels going in on the 6th floor)

A. Safe
B. Unsafe
C. I am not sure

12. Beams and decking on the 7th floor are being erected, when the bolting/detailing on the 3rd floor is incomplete.



Is this situation (The number of floors between the bolting/detailing and the erection)

A. Safe
B. Unsafe
C. I am not sure

13. Removing the fall protection while transferring from a beam to the hoisting crane.

Is this situation (removal of fall protection during transfer)

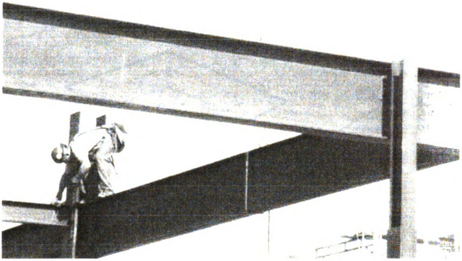
A. Safe
B. Unsafe
C. I am not sure

14. A column is bolted in place with 3 anchor rods while beams are being connected on the 2^{nd} floor.

Is this situation (

A. Safe
B. Unsafe
C. I am not sure

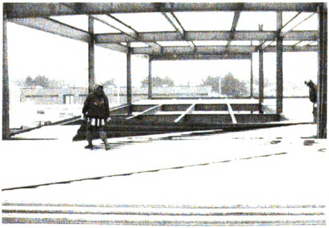
15. Ironworker climbs on the steel beam, when it is held by the crane (tied with a choker), to bolt it in place.



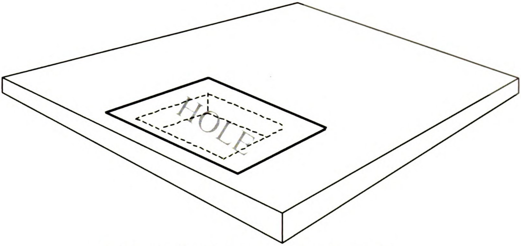
Is this situation (worker on the choker tied beam)
A. Safe
B. Unsafe
C. I am not sure

16. Working on 2,500 square feet of decking that has an unsecured connection.

Is this situation (decking is unsecured)
A. Safe
B. Unsafe
C. I am not sure



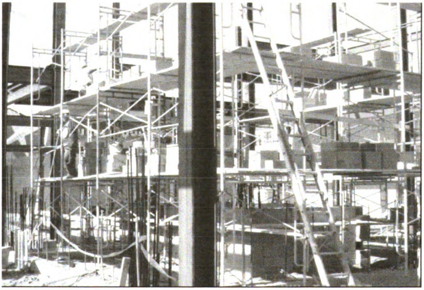
17. **A shaft opening 3 ft. X 1.5 ft., on the 3rd floor is covered by ¾" ply and painted with high visibility paint and marked with the word "HOLE".**



Is this situation (hole is covered and marked)

A. Safe
B. Unsafe
C. I am not sure

18. **Working on a scaffold 5 feet above the lower level without a guardrail system.**



Is this situation (no guardrail, 5ft above surface)

A. Safe
B. Unsafe
C. I am not sure

PERSONALITY QUESTIONS[2]

On the following pages, there are phrases describing people's behaviors. Please use the rating scale below each question to describe how accurately each statement describes **you**. *Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then circle the answer that is most appropriate for you. Please circle only one answer per question.*

1. **I am the life of the party**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate
2. **I feel little concern for others**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate
3. **I am always prepared**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate
4. **I get stressed out easily**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate
5. **I have a rich vocabulary**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

6. **I don't talk a lot**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

7. **I am interested in people**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

8. **I leave my belongings around**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

9. **I am relaxed most of the time**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

10. **I have difficulty understanding abstract ideas**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

11. **I feel comfortable around people**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

12. **I insult people often**
    a. Very Inaccurate
    b. Moderately Inaccurate
    c. Neither Inaccurate nor Accurate
    d. Moderately Accurate
    e. Very Accurate

13. I pay attention to details

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

14. I worry about things

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

15. I have a vivid imagination

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

16. I keep in the background

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

17. I sympathize with others' feelings

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

18. I make a mess of things

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

19. I seldom feel blue

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

20. I am not interested in abstract ideas
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

21. I start conversations
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

22. I am not interested in other people's problems
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

23. I get chores done right away
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

24. I am easily disturbed
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

25. I have excellent ideas
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

26. I have little to say
  a. Very Inaccurate
  b. Moderately Inaccurate
  c. Neither Inaccurate nor Accurate
  d. Moderately Accurate
  e. Very Accurate

27. I have a soft heart

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

28. I often forget to put things back in their proper place

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

29. I get upset easily

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

30. I do not have a good imagination

a. Very Inaccurate
b. Moderately Inaccurate
c. Neither Inaccurate nor Accurate
d. Moderately Accurate
e. Very Accurate

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[1] This survey adapted from Narang (2006)
[2] This survey adapted from IPIP (2005) http://ipip.ori.org

Appendix B
SURVEY RESPONSES AND ANALYSIS (SDT)

Ques.	Worker 1 Age=42 Exp=20 Acc=0				Worker 2 Age=26 Exp=2 Acc=0				Worker 3 Age=52 Exp=30 Acc=1				Worker 4 Age=37 Exp=20 Acc=0			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1	X				X				X				X			
Q2			X				X					X			X	
Q3	X					X			X					X		
Q4	X				X					X			X			
Q5	X					X				X			X			
Q6	X				X				X				X			
Q7		X				X			X				X			
Q8	X				X					X			X			
Q9			X				X				X					X
Q10			X					X				X				X
Q11				X				X				X				X
Q12	X				X				X				X			
Q13	X				X				X				X			
Q14	X				X				X				X			
Q15			X				X				X				X	
Q16	X					X				X			X			
Q17				X				X				X				X
Q18				X				X				X			X	
Total	10	1	4	3	7	4	3	4	7	4	2	5	10	1	3	4
Prob.	0.91	0.09	0.57	0.43	0.64	0.36	0.43	0.57	0.64	0.36	0.29	0.71	0.91	0.09	0.43	0.57

Table B.1 Survey Responses and Analysis (SDT)

Ques.	Worker 5				Worker 6				Worker 7				Worker 8			
	Age=49 Exp=30 Acc=0				Age=50 Exp=31 Acc=0				Age=24 Exp=2 Acc=0				Age=48 Exp=25 Acc=0			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1	X					X			X				X			
Q2				X				X				X				X
Q3	X				X					X				X		
Q4		X			X					X			X			
Q5	X				X				X				X			
Q6	X				X					X			X			
Q7	X				X				X				X			
Q8		X			X				X				X			
Q9			X				X				X				X	
Q10				X			X				X				X	
Q11				X			X					X				X
Q12	X				X				X				X			
Q13	X				X				X				X			
Q14	X				X				X				X			
Q15			X				X					X			X	
Q16		X			X				X				X			
Q17				X				X				X				X
Q18				X				X			X				X	
Total	8	3	2	5	10	1	4	3	8	3	3	4	10	1	4	3
Prob.	0.73	0.27	0.29	0.71	0.91	0.09	0.57	0.43	0.73	0.27	0.43	0.57	0.91	0.09	0.57	0.43

Table B.1 (cont.)

Ques.	Worker 9				Worker 10				Worker 11				Worker 12			
	Age=48 Exp=20 Acc=0				Age=49 Exp=32 Acc=0				Age=33 Exp=11 Acc=0				Age=48 Exp=29 Acc=0			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1		X				X			X					X		
Q2				X				X				X				X
Q3		X			X					X				X		
Q4	X				X					X			X			
Q5	X					X			X					X		
Q6	X				X				X				X			
Q7		X			X					X			X			
Q8	X				X				X				X			
Q9			X				X				X				X	
Q10			X				X					X			X	
Q11				X			X					X				X
Q12		X				X			X				X			
Q13	X				X				X				X			
Q14	X				X				X				X			
Q15				X			X					X			X	
Q16	X				X				X				X			
Q17				X			X					X				X
Q18			X				X				X				X	
Total	7	4	3	4	8	3	6	1	8	3	2	5	8	3	4	3
Prob.	0.64	0.36	0.43	0.57	0.73	0.27	0.86	0.14	0.73	0.27	0.29	0.71	0.73	0.27	0.57	0.43

Table B.1 (cont.)

Ques.	Worker 13 Age=42 Exp=14 Acc=0				Worker 14 Age=28 Exp=8 Acc=0				Worker 15 Age=49 Exp=29 Acc=0				Worker 16 Age=50 Exp=28 Acc=1			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1	X				X					X			X			
Q2				X				X				X				X
Q3		X				X			X				X			
Q4		X				X			X					X		
Q5		X			X				X				X			
Q6	X					X			X				X			
Q7		X				X			X					X		
Q8	X				X				X				X			
Q9			X					X			X				X	
Q10			X				X				X				X	
Q11			X					X			X					X
Q12		X			X				X					X		
Q13	X				X				X				X			
Q14	X				X				X				X			
Q15			X					X			X					X
Q16	X					X			X				X			
Q17			X					X			X					X
Q18			X					X				X				X
Total	6	5	6	1	6	5	1	6	10	1	5	2	8	3	2	5
Prob.	0.55	0.45	0.86	0.14	0.55	0.45	0.14	0.86	0.91	0.09	0.71	0.29	0.73	0.27	0.29	0.71

Table B.1 (cont.)

Ques.	Worker 17 Age=47 Exp=29 Acc=1				Worker 18 Age=39 Exp=18 Acc=0				Worker 19 Age=42 Exp=20 Acc=0				Worker 20 Age=26 Exp=5 Acc=0			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1		X			X				X				X			
Q2				X				X				X			X	
Q3	X					X			X					X		
Q4	X				X				X				X			
Q5	X				X				X				X			
Q6	X				X				X				X			
Q7	X					X				X				X		
Q8	X				X				X				X			
Q9			X				X				X				X	
Q10			X					X			X					X
Q11			X					X				X				X
Q12	X					X			X				X			
Q13	X				X				X				X			
Q14	X					X			X				X			
Q15				X				X			X				X	
Q16	X					X			X					X		
Q17				X				X				X				X
Q18			X				X					X				X
Total	10	1	4	3	6	5	2	5	10	1	3	4	8	3	3	4
Prob.	0.91	0.09	0.57	0.43	0.55	0.45	0.29	0.71	0.91	0.09	0.43	0.57	0.73	0.27	0.43	0.57

Table B.1 (cont.)

Ques.	Worker 21				Worker 22				Worker 23				Worker 24			
	Age=43 Exp=20 Acc=0				Age=49 Exp=21 Acc=0				Age=52 Exp=33 Acc=1				Age=44 Exp=21 Acc=0			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1		X			X					X				X		
Q2				X				X				X				X
Q3	X					X			X				X			
Q4	X				X				X				X			
Q5	X				X					X			X			
Q6	X					X			X				X			
Q7		X			X				X					X		
Q8	X				X				X				X			
Q9			X				X				X				X	
Q10			X				X					X			X	
Q11				X				X			X					X
Q12		X			X					X				X		
Q13	X				X				X				X			
Q14	X				X				X				X			
Q15			X				X				X				X	
Q16	X				X				X				X			
Q17			X					X			X				X	
Q18			X				X				X					X
Total	8	3	5	2	9	2	4	3	8	3	5	2	8	3	4	3
Prob.	0.73	0.27	0.71	0.29	0.82	0.18	0.57	0.43	0.73	0.27	0.71	0.29	0.73	0.27	0.57	0.43

Table B.1 (cont.)

Ques.	Worker 25				Worker 26				Worker 27				Worker 28			
	Age=43 Exp=20 Acc=0				Age=52 Exp=30 Acc=1				Age=48 Exp=20 Acc=0				Age=31 Exp=11 Acc=0			
	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR	H	M	FA	CR
Q1	X				X					X			X			
Q2				X			X					X			X	
Q3	X				X					X				X		
Q4		X				X			X					X		
Q5	X					X			X				X			
Q6	X				X				X				X			
Q7		X			X					X				X		
Q8	X					X			X				X			
Q9			X				X				X				X	
Q10			X					X			X					X
Q11				X				X				X				X
Q12	X				X					X			X			
Q13	X				X				X				X			
Q14	X				X				X				X			
Q15			X				X					X				X
Q16	X					X			X				X			
Q17				X				X				X				X
Q18				X				X			X				X	
Total	9	2	3	4	7	4	3	4	7	4	3	4	8	3	3	4
Prob.	0.82	0.18	0.43	0.57	0.64	0.36	0.43	0.57	0.64	0.36	0.43	0.57	0.73	0.27	0.43	0.57

Table B.1 (cont.)

Ques.	Worker 29 Age=52 Exp=30 Acc=1				Worker 30 Age=49 Exp=29 Acc=0			
	H	M	FA	CR	H	M	FA	CR
Q1	X					X		
Q2				X				X
Q3	X				X			
Q4		X			X			
Q5		X				X		
Q6	X				X			
Q7	X				X			
Q8	X				X			
Q9			X				X	
Q10				X			X	
Q11				X			X	
Q12	X				X			
Q13	X				X			
Q14	X				X			
Q15			X				X	
Q16		X			X			
Q17				X			X	
Q18				X				X
Total	8	3	2	5	9	2	5	2
Prob.	0.73	0.27	0.29	0.71	0.82	0.18	0.71	0.29

Table B.1 (cont.)

Appendix C
SURVEY RESPONSES AND ANALYSIS (FFM)

Question		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
1	EX	4	4	3	3	3	1	4	2	2	3	3	2	3	1	3
2	A	5	5	5	5	5	4	5	5	1	5	5	5	1	4	5
3	C	4	4	4	4	4	3	5	4	2	4	4	2	1	4	2
4	ES	3	4	4	5	4	4	2	3	5	3	4	4	3	3	3
5	O	3	4	3	5	3	1	3	3	5	3	4	1	4	5	3
6	EX	3	2	5	3	5	1	4	3	3	2	3	1	4	3	3
7	A	4	5	3	2	3	3	5	3	4	4	4	4	1	4	3
8	C	4	5	4	2	4	4	4	4	2	4	3	2	4	1	4
9	ES	4	4	3	1	3	4	3	3	5	3	3	4	1	3	4
10	O	5	5	2	5	2	3	2	3	1	4	3	2	4	4	4
11	EX	5	5	1	4	1	2	5	2	4	3	4	4	1	3	4
12	A	4	5	2	5	2	5	5	3	5	3	4	3	3	4	5
13	C	5	5	4	4	4	4	5	3	5	4	4	4	1	4	4
14	ES	2	2	2	2	2	3	5	4	4	2	3	1	5	3	2
15	O	4	5	4	5	4	3	5	3	1	4	4	2	2	5	3
16	EX	4	2	3	2	3	2	2	2	3	2	3	4	2	4	4
17	A	5	5	4	5	4	4	5	3	2	3	3	2	1	4	4
18	C	4	5	5	5	5	5	2	2	5	4	5	4	4	5	4
19	ES	3	4	5	4	5	3	4	2	4	4	4	2	2	2	4
20	O	3	4	3	5	3	2	3	3	1	3	3	1	4	4	4
21	EX	4	4	4	3	4	2	5	2	2	3	3	2	1	4	3
22	A	3	4	3	4	3	4	5	4	5	3	3	2	3	2	4
23	C	5	3	4	2	4	3	5	3	4	3	4	2	1	1	3
24	ES	3	2	5	5	5	3	3	3	5	3	3	4	3	5	3
25	O	4	4	4	4	4	3	3	3	4	4	3	4	1	4	4
26	EX	3	2	4	4	4	1	5	4	1	2	3	2	2	4	4
27	A	5	4	3	1	3	4	5	3	5	3	3	2	2	4	3
28	C	3	5	3	3	3	3	5	2	5	3	5	2	4	3	4
29	ES	3	2	5	5	5	2	3	2	5	3	4	2	4	3	3
30	O	5	4	3	5	3	4	5	3	5	3	4	2	3	5	4

	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
EX	23	19	20	19	20	9	25	15	15	15	19	15	13	19	21
A	26	28	20	22	20	24	30	21	22	21	22	18	11	22	24
C	25	27	24	20	24	22	26	18	23	22	25	16	15	18	21
ES	18	18	24	22	24	19	20	17	28	18	21	17	18	19	19
O	24	26	19	29	19	16	21	18	17	21	21	12	18	27	22

Table C.1 Survey Responses and Analysis (FFM)

Question		W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
1	EX	4	4	4	4	5	4	2	3	4	4	3	3	3	4	3
2	A	5	5	1	5	4	4	5	5	4	5	5	2	5	4	5
3	C	4	1	5	4	4	5	4	4	5	5	4	3	4	3	2
4	ES	4	4	3	3	4	3	3	3	3	3	4	4	4	5	3
5	O	4	3	1	3	4	3	3	3	3	2	3	4	4	2	3
6	EX	4	4	1	3	2	4	3	2	4	3	5	3	3	5	3
7	A	4	1	4	4	5	2	3	4	2	4	3	4	4	3	3
8	C	5	5	2	4	5	5	4	4	5	4	4	2	3	4	4
9	ES	3	4	5	4	4	1	3	3	1	4	3	5	3	3	4
10	O	3	5	4	5	5	3	3	4	3	5	1	1	3	2	4
11	EX	2	5	5	5	5	2	2	3	2	5	1	4	4	1	4
12	A	3	3	3	4	5	3	3	3	3	4	2	5	4	2	5
13	C	4	5	4	5	5	5	3	4	5	5	4	5	4	4	4
14	ES	2	2	2	2	2	1	4	2	1	2	2	4	3	2	2
15	O	2	4	5	4	5	3	3	4	3	4	4	1	4	4	3
16	EX	3	3	4	4	2	4	2	2	4	4	3	3	3	3	4
17	A	3	5	5	5	5	4	3	3	4	5	4	2	3	4	4
18	C	5	5	3	4	5	1	2	4	1	4	5	5	5	5	4
19	ES	4	5	3	3	4	3	2	4	3	3	5	4	4	5	4
20	O	3	5	3	3	4	3	3	3	3	3	3	1	3	3	4
21	EX	4	3	4	4	4	3	2	3	3	4	4	2	3	4	3
22	A	3	5	2	3	4	4	4	3	4	3	3	5	3	3	4
23	C	4	4	5	5	3	5	3	3	5	5	4	4	4	4	3
24	ES	4	4	3	3	2	3	3	3	3	3	5	5	3	5	3
25	O	4	4	2	4	4	4	3	4	4	4	4	4	3	4	4
26	EX	4	4	2	3	2	4	4	2	4	3	4	1	2	4	5
27	A	4	4	4	5	4	4	3	3	4	5	3	5	4	3	4
28	C	5	5	2	3	5	4	2	3	4	4	4	5	4	3	5
29	ES	4	4	2	3	2	3	2	3	3	3	5	5	5	5	4
30	O	4	5	1	4	4	4	3	3	4	5	3	5	5	3	5

	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30
EX	21	23	20	23	20	21	15	15	21	23	20	16	18	21	22
A	22	23	19	26	27	21	21	21	21	26	20	23	23	19	25
C	27	25	21	25	27	25	18	22	25	27	25	24	24	23	22
ES	21	23	18	18	18	14	17	18	14	18	24	27	22	25	20
O	20	26	16	23	26	20	18	21	20	23	18	16	22	18	23

Table C.1 (cont.)

Appendix D
REGRESSION ANALYSIS: MINITAB RESULTS

Regression Analysis: d´ versus Age

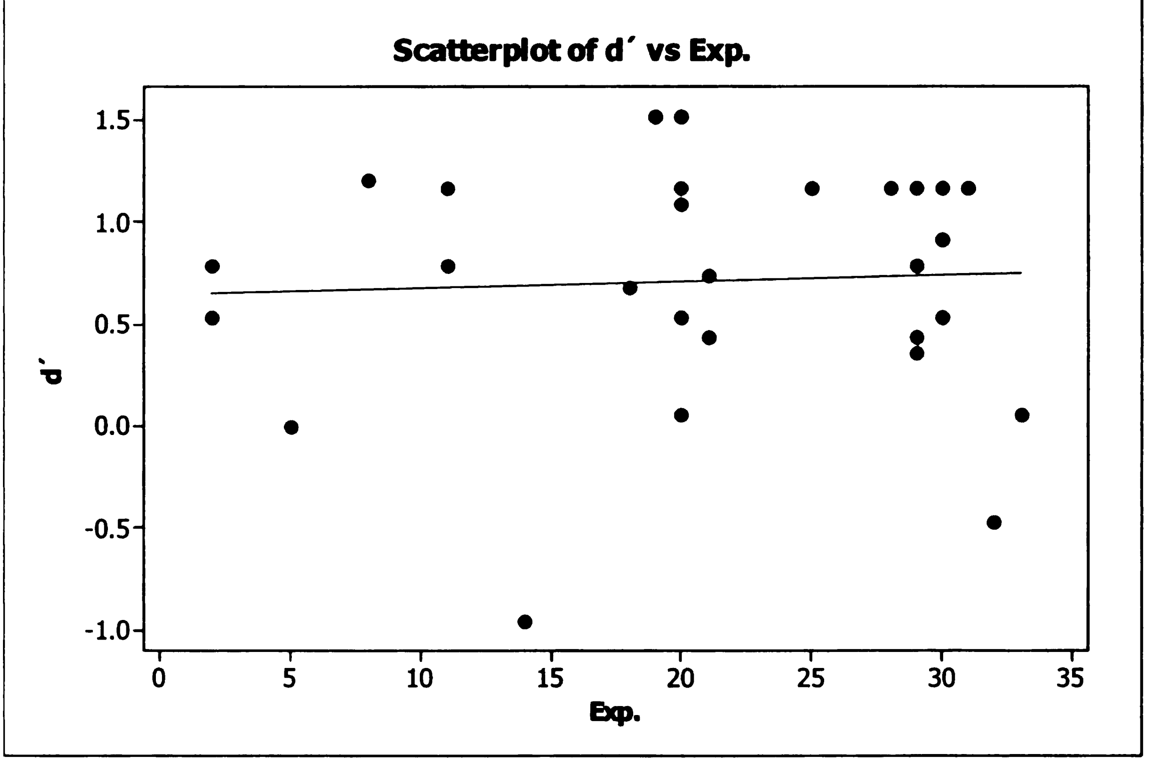
```
The regression equation is
d´ = 0.792 - 0.0018 Age

Predictor       Coef  SE Coef      T      P
Constant      0.7920   0.5420   1.46  0.155
Age         -0.00181  0.01234  -0.15  0.884

S = 0.576609   R-Sq = 0.1%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF       SS       MS     F      P
Regression       1  0.0072   0.0072  0.02  0.884
Residual Error  28  9.3094   0.3325
Total           29  9.3166

Unusual Observations

Obs   Age      d´     Fit  SE Fit  Residual  St Resid
 10  49.0  -0.468  0.703   0.128    -1.171    -2.08R
 13  42.0  -0.955  0.716   0.106    -1.671    -2.95R

R denotes an observation with a large standardized residual.
```

Scatterplot of d´ vs Age

Regression Analysis: d´ versus Exp.

```
The regression equation is
d´ = 0.649 + 0.0030 Exp.

Predictor      Coef   SE Coef     T      P
Constant     0.6494    0.2699  2.41  0.023
Exp.        0.00303   0.01170  0.26  0.797

S = 0.576141   R-Sq = 0.2%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.0223  0.0223  0.07  0.797
Residual Error  28  9.2943  0.3319
Total           29  9.3166

Unusual Observations

Obs  Exp.      d´    Fit  SE Fit  Residual  St Resid
 10  32.0  -0.468  0.747   0.164    -1.215    -2.20R
 13  14.0  -0.955  0.692   0.135    -1.647    -2.94R

R denotes an observation with a large standardized residual.
```

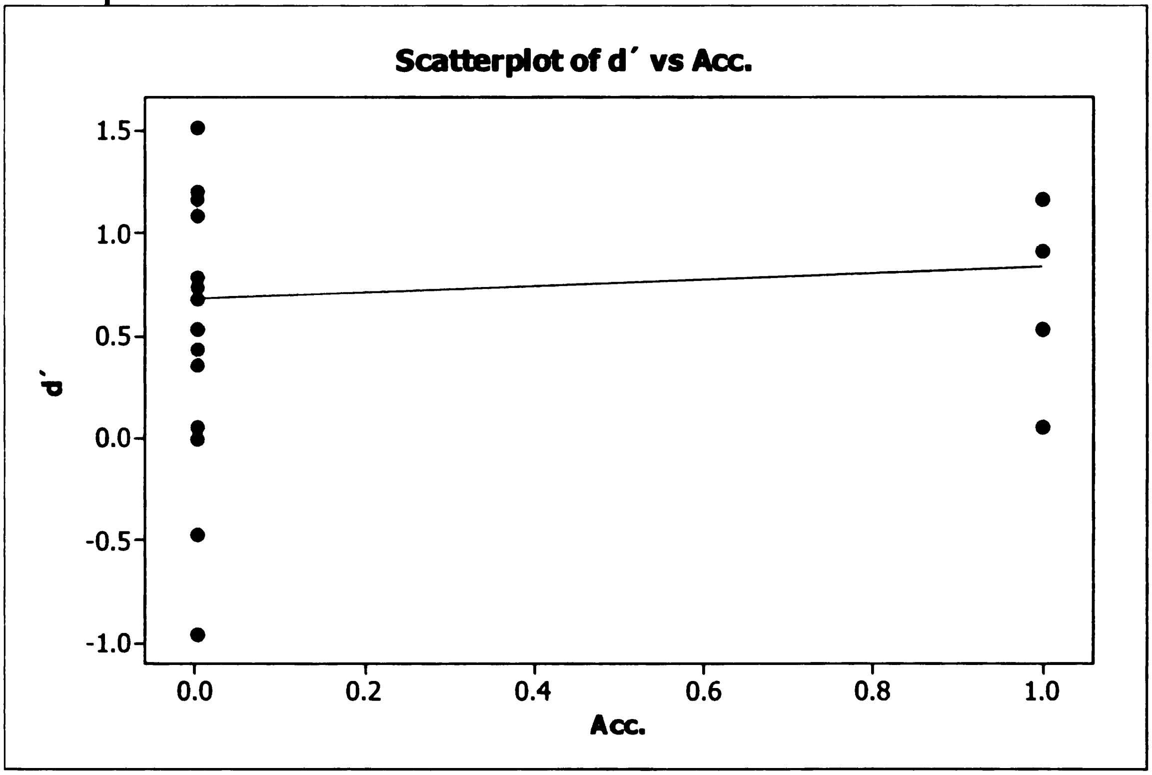
Scatterplot of d´ vs Exp.



Regression Analysis: d´ versus Acc.

```
The regression equation is
d´ = 0.684 + 0.150 Acc.

Predictor     Coef  SE Coef     T      P
Constant    0.6839   0.1171  5.84  0.000
Acc.        0.1497   0.2618  0.57  0.572

S = 0.573490   R-Sq = 1.2%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.1076  0.1076  0.33  0.572
Residual Error  28  9.2089  0.3289
Total           29  9.3166

Unusual Observations

Obs  Acc.      d´    Fit  SE Fit  Residual  St Resid
 10  0.00  -0.468  0.684   0.117    -1.152    -2.05R
 13  0.00  -0.955  0.684   0.117    -1.639    -2.92R

R denotes an observation with a large standardized residual.
```

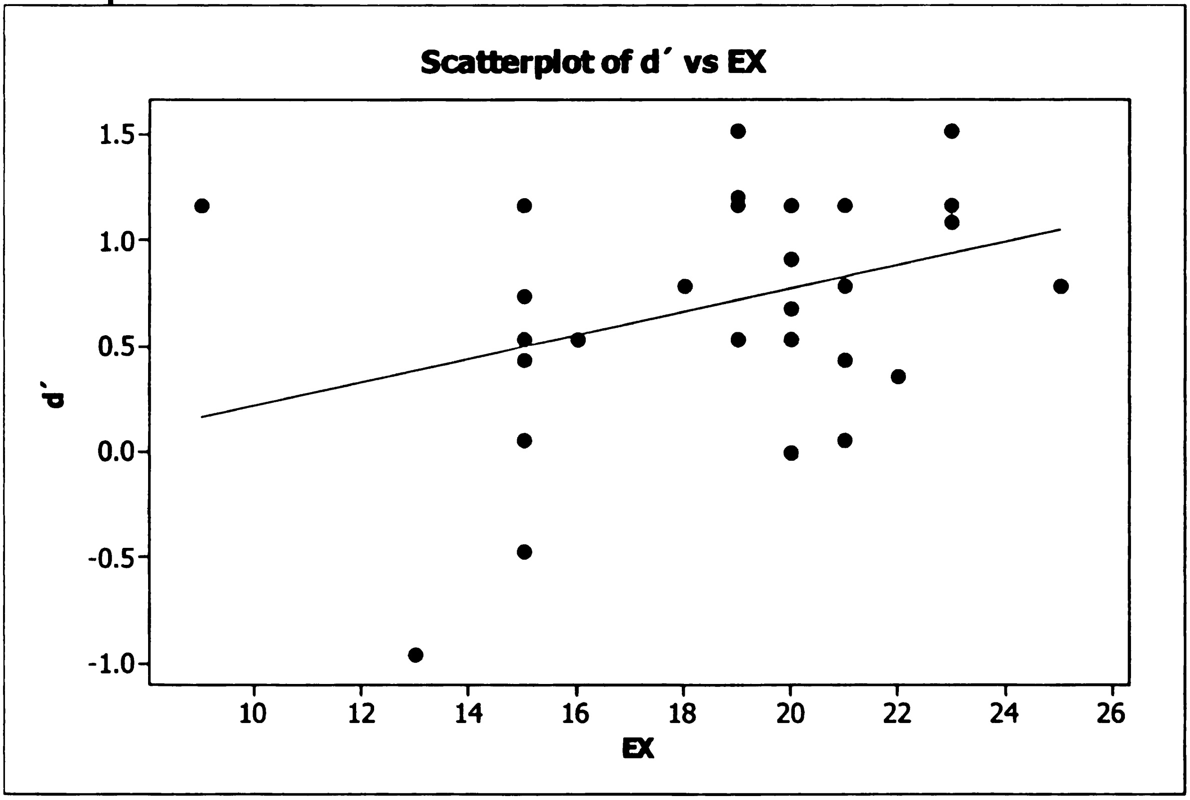
Scatterplot of d´ vs Acc



Regression Analysis: d´ versus EX

```
The regression equation is
d´ = - 0.330 + 0.0553 EX

Predictor       Coef  SE Coef      T      P
Constant     -0.3303   0.5350  -0.62  0.542
EX           0.05534  0.02787   1.99  0.057

S = 0.540059   R-Sq = 12.3%   R-Sq(adj) = 9.2%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  1.1500  1.1500  3.94  0.057
Residual Error  28  8.1666  0.2917
Total           29  9.3166

Unusual Observations

Obs    EX       d´     Fit  SE Fit  Residual  St Resid
  6   9.0   1.1640  0.1678  0.2921    0.9962     2.19RX
 13  13.0  -0.9550  0.3892  0.1909   -1.3442    -2.66R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

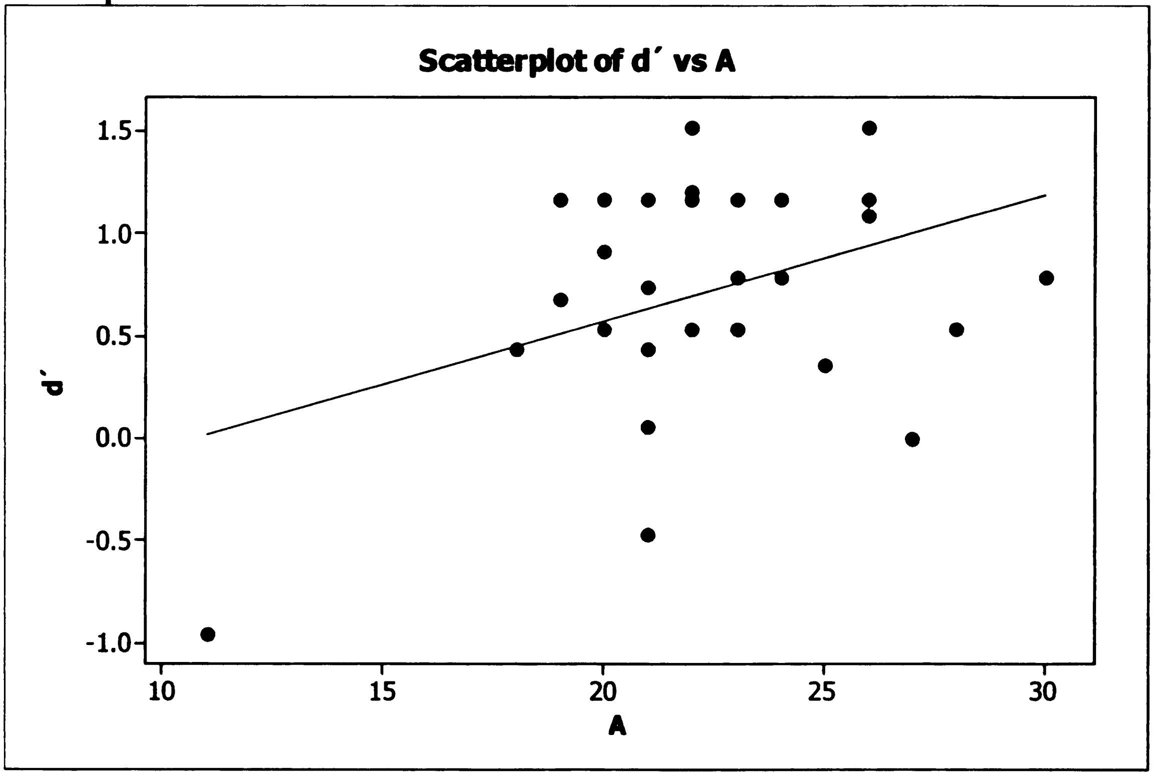
Scatterplot of d´ vs EX



Regression Analysis: d′ versus A

```
The regression equation is
d´ = - 0.656 + 0.0615 A

Predictor      Coef   SE Coef      T      P
Constant    -0.6563    0.6291  -1.04  0.306
A           0.06153   0.02791   2.20  0.036

S = 0.532475   R-Sq = 14.8%   R-Sq(adj) = 11.7%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  1.3777  1.3777  4.86  0.036
Residual Error  28  7.9388  0.2835
Total           29  9.3166

Unusual Observations

Obs     A        d´     Fit  SE Fit  Residual  St Resid
 10  21.0  -0.4680  0.6359  0.1034   -1.1039     -2.11R
 13  11.0  -0.9550  0.0206  0.3292   -0.9756     -2.33RX

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

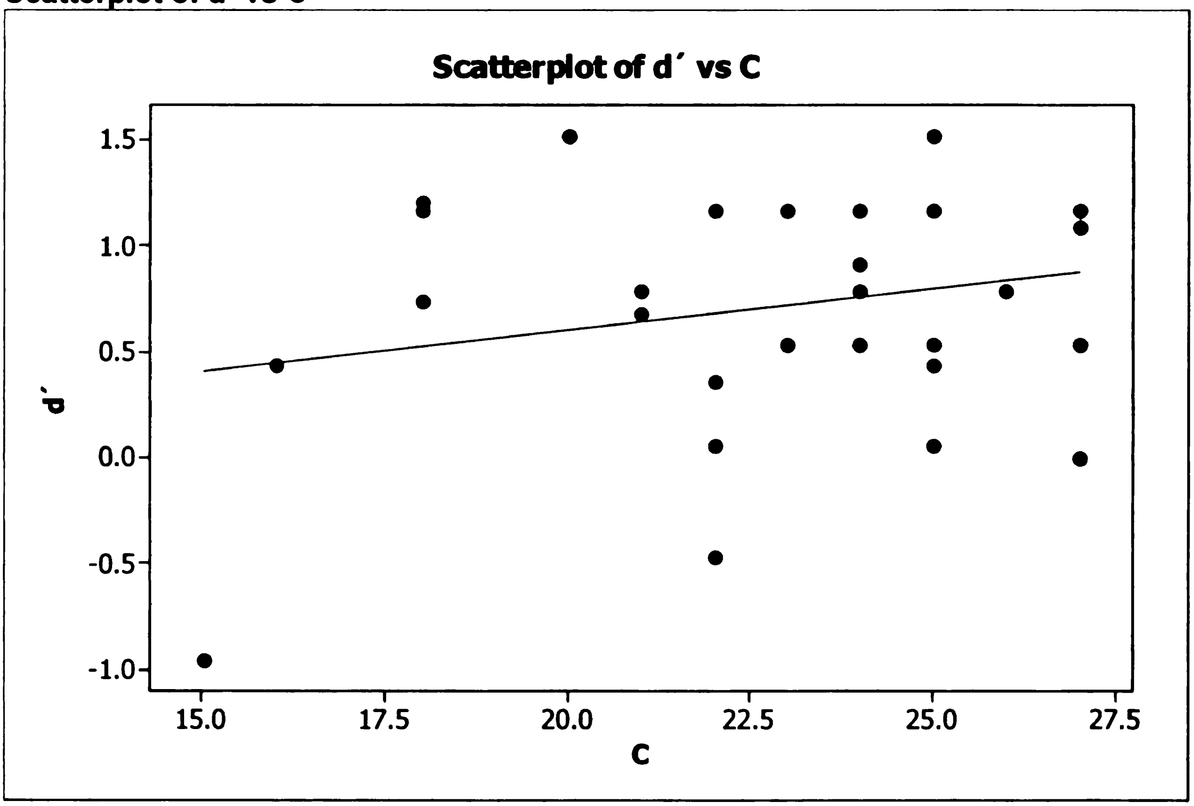
Scatterplot of d′ vs A



Regression Analysis: d′ versus C

```
The regression equation is
d′ = - 0.185 + 0.0393 C

Predictor      Coef   SE Coef      T      P
Constant    -0.1850    0.7326  -0.25  0.803
C           0.03931   0.03172   1.24  0.226

S = 0.561639   R-Sq = 5.2%   R-Sq(adj) = 1.8%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.4843  0.4843  1.54  0.226
Residual Error  28  8.8323  0.3154
Total           29  9.3166

Unusual Observations

Obs     C      d′    Fit  SE Fit  Residual  St Resid
 10  22.0  -0.468  0.680   0.106    -1.148    -2.08R
 13  15.0  -0.955  0.405   0.270    -1.360    -2.76RX

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

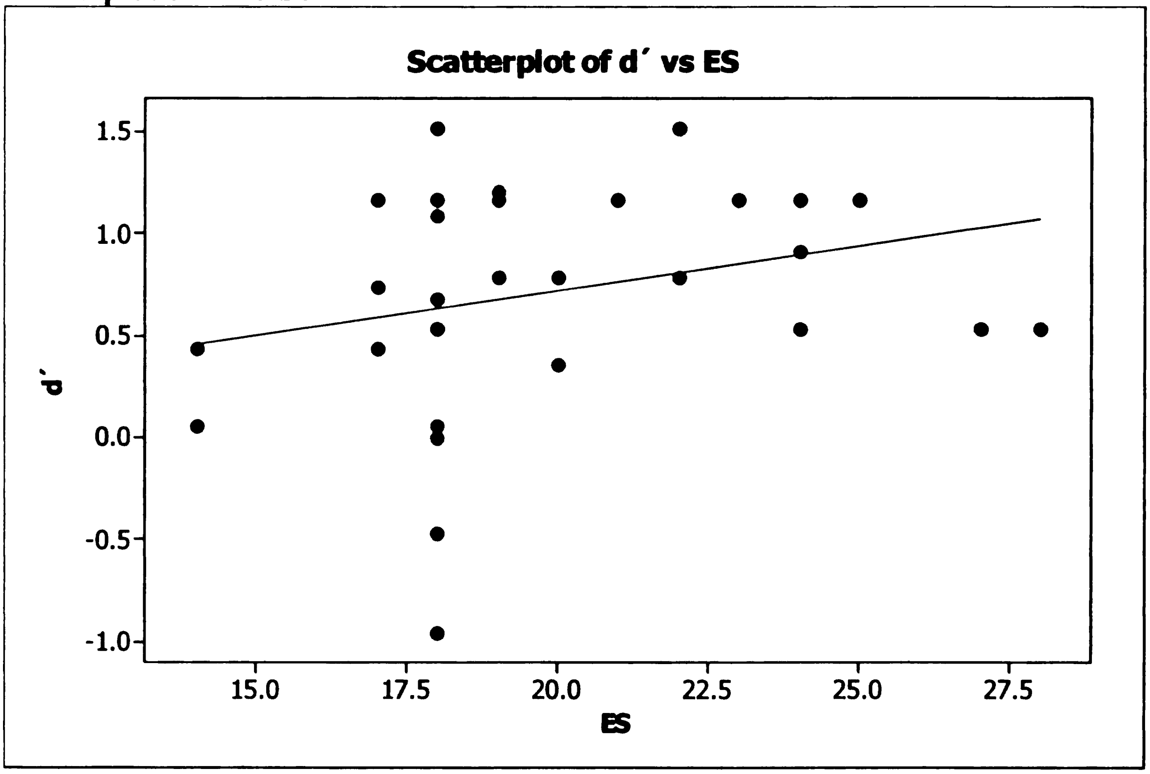
Scatterplot of d′ vs C



Regression Analysis: d′ versus ES

```
The regression equation is
d´ = - 0.163 + 0.0439 ES

Predictor      Coef   SE Coef      T      P
Constant    -0.1633    0.6079  -0.27  0.790
ES          0.04393   0.03002   1.46  0.155

S = 0.555964   R-Sq = 7.1%   R-Sq(adj) = 3.8%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.6619  0.6619  2.14  0.155
Residual Error  28  8.6547  0.3091
Total           29  9.3166

Unusual Observations

Obs    ES      d´     Fit  SE Fit  Residual  St Resid
  9  28.0   0.535  1.067   0.262    -0.532     -1.08 X
 10  18.0  -0.468  0.627   0.117    -1.095     -2.02R
 13  18.0  -0.955  0.627   0.117    -1.582     -2.91R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

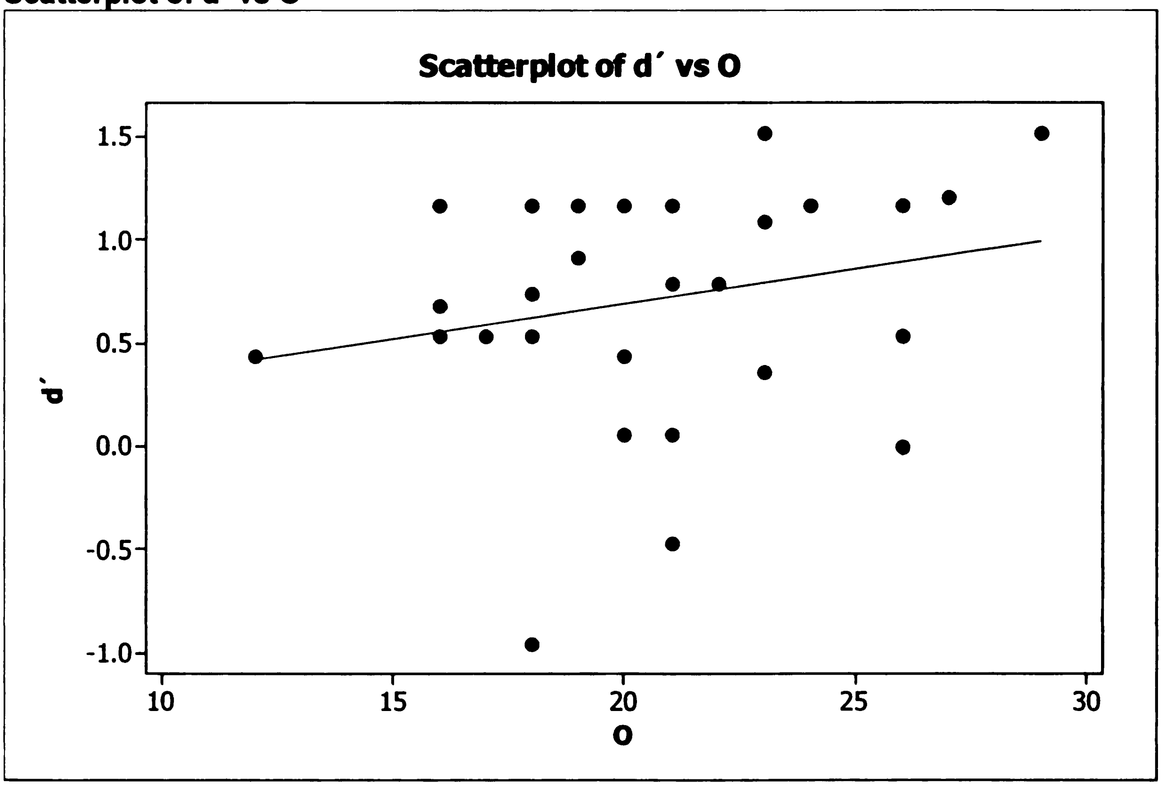
Scatterplot of d′ vs ES



Regression Analysis: d′ versus O

```
The regression equation is
d´ = 0.015 + 0.0338 O

Predictor      Coef  SE Coef     T      P
Constant     0.0148   0.5738  0.03  0.980
O           0.03383  0.02732  1.24  0.226

S = 0.561660   R-Sq = 5.2%   R-Sq(adj) = 1.8%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.4837  0.4837  1.53  0.226
Residual Error  28  8.8329  0.3155
Total           29  9.3166

Unusual Observations

Obs     O      d´    Fit  SE Fit  Residual  St Resid
 10  21.0  -0.468  0.725   0.103    -1.193    -2.16R
 12  12.0   0.436  0.421   0.258     0.015     0.03 X
 13  18.0  -0.955  0.624   0.126    -1.579    -2.88R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

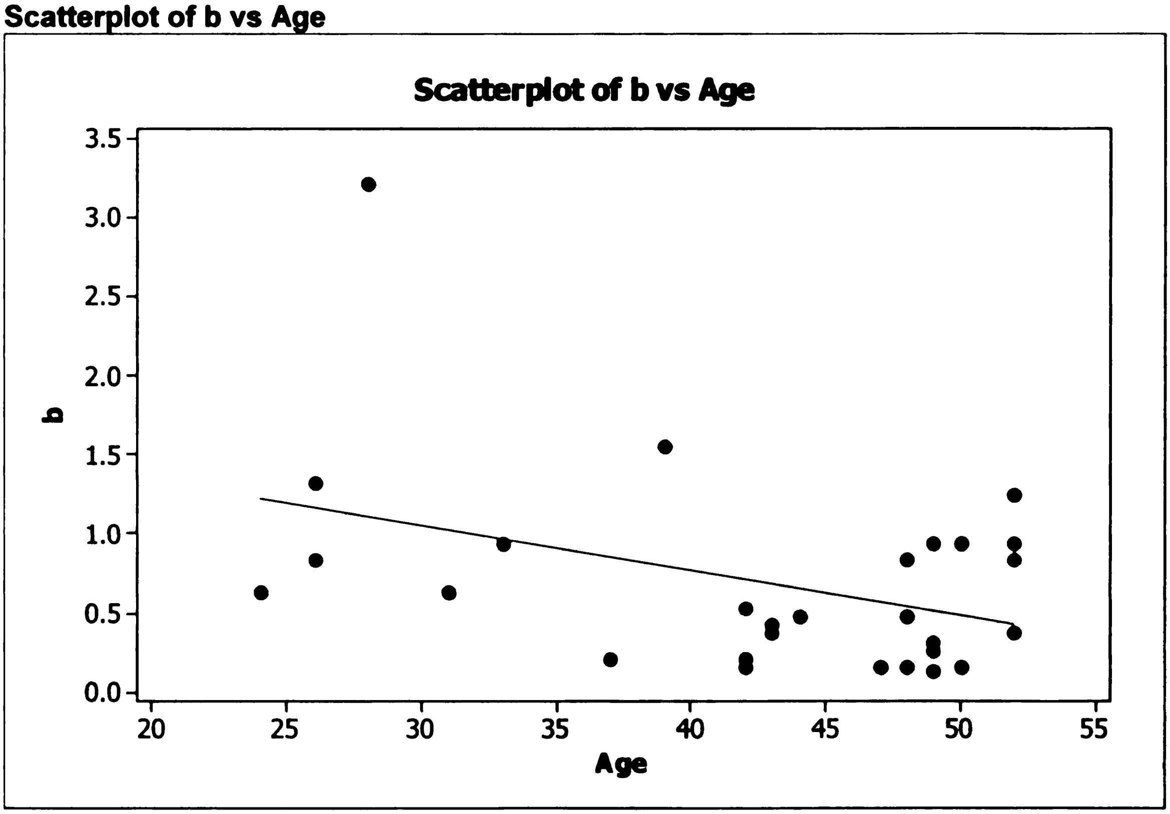
Scatterplot of d′ vs O



Regression Analysis: b versus Age

```
The regression equation is
b = 1.88 - 0.0280 Age

Predictor       Coef  SE Coef      T      P
Constant      1.8842   0.5389   3.50  0.002
Age         -0.02798  0.01228  -2.28  0.030

S = 0.573397   R-Sq = 15.7%   R-Sq(adj) = 12.6%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   1.7086  1.7086  5.20  0.030
Residual Error  28   9.2059  0.3288
Total           29  10.9146

Unusual Observations

Obs   Age      b    Fit  SE Fit  Residual  St Resid
 14  28.0  3.214  1.101   0.213     2.113     3.97R

R denotes an observation with a large standardized residual.
```

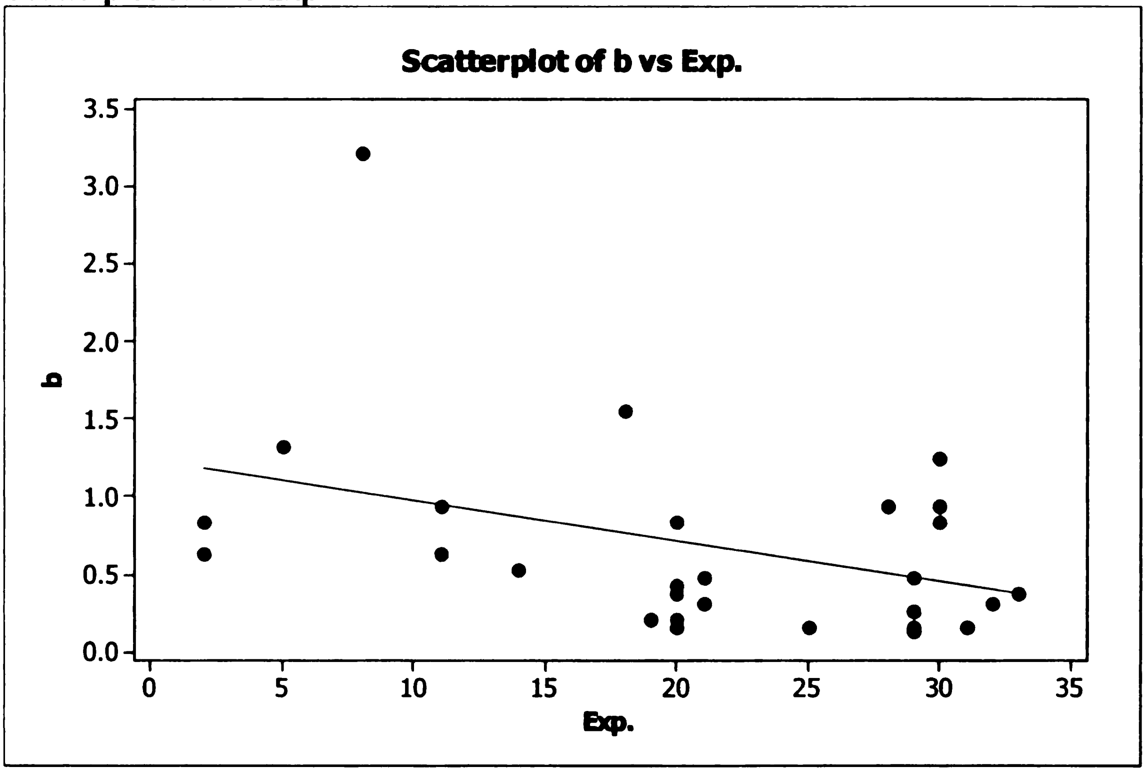
Scatterplot of b vs Age



Regression Analysis: b versus Exp.

```
The regression equation is
b = 1.23 - 0.0258 Exp.

Predictor        Coef  SE Coef      T      P
Constant       1.2262   0.2700   4.54  0.000
Exp.         -0.02577  0.01171  -2.20  0.036

S = 0.576489   R-Sq = 14.7%   R-Sq(adj) = 11.7%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   1.6090  1.6090  4.84  0.036
Residual Error  28   9.3055  0.3323
Total           29  10.9146

Unusual Observations

Obs  Exp.      b    Fit  SE Fit  Residual  St Resid
 14   8.0  3.214  1.020   0.187     2.194     4.02R

R denotes an observation with a large standardized residual.
```

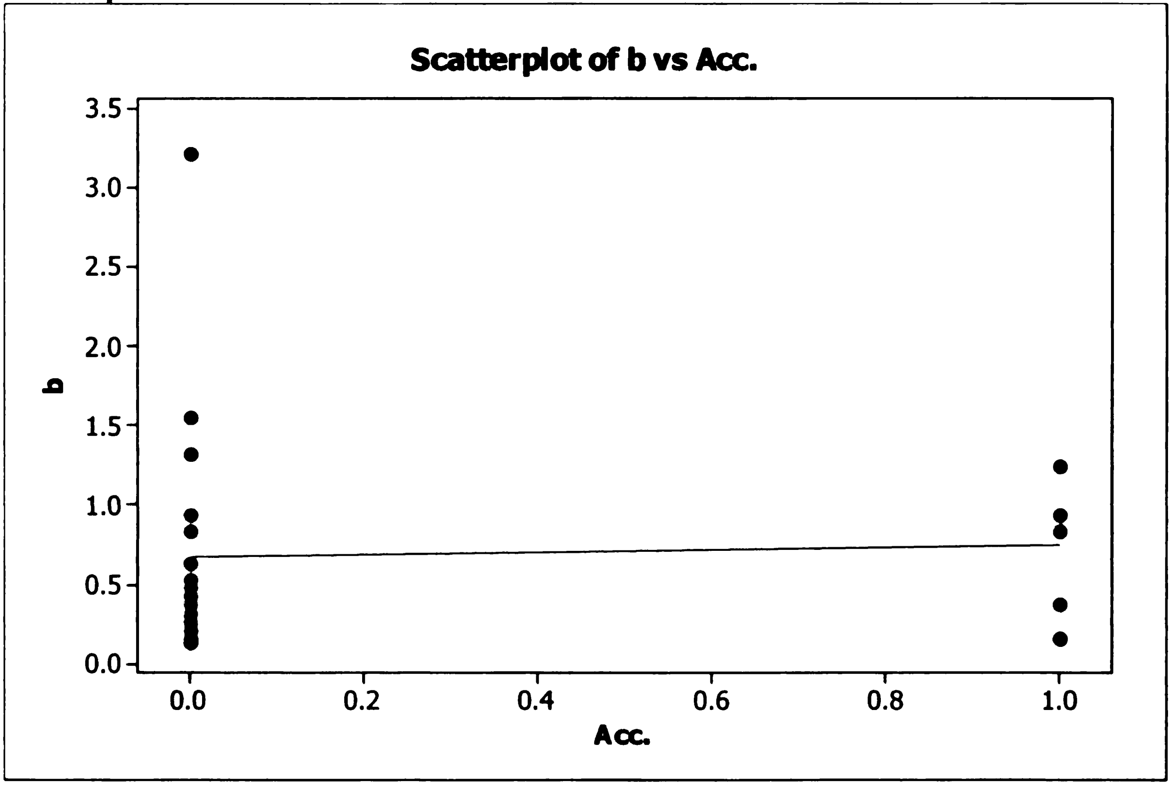
Scatterplot of b vs Exp.



Regression Analysis: b versus Acc.

```
The regression equation is
b = 0.662 + 0.084 Acc.

Predictor     Coef  SE Coef     T      P
Constant    0.6623   0.1272  5.20  0.000
Acc.        0.0841   0.2845  0.30  0.770

S = 0.623373   R-Sq = 0.3%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   0.0339  0.0339  0.09  0.770
Residual Error  28  10.8806  0.3886
Total           29  10.9146

Unusual Observations

Obs  Acc.      b    Fit  SE Fit  Residual  St Resid
 14  0.00  3.214  0.662   0.127     2.552     4.18R

R denotes an observation with a large standardized residual.
```

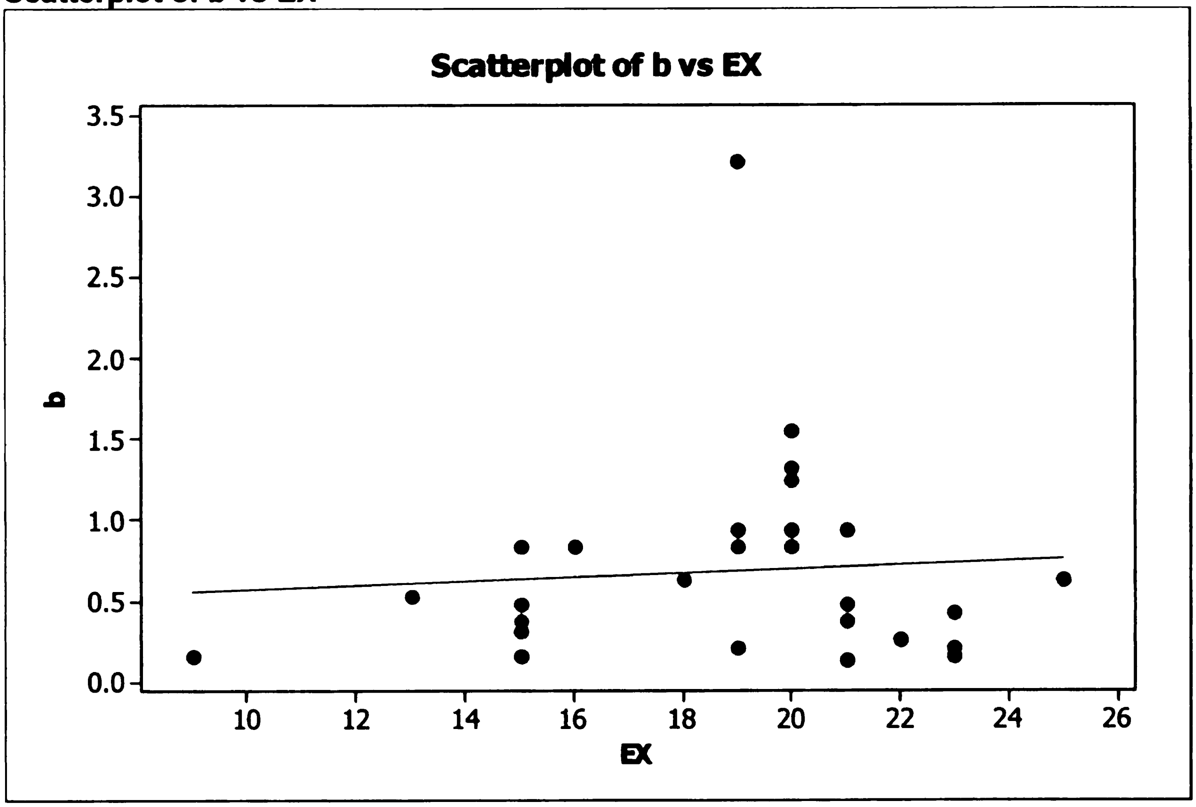
Scatterplot of b vs Acc.



Regression Analysis: b versus EX

```
The regression equation is
b = 0.437 + 0.0128 EX

Predictor      Coef   SE Coef     T      P
Constant     0.4368    0.6167  0.71  0.485
EX          0.01284   0.03213  0.40  0.692

S = 0.622570   R-Sq = 0.6%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   0.0619  0.0619  0.16  0.692
Residual Error  28  10.8526  0.3876
Total           29  10.9146

Unusual Observations

Obs    EX      b    Fit  SE Fit  Residual  St Resid
  6   9.0  0.158  0.552   0.337    -0.394    -0.75 X
 14  19.0  3.214  0.681   0.114     2.533     4.14R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

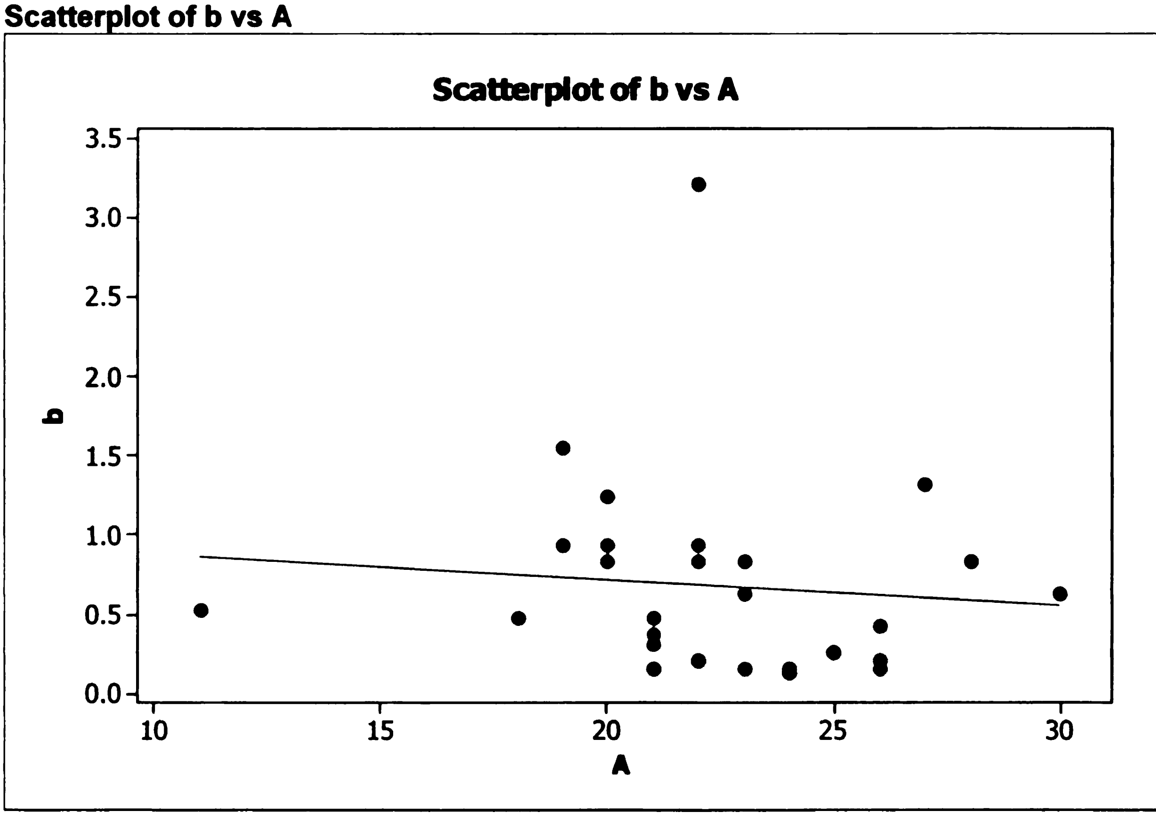
Scatterplot of b vs EX



Regression Analysis: b versus A

```
The regression equation is
b = 1.03 - 0.0159 A

Predictor       Coef  SE Coef      T      P
Constant      1.0337   0.7345   1.41  0.170
A           -0.01593  0.03259  -0.49  0.629

S = 0.621698   R-Sq = 0.8%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   0.0923  0.0923  0.24  0.629
Residual Error  28  10.8222  0.3865
Total           29  10.9146

Unusual Observations

Obs     A      b    Fit  SE Fit  Residual  St Resid
 13  11.0  0.523  0.859   0.384    -0.336    -0.69 X
 14  22.0  3.214  0.683   0.114     2.531     4.14R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

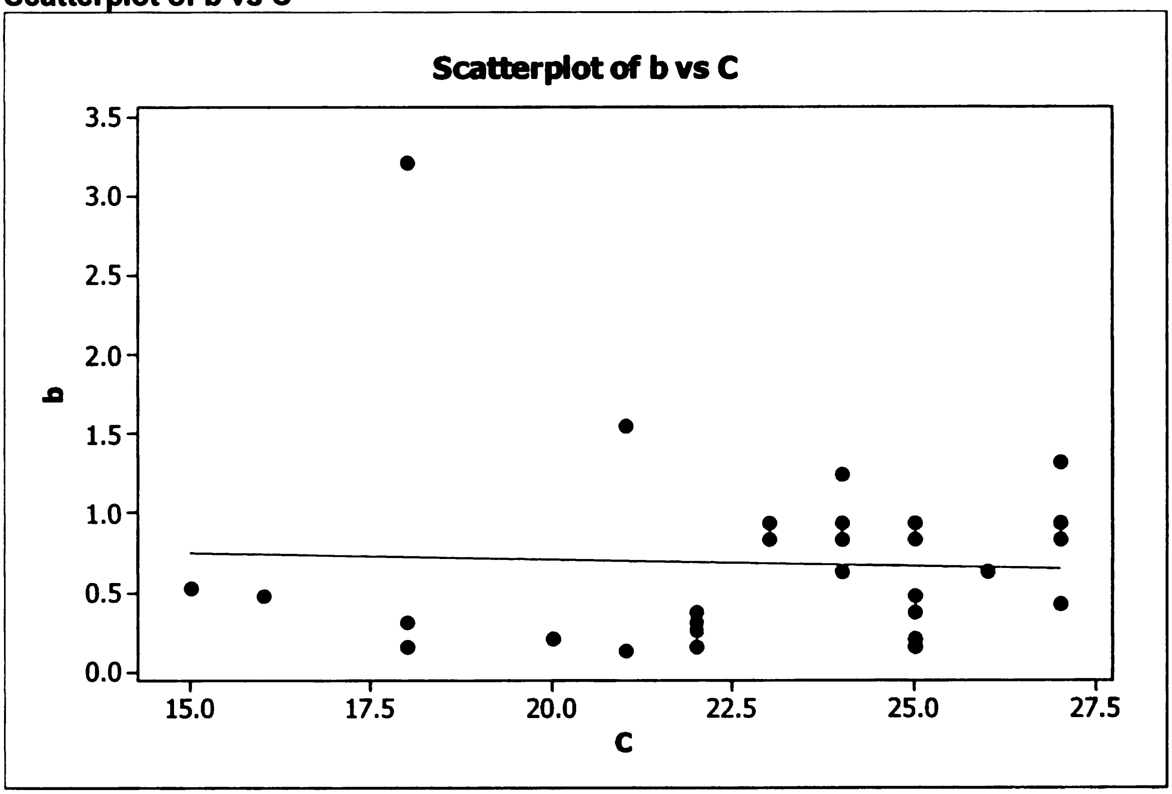
Scatterplot of b vs A



Regression Analysis: b versus C

```
The regression equation is
b = 0.858 - 0.0078 C

Predictor        Coef   SE Coef      T      P
Constant       0.8578    0.8137   1.05  0.301
C            -0.00781   0.03523  -0.22  0.826

S = 0.623796   R-Sq = 0.2%   R-Sq(adj) = 0.0%

Analysis of Variance

Source            DF       SS      MS     F      P
Regression         1   0.0191  0.0191  0.05  0.826
Residual Error    28  10.8954  0.3891
Total             29  10.9146

Unusual Observations

Obs     C      b    Fit  SE Fit  Residual  St Resid
 13  15.0  0.523  0.741   0.300    -0.218    -0.40 X
 14  18.0  3.214  0.717   0.206     2.497     4.24R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

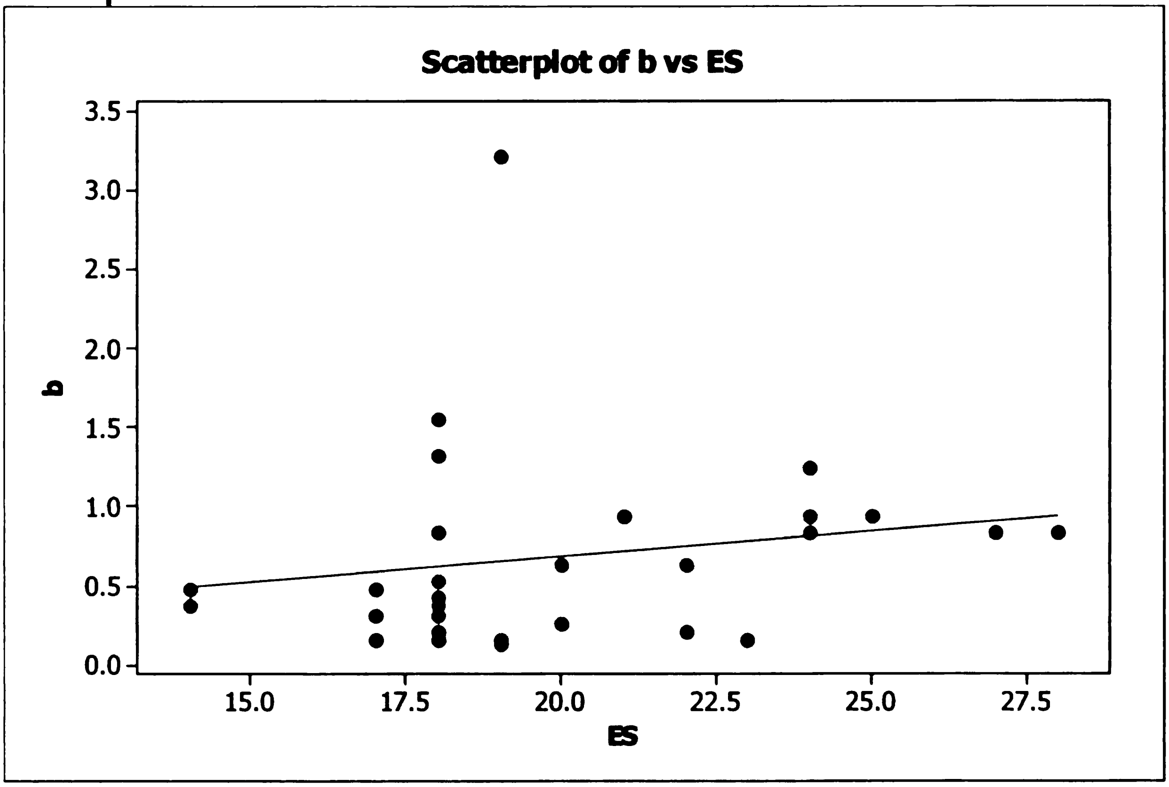
Scatterplot of b vs C



Regression Analysis: b versus ES

```
The regression equation is
b = 0.037 + 0.0322 ES

Predictor      Coef   SE Coef     T      P
Constant     0.0368    0.6715  0.05  0.957
ES          0.03217   0.03316  0.97  0.340

S = 0.614111   R-Sq = 3.3%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   0.3549  0.3549  0.94  0.340
Residual Error  28  10.5597  0.3771
Total           29  10.9146

Unusual Observations

Obs   ES      b    Fit  SE Fit  Residual  St Resid
  9  28.0  0.837  0.937   0.289    -0.100     -0.19 X
 14  19.0  3.214  0.648   0.117     2.566      4.26R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

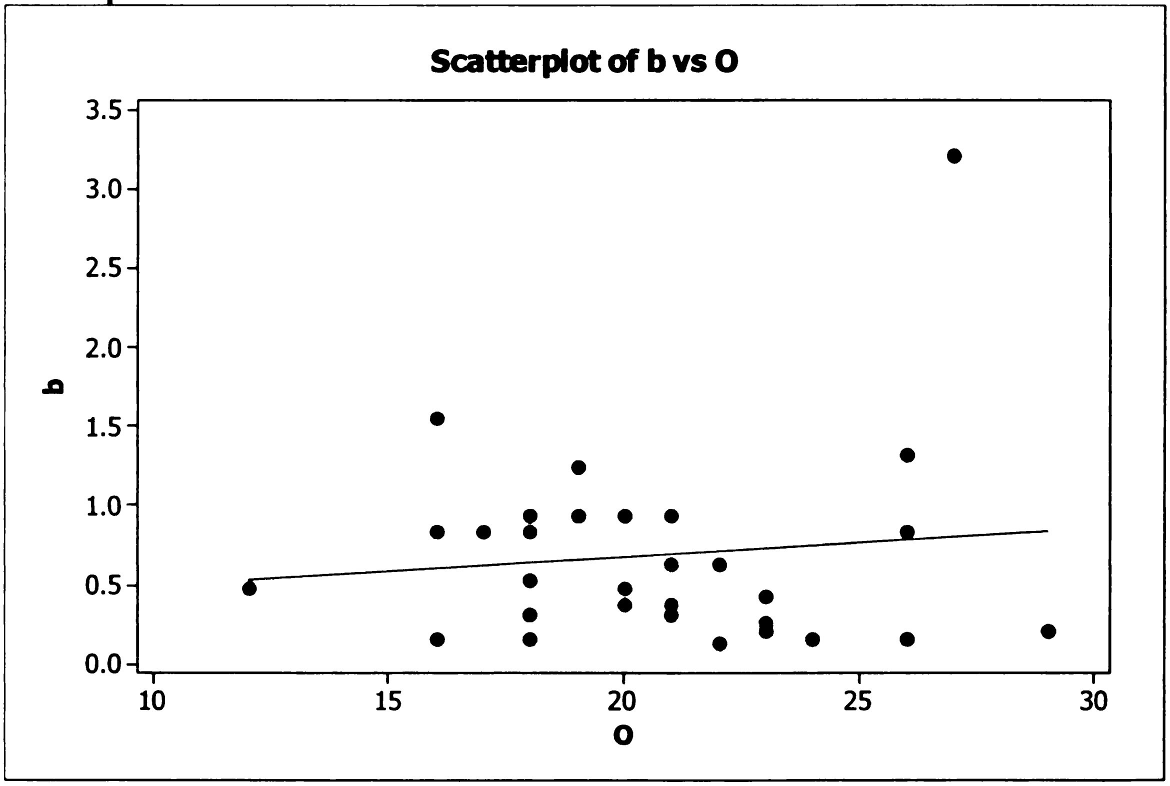
Scatterplot of b vs ES



Regression Analysis: b versus O

```
The regression equation is
b = 0.309 + 0.0179 O

Predictor      Coef   SE Coef     T      P
Constant     0.3088    0.6339  0.49  0.630
O           0.01791   0.03018  0.59  0.558

S = 0.620453   R-Sq = 1.2%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   0.1356  0.1356  0.35  0.558
Residual Error  28  10.7789  0.3850
Total           29  10.9146

Unusual Observations

Obs     O      b    Fit  SE Fit  Residual  St Resid
 12  12.0  0.474  0.524   0.285    -0.050     -0.09 X
 14  27.0  3.214  0.793   0.222     2.421      4.18R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```

Scatterplot of b vs O



Appendix E
NORMAL DEVIATES AND ORDINATES FOR d′ AND β

p	Normal Deviate Z	Ordinates
0.01	2.326	0.027
0.02	2.054	0.048
0.03	1.881	0.068
0.04	1.751	0.086
0.05	1.645	0.103
0.06	1.555	0.119
0.07	1.476	0.134
0.08	1.405	0.149
0.09	1.341	0.162
0.1	1.282	0.176
0.11	1.227	0.188
0.12	1.175	0.2
0.13	1.126	0.212
0.14	1.08	0.223
0.15	1.036	0.233
0.16	0.994	0.243
0.17	0.954	0.253
0.18	0.915	0.263
0.19	0.878	0.272
0.2	0.842	0.28
0.21	0.806	0.288
0.22	0.772	0.296
0.23	0.739	0.304
0.24	0.706	0.311
0.25	0.674	0.318

p	Normal Deviate Z	Ordinates
0.26	0.643	0.325
0.27	0.613	0.331
0.28	0.583	0.337
0.29	0.553	0.342
0.3	0.524	0.348
0.31	0.496	0.353
0.32	0.468	0.358
0.33	0.44	0.362
0.34	0.412	0.367
0.35	0.385	0.371
0.36	0.358	0.374
0.37	0.332	0.378
0.38	0.305	0.381
0.39	0.279	0.384
0.4	0.253	0.386
0.41	0.228	0.389
0.42	0.202	0.391
0.43	0.176	0.393
0.44	0.151	0.394
0.45	0.126	0.396
0.46	0.1	0.397
0.47	0.075	0.398
0.48	0.05	0.398
0.49	0.025	0.399
0.5	0	0.399

Table E.1 Normal Deviates and Ordinates for Calculating d′ and β

(Adapted from Patel, 2003)

Appendix F
MULTPILE REGRESSION RESULTS

Regression Analysis: d′ versus Age, Exp., Acc., EX, A, C, ES, O

The regression equation is
d′ = - 1.45 - 0.0212 Age + 0.0295 Exp. + 0.041 Acc. + 0.0514 EX + 0.0820 A
- 0.0567 C + 0.0526 ES - 0.0051 O

Predictor	Coef	SE Coef	T	P
Constant	-1.453	1.821	-0.80	0.434
Age	-0.02117	0.04172	-0.51	0.617
Exp.	0.02948	0.03663	0.80	0.430
Acc.	0.0409	0.3503	0.12	0.908
EX	0.05141	0.03766	1.37	0.187
A	0.08200	0.04636	1.77	0.091
C	-0.05666	0.05018	-1.13	0.272
ES	0.05260	0.03240	1.62	0.119
O	-0.00512	0.03795	-0.13	0.894

S = 0.537666   R-Sq = 34.9%   R-Sq(adj) = 10.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	8	3.2477	0.4060	1.40	0.252
Residual Error	21	6.0708	0.2891		
Total	29	9.3185			

Source	DF	Seq SS
Age	1	0.0077
Exp.	1	0.4719
Acc.	1	0.0797
EX	1	0.9176
A	1	0.7411
C	1	0.2596
ES	1	0.7649
O	1	0.0053

Unusual Observations

Obs	Age	d′	Fit	SE Fit	Residual	St Resid
10	49.0	-0.4700	0.5389	0.2796	-1.0089	-2.20R

R denotes an observation with a large standardized residual.

Regression Analysis: d′ versus Exp., EX, A, C, ES

The regression equation is
d′ = - 2.17 + 0.0129 Exp. + 0.0540 EX + 0.0847 A - 0.0575 C + 0.0510 ES

Predictor	Coef	SE Coef	T	P
Constant	-2.1689	0.9527	-2.28	0.032
Exp.	0.01294	0.01133	1.14	0.265
EX	0.05400	0.03296	1.64	0.114
A	0.08466	0.03770	2.25	0.034

```
C           -0.05751  0.04324  -1.33  0.196
ES           0.05105  0.02883   1.77  0.089


S = 0.506378   R-Sq = 34.0%   R-Sq(adj) = 20.2%


Analysis of Variance

Source          DF      SS      MS     F      P
Regression       5  3.1645  0.6329  2.47  0.061
Residual Error  24  6.1541  0.2564
Total           29  9.3185


Source  DF  Seq SS
Exp.     1  0.0218
EX       1  1.2790
A        1  0.8587
C        1  0.2012
ES       1  0.8038


Unusual Observations

Obs  Exp.       d´     Fit  SE Fit  Residual  St Resid
 10  32.0  -0.4700  0.4867  0.1926   -0.9567    -2.04R
 30  29.0   0.3600  1.2666  0.2277   -0.9066    -2.00R

R denotes an observation with a large standardized residual.
```

Regression Analysis: d´ versus EX, A, ES

```
The regression equation is
d´ = - 1.88 + 0.0336 EX + 0.0469 A + 0.0456 ES


Predictor     Coef  SE Coef      T      P
Constant   -1.8755   0.8726  -2.15  0.041
EX         0.03360  0.03013   1.12  0.275
A          0.04694  0.03063   1.53  0.137
ES         0.04559  0.02783   1.64  0.113


S = 0.514827   R-Sq = 26.0%   R-Sq(adj) = 17.5%


Analysis of Variance

Source          DF      SS      MS     F      P
Regression       3  2.4273  0.8091  3.05  0.046
Residual Error  26  6.8912  0.2650
Total           29  9.3185


Source  DF  Seq SS
EX       1  1.1552
A        1  0.5609
ES       1  0.7112
```

Unusual Observations

Obs	EX	d´	Fit	SE Fit	Residual	St Resid
6	9.0	1.1600	0.4198	0.3392	0.7402	1.91 X
13	13.0	-0.9500	-0.1017	0.3256	-0.8483	-2.13R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Regression Analysis: b versus Age, Exp., Acc., EX, A, C, ES, O

The regression equation is
b = 3.85 - 0.0566 Age + 0.0026 Exp. + 0.411 Acc. + 0.0156 EX - 0.0429 A
- 0.0299 C + 0.0449 ES - 0.0205 O

Predictor	Coef	SE Coef	T	P
Constant	3.853	1.912	2.01	0.057
Age	-0.05662	0.04380	-1.29	0.210
Exp.	0.00256	0.03845	0.07	0.948
Acc.	0.4108	0.3678	1.12	0.277
EX	0.01559	0.03954	0.39	0.697
A	-0.04293	0.04867	-0.88	0.388
C	-0.02987	0.05269	-0.57	0.577
ES	0.04490	0.03401	1.32	0.201
O	-0.02048	0.03984	-0.51	0.613

S = 0.564465   R-Sq = 38.6%   R-Sq(adj) = 15.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	8	4.1990	0.5249	1.65	0.171
Residual Error	21	6.6910	0.3186		
Total	29	10.8900			

Source	DF	Seq SS
Age	1	1.7132
Exp.	1	0.0131
Acc.	1	0.8408
EX	1	0.1662
A	1	0.7757
C	1	0.0411
ES	1	0.5647
O	1	0.0842

Unusual Observations

Obs	Age	b	Fit	SE Fit	Residual	St Resid
13	42.0	0.520	1.233	0.443	-0.713	-2.04R
14	28.0	3.210	1.402	0.341	1.808	4.02R

R denotes an observation with a large standardized residual.

Regression Analysis: b versus Age, Acc., A, ES

The regression equation is
b = 3.30 - 0.0502 Age + 0.324 Acc. - 0.0621 A + 0.0430 ES

Predictor	Coef	SE Coef	T	P
Constant	3.302	1.183	2.79	0.010
Age	-0.05022	0.01389	-3.62	0.001
Acc.	0.3242	0.2832	1.14	0.263
A	-0.06214	0.03091	-2.01	0.055
ES	0.04301	0.03063	1.40	0.173

S = 0.523800   R-Sq = 37.0%   R-Sq(adj) = 26.9%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	4.0308	1.0077	3.67	0.017
Residual Error	25	6.8592	0.2744		
Total	29	10.8900			

Source	DF	Seq SS
Age	1	1.7132
Acc.	1	0.7684
A	1	1.0083
ES	1	0.5409

Unusual Observations

Obs	Age	b	Fit	SE Fit	Residual	St Resid
13	42.0	0.5200	1.2835	0.3698	-0.7635	-2.06R
14	28.0	3.2100	1.3462	0.2185	1.8638	3.92R

R denotes an observation with a large standardized residual.

Regression Analysis: b versus Age, A

The regression equation is
b = 3.67 - 0.0390 Age - 0.0590 A

Predictor	Coef	SE Coef	T	P
Constant	3.673	1.108	3.31	0.003
Age	-0.03899	0.01323	-2.95	0.007
A	-0.05902	0.03239	-1.82	0.079

S = 0.550142   R-Sq = 25.0%   R-Sq(adj) = 19.4%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	2.7183	1.3591	4.49	0.021
Residual Error	27	8.1717	0.3027		
Total	29	10.8900			

Source	DF	Seq SS
Age	1	1.7132
A	1	1.0051

Unusual Observations

Obs	Age	b	Fit	SE Fit	Residual	St Resid
13	42.0	0.520	1.386	0.385	-0.866	-2.20RX
14	28.0	3.210	1.283	0.227	1.927	3.85R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.

Appendix G
SAMPLE DISTRIBUTIONS FOR THE FIVE FACTOR RANGES

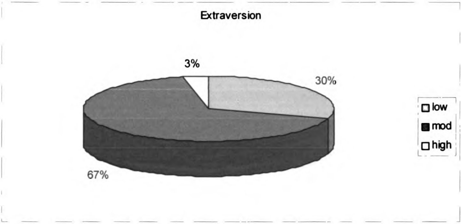


Figure 4.6 Low, Moderate and High Extraversion Percentages

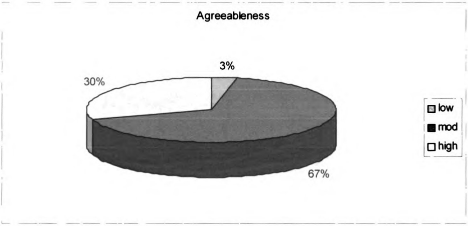


Figure 4.7 Low, Moderate and High Agreeableness Percentages

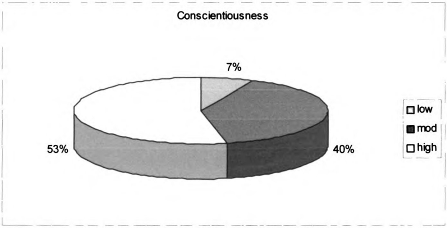


Figure 4.8 Low, Moderate and High Conscientiousness

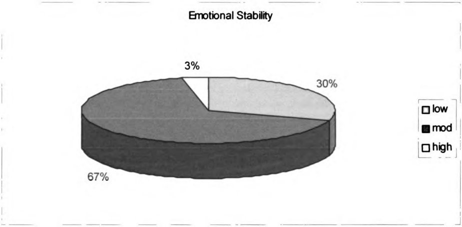


Figure 4.9 Low, Moderate and High Emotional Stability

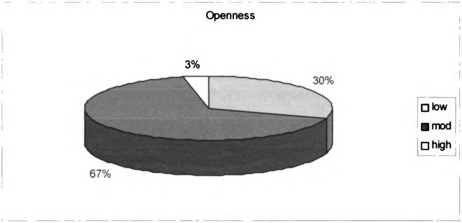


Figure 4.10 Low, Moderate and High Openness

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