Cultural Differences in Risk Perception: An Examination of USA and Ghanaian Perception of Risk Communication

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(ABSTRACT)

The increase in globalization and trade among larger industrialized countries and smaller developing countries has increased the awareness and need to better communicate risk and hazard information for consumer and manufacturing products. The purpose of this research was to examine cultural differences associated with risk communication and risk perception. The research observed cultural differences in hazard perception associated with color, signal words, and symbols among industry workers from the United States of America and the Republic of Ghana. The research also examined the perception of risk associated with general everyday statements as well as locus of control.

A total of 96 industry workers from both the USA and the Republic of Ghana participated in this study (USA = 46, Ghana = 50). Four different hypotheses were tested in this research. The hypotheses that were tested focused on risk perception (21 items) and locus of control (9 items), hazard perception and attention-getting for 6 symbols (carefulness, severity of injury implied, and understanding were also measured for the symbols) and 16 hazard signs. A pair wise comparison was used in one portion of the study in which 120 different signal word and color combination hazard signs were used. A nine-point Likert-type scale was used to evaluate the risk perception items. A four point Likert-type scale was used to measure locus of control.

The results from the study concluded that there are significant differences between the two cultures and the way individuals perceive risk, perceive hazards associated symbols, evaluate hazard signs, and locus of control. A total risk perception score as well as individual

risk perception scores were calculated for the 21 items using an independent sample t-test. The results for the total risk perception revealed significant differences between the two groups (t (84) = 6.43, $p < .0001$) with the participants from the USA having an overall higher risk perception with the mean equaling 6.39 and the participants from Ghana equaling 5.28.

Significant findings such as those from the risk perception portion of this study as well as other significant findings in this study will contribute to suggested guidelines and implications for safety training in a global work environment. Such guidelines and implications include using the SKULL symbol instead of the MR YUCK symbol to communicate hazard in Ghana and suggesting that the BOLT and ELECTRIC SHOCK symbol can be used interchangeably.

Dedication

I would like to dedicate this document to my parents James and Patricia Martin. Thanks mom and dad for all the love and support that you have given me throughout the years. You both have always been there to pick me up when I was down and to encourage me to go on. I could not have asked for better parents than the two of you. I love you and I am forever grateful for all you have done for me.

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INTRODUCTION

Risk communications – such as warnings – have been studied for many years and in different areas. Researchers have examined risk perception among diverse populations that differ by such factors as gender, age, and social status. However, relatively little research has been conducted on culture and its influence on how people perceive risk.

Risk communications and the ways in which risks are communicated among diverse populations are more important than ever due to globalization. The fact that the world is becoming more diverse in its communication and trade with different countries increases the need to study risk perception across cultures (Tomlinson, 1999). Globalization is the rapidly developing network of interactions and interdependencies that characterize modern social life (Tomlinson, 1999). It offers opportunities for smaller, less-industrialized countries to trade and be accessible to markets around the world. According to Tomlinson (1999), globalization lies at the heart of modern culture; and cultural practices lie at the heart of globalization.

Globalization has contributed to the reduction of poverty levels in several countries and has increased employment opportunities in others. With the increase in employment comes the potential increase in work related accidents. In the United States, Mexican immigration has increased from 4.3 million people in 1990 to 7.8 million people in 2000. Thirteen percent of the total workforce in the United States is made up of relatively new immigrants (Medina and Nurczky, 2002). According to Bureau of Labor Statistics, 14% of all fatal accidents that occur in the workforce are associated with the Hispanic population, and yet Hispanics make up only 11% of the entire workforce. OSHA reports that lack of training understandable to the individual worker is the main cause of fatal accidents in the workplace (Medina and Nurczky, 2002). Communications, both verbal and written, are contributing factors to the way individuals

perceive and process information. Cultural differences, globalization, and the way individuals perceive information should be considered in safety research.

Culture is mental software; it is learned, not inherited (Hofstede, 1997). Culture plays an important role in the way a person or a group of people acts, judges, and reacts to an environment. Culture is an important aspect of daily life and should be considered more in the context of safety and even more specifically, risk perception. Cultural ergonomics is a relatively new field that considers situation- and trait-based variations among cultures (Kaplan, 1995). It attempts to take what is known about culture and apply it to the design and development of systems using Human Factors techniques and principles. The goal of Cultural Ergonomics is to identify cultural variations and conflicts that could pose a threat to human-machine system interactions and address them before they stand to pose a serious problem. Its goal is to make sure that cultural issues that can impact the human and the system or the human-system interaction are addressed in all stages of development and design of systems (Smith-Jackson and Essuman-Johnson, 2002). Given the increase in industrialization and trade and the increasing prevalence of communications among different countries, the need to understand different cultures and their perceptions of risks and hazards is paramount.

Safety culture has been studied in corporate and industrial settings with respect to individual safety and the safety culture of the corporation itself. Safety culture is defined as the balance of business intellect and employee moral judgment (Kohn, Friend, and Winterberger, 1996). Safety culture represents a new way of conceptualizing processes of risk handling and management in organizational and other contexts (Pidgeon, 1991). It provides a global characterization of some of the common behavioral precautions to disasters and accidents in high-risk socio-technical systems, and might also prove to be a heuristic tool to aid risk

management in strategies to complement current risk assessment practices (Pidgeon, 1991). Safety culture and how a company's safety culture is communicated to its employees has a great deal to do with the education and training of its employees. Safety concerns among individuals are likely universal, but the importance or propriety given to safety, or decision-making regarding safety, may vary among cultures. The objective of this research was to identify relevant cultural conflicts associated with risk perception and hazard communication.

LITERATURE REVIEW

Cultural Ergonomics

Culture, as the *Merriam Webster's Collegiate Dictionary* (1995) defines it, "is the integrated pattern of human knowledge, belief, and behavior that depends upon people's capacity for learning and transmitting knowledge to succeeding generations; the customary beliefs, social forms, and material traits of a racial, religious, or social group; and the set of shared attitudes, values, goals and practices that characterizes a company or corporation" (p. 282). Hofstede (1997) describes culture as the collective programming of the mind, which distinguishes the members of one group or category from members of another. Culture is a learned behavior that is derived from a person's social environment and family upbringing. Culture is not inherited, it is not an involuntary action or behavior over which an individual or an individual's family has little or no control. Culture can be changed and it can be nurtured. Culture affects the ways in which people think, perceive information, act and react to daily situations, and interpret information. Cross-cultural research examines the differences across two or more populations and attempts to explain them on the basis of culture (Johnson, 1991).

Cultural ergonomics has been applied to the field of aviation and in international user interface designs. To date, a number of studies have examined different aspects of culture and how cultural influences affect individual perceptions of risk. Kleinhesselink and Rosa (1991) found that Japanese and American students used similar dimensions to rank order hazards, but their individual risk perceptions weighed differently in those dimensions. Bontempo, Bottom, and Weber (1997) assessed cross-cultural differences in the perception of financial risk among students from universities in Hong Kong, Taiwan, the Netherlands, and the United States and security analysts from Taiwan. They concluded that risk judgments among the participants differed across nationalities and not occupations. Different models have been developed to analyze and interpret results of cultural research and risk perception research. Bontempo et al. (1997) used the Conjunct Expected Risk (CER) model to describe the results of their study.

The CER model, first introduced by Luce and Weber in 1981, captures both similarities in individual's risk judgments as well as individual differences (Bontempo, et al., 1997). The CER model has five variables in which riskiness is evaluated: probability of a loss, probability of a gain, no change, expected loss, and expected gain. The CER model can be used to evaluate health and safety risks as well as financial risks.

The psychometric paradigm is another model that has been used in cross-cultural and risk perception research. The psychometric paradigm, which was developed by psychologists in the 1970s, initially resulted from investigating the different definitions of the term "riskiness" between expert and lay people (Marris, Langford, and O'Riordan, 1998). Later studies of the psychometric paradigm have investigated the relationship between risk perceptions and standard sociodemographic variables such a gender, age, occupation, and ethnicity (Marris, et al., 1998).

Another model that has been used in cross-cultural research and risk perception research is the five-factor model (FFM) (McCrae, Costa, Del Pilar, Rolland, & Parker, 1998). The FFM is a representation of the patterns of covariation of personality traits in terms of five broad factors, which include Neuroticism (N), Extraversion (E), Openness to Experience (O), Agreeableness (A), and Conscientiousness (C) (McCrae, et al., 1998). Researchers have argued that different dimension of the FFM have appeared to show up in different cultures and often differ on terms of collectivist and individualist societies. The two dimensions of N and E have been representative of and found in many cultures and not in others (Eysenck, 1983).

The cultural theory of risk perception is another model that has been used to examine the relationships between risk perception and culture. The cultural theory, which was developed by Mary Douglas in 1982, argues that differing risk perceptions can be explained in terms of four distinct cultural biases: hierarchy, egalitarianism, individualism, and fatalism (Brenot, Bonnefous, & Marris, 1998). Adams (1995) describes the four personalities as follows:

- *Individualists* are enterprising "self-made" people, relatively free from control by others, and who strive to exert control over their environment and the people in it. Their success is often measured by their wealth and the number of followers they can command. The self-made Victorian mill owner would make a good representative of this category.
- *Hierarchists* inhabit a world with strong group boundaries and binding prescriptions. Social relationships in this world are hierarchical, with everyone knowing his or her place. Members of a cast-bound Hindu society, soldiers of all ranks, and civil servants, are exemplars of this category.

- *Egalitarians* have strong group loyalties but little respect for externally imposed rules, other than those imposed by nature. Group decisions are arrived at democratically and leaders rule by force of personality and persuasion. Members of religious sects, communards, and environmental pressure groups all belong to this category.
- *Fatalists* believe they have minimal control over their own lives. They belong to no groups responsible for the decisions that rule their lives. They are non-unionized employees, outcasts, untouchables. They are resigned to their fate and they see no point in attempting to change it (p. 36).

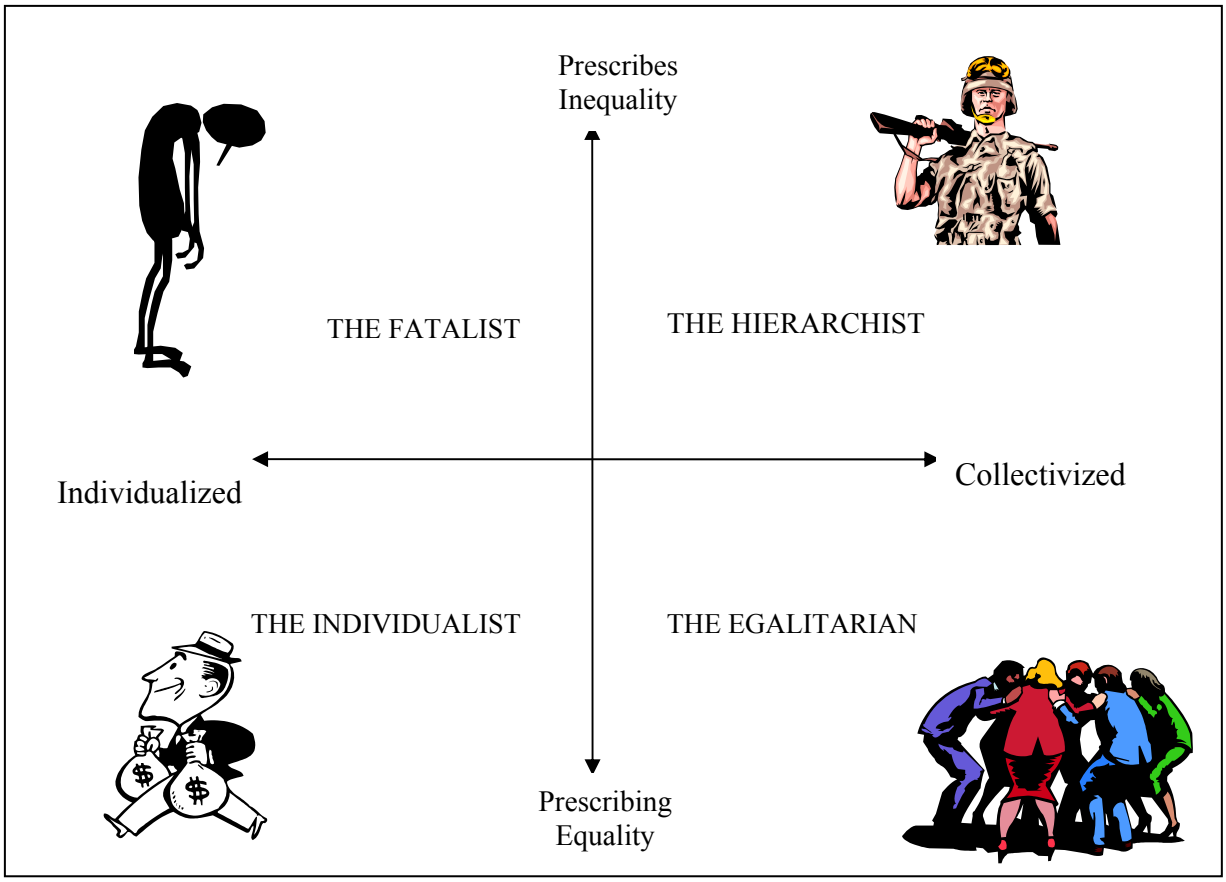

Figure 1: The four myths of human nature (Adams, 1995). "Reprinted from *Risk,* Adams (1998), with permission from Thomson Publishing"

Figure 1 illustrates the cultural patterns of the four personalities explained by Adams (1995) in a fourfold typology. As one moves from left to right on the horizontal axis, human nature becomes less individualistic and more collectivist. Moving along the vertical axis from top to bottom, at the top of the axis, human behavior is "prescribed," meaning it is constrained by restrictions on choice imposed by superior authority, and social and economic transactions are characterized by inequality (Adam, 1995). The bottom of the axis indicates that there are no externally prescribed constraints, meaning that people negotiate the rules as they go along (Adam, 1995).

As noted earlier and as Figure 1 displays, human nature becomes more collective and less individualistic as you move from left to right along the horizontal axis. Individualism and

collectivism, as introduced in this diagram, are important factors that need to be considered when conducting cultural research. Countries that are considered collectivist societies will tend to focus on the society as a whole versus individually. Hofstede (1997) identifies four dimensions that are aspects of culture and thus can be measured relative to other cultures. The dimensions are *power distance*, *collectivism versus individualism*, *femininity versus masculinity*, and *uncertainty avoidance* (Table 1). Hofstede's dimensions of individualism versus collectivism and power distance overlap with the personalities of the individualistic and those of the egalitarian and the hierarchist described by Adams (1995).

Table 1: Hofstede's Dimensions (1997)

Dimension	Definition
Power Distance	The extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally (1997, p. 28).
Individualism vs. Collectivism	*Individualism* pertains to societies in which the ties between individuals are loose: everyone is expected to look after himself of herself and his or her immediate family. *Collectivism* as its opposite pertains to societies in which people from birth onwards are integrated into strong cohesive ingroups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty (1997, p. 51).
Masculinity vs. Femininity	Masculinity pertains to societies in which social gender roles are clearly distinct; femininity pertains to societies in which social gender roles overlap (1997, p. 82-83).
Uncertainty Avoidance	The extent to which the members of a culture feel threatened by uncertain or unknown situations (1997, p. 113).

The first and second dimension, *power distance* and *individualism versus collectivism* respectively, are central to this research and will be explained in further detail.

Hofstede developed the four dimensions of culture as a result of a study conducted with IBM, using data representative of 50 countries around the world (Hofstede, 1997). The study revealed that IBM employees in different countries had common problems associated with values, but the solutions differed from country to country. The IBM study created an enormous amount of data reflective of culture and its different aspects such as collectivism and individualism.

Collectivism and individualism are factors that play a large role in the way people from different cultures follow orders and may influence how they perceive risk. Hofstede (1997) distinguishes collectivist societies from individualist societies by stating that when the interest of the group prevails over the interest of the individual, then the society is considered to be collectivist. The statement is completely opposite when considering individualistic societies. When the interest of the individual prevails over the interest of the group, the society is considered individualistic (Hofstede, 1997). Table 3.3 from Hofstede 1997 (p. 67), summarizes differences between collectivist and individualist societies with respect to general norms, family, economy, school, and workplace.

The individualism index was also developed as a result of the IBM study. The individualism index (IDV) lists the 50 countries and regions that were involved in the study. The IDV values for each country were computed using a factor score produced from each country. The factor score for the individualism dimension was multiplied by 25 and a constant of 50 points was added (Hofstede, 1997). The score range was 0-100 with scores close to 0 being the most collectivist countries and scores close to 100 being more individualistic. Table 3.1 from Hofstede 1997 (p. 53) lists the IDV values for the 50 countries.

In observing the IDV scores, the USA ranks number one with an IDV score of 91 and West Africa, which contains the countries of Nigeria, Sierra Leone, and Ghana ranks 39/41 with an IDV score of 20. As Hofstede (1997) explains, countries with relatively high individualism indices tend to be wealthier than countries with lower scores. There is a strong relationship between a country's national wealth and the degree of individualism in its culture (Hofstede, 1997). For the purpose of this research, it is necessary to know that in most cases, collectivistic societies (such as Ghana) are likely to make decisions that favor the group as a whole, and people from individualistic societies (such as the USA) are likely to be more concerned with themselves and make decisions that enhance ones own personal wellbeing.

Another one of Hofstede's dimensions is labeled *power distance*. Power distance, as it relates to a society, is the equality of power distribution among people in that particular country. Power distance is the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally (Hofstede, 1997). PDI scores are used to inform one about dependence relationships in a country (Hofstede, 1997). Table 2.1 from Hofstede 1997 (p. 26), lists the PDI values for the same 50 countries and three regions that were used in the IBM study and that were displayed for the IDV. West Africa, which – Nigeria, Sierra Leone, and Ghana – ranks 10/11 with a PID score of 77, while the USA ranks 38 with a PID score of 40.

In the context of safety, these dimensions could mean a great deal in regard to a company's overall goal which is to provide a safe work environment for its employees. Individuals who come from individualistic societies or who tend to put themselves above the group will more likely contribute to the company's problem with safety. These individuals are

the ones that are going to have lower perceptions of risk and in turn take more chances and possibly cause more accidents.

Hofstede (1997, p. 26) indicates, countries with higher PID values tend to be Latin, Asian, and African countries. According to Hofstede (1997), countries that have high power index scores tend to have a considerable dependence of subordinates on bosses. Subordinates respond by either preferring such dependence, or by rejecting it entirely (Hofstede, 1997). In countries such as the USA, Great Britain, and Germany, where the power distance index is lower, there is limited dependence of subordinates on bosses, and a preference for independence for their bosses by the subordinates (Hofstede, 1997).

As the term power distance indicates, countries with higher power index scores tend to rely on their bosses and therefore will be more likely to follow rules and orders set by their superiors. They tend to rely on them for advice and guidance. Individuals from countries that have low power index scores will have a tendency to want to do things without the help of a leader or others and may have a tendency to challenge authority and contradict their bosses. This can pose a threat to the individual's safety as well as the safety of others. Since safety is the overall goal that is ultimately trying to be addressed, power distance should be of some concern.

Based on the PID scores mentioned preciously, the United States is ranked lower than West Africa indicating that West Africans will tend to follow orders and regulations without reservation. The fact that the USA ranks lower according to PID scores than West Africa could possibly indicate that individuals from the USA are more willing and subject to challenge authority and therefore may be reluctant to perform certain tasks. The reluctance of individuals from the USA and their willingness to question authority can contribute to safety problems and draw a number of concerns.

Another model that examines culture is one created by Gullsetrup (1992) that argues that many cultures or cultural institutions in society have eight distinct characteristics which include:

- *Technology* – the mode of cultivation.
- *Economic systems* – the manner in which the society produces and distributes its goods and services.
- *Political Institutions* – the dominant means of governance maintaining order and exercising power and authority.
- *Association systems* – the mode of co-habitation and of social groupings that people form. This may range from fraternal and secret societies to professional or trade organizations.
- *Communication* – the mode of disseminating information, skills and knowledge
- *Reproduction, socialization and education* – the mode of integration and development of individuals and groups.
- *The ideological foundations of people's life* – i.e. the way of establishing and maintaining common identity.
- *Religious systems* – that is the institutions forming the manifest characteristics of peoples' religious beliefs (Kuada, 1999).

Gullestrup (1992) also argues that underlying different institutions and societies there are vertical dimensions of culture which include:

- *The underlying cultural structures:* unwritten rules governing the patterns of society and the relationships between people in that society.
- *Morals*: unwritten rules of how to behave.

- *Values*: beliefs that help members of a society to determine what is considered desirable behavior and what is not.
- *Fundamental world values of the society*: views that are held by members of a society as indisputable truths (Kuada, 1999 p. 4).

The eight characteristics of societies and the four vertical dimensions of culture that Gullestrup addresses are an alternative way to study culture. The eight characteristics broaden the degree in which culture can be defined and easily distinguished. They examine technology and economic systems of the country as well as communication, religious beliefs, and customs.

In reviewing other areas of culture, current and past research has examined culture as a primary factor in the ways in which individuals perceive risk in different situations. Smith-Jackson and Essuman-Johnson (2002) investigated how different interpretations of six symbols from the American National Standards Institute (ANSI) Z535.3 Standard and the International Organization for Standardization (ISO) 3864 Standards were interpreted among trade workers in industry. They surveyed trade and industry workers in Accra-Tema, Ghana on their interpretations of and the meanings of six symbols that are commonly used in the USA and abroad. They found that, out of the six symbols tested, the SKULL symbol had the most consistent response among the workers. The Ghanaians in this study did not recognize the SHOCK symbol that is commonly used in the USA to imply electric hazard. A large portion of the Ghanaians interpreted the symbol to mean rough, winding road, or thunder and lightning. Based on other conclusions from this study, it is evident that there is a need to standardize symbols used in risk communications.

Vaughn and Nordenstam's (1991) review of literature examined the perception of risk among ethnically diverse groups and concluded that ethnic background is one factor associated

with systematic differences in judgments on risk issues and that there are several reasons why ethnicity may be predictive of dissimilar perception. They concluded that there are three hypotheses suggesting mechanisms through which ethnic diversity could act to result in differences in perceptions: 1) differences in levels of exposure to risks or prior experience, 2) dissimilarities in general perspective on risk and the environment, and 3) nonequivalent values on those qualitative dimensions that likely influence lay assessments of environmental risk.

Douglas and Wildavsky (1982) explained that perceptions of risk are the result of prior experiences that provide cognitive schemas for defining and understanding risk, and also help shape value systems that affect how much weight is given to various dimensions when evaluating a hazardous situation. Ethnicity can be associated with certain life situations related to the evaluation of risk (Perry & Greene, 1982; Turner & Kiecolt, 1984). Ethnicity has also been associated with general interpretations of situations of uncertainty (Mirowsky & Ross, 1980; Turner & Kiecolt, 1984). The cultural theory of risk perception introduced by Douglas and Wildavsky (1982) would predict that individuals from varying ethnic backgrounds might differ in their tendency to emphasize certain risks and downplay others. In environmental situations, ethnic minorities judge risk to be greater when compared to Caucasians (e.g., nuclear waste disposal), but for other hazards, the relationship is just the opposite (Vaughn and Nordenstam 1991). There is evidence that for many environmental risks, significant differences in judgments may be observed for those who differ in ethnicity, gender, socioeconomic status, or educational level (e.g. Cambridge Reports, Inc., 1978; Fessenden-Raden, Fitchen, & Heath, 1987; Harris & Associates, 1980; Pilisuk & Acedolo, 1988; Wandersman, Berman, & Hallman, 1989).

Culture is one of many factors that influence individual perceptions of hazards in daily activities and in risk perception. Cultural influences and beliefs in many situations are deciding

factors that contribute to the misinterpretation of warning and risk communications in hazardous situations and events.

Warnings and Risk Communications

Risk communication is the exchange of information and opinions among individuals, groups, and institutions involving messages, concerns, opinions or reactions about risks (National Research Council [NRC], 1989). Risk communications should be designed to facilitate the formation of accurate knowledge of the risks (Tanka, 1997).

Tanka (1997) summarizes risk communications by saying that they should convey the message containing information, concerns, and opinions about risks. They should include a continuous feedback loop among the source and the receiver, and that they should be persuasive, involving sociocultural and psychological factors. Other researchers have used the mental model approach, concentrating on information processing (Atman, Bostrom, Fischhoff, & Morgan, 1994).

The mental model approach suggests the recipient of a communication needs a basic understanding of the exposure, effects, and mitigation processes relevant to making decisions about the hazardous process. It also suggests that a person's existing beliefs can affect how they interpret and use any new information received in the process. The model also proposes that information should be presented with appropriate text structure and that the structure of the text should be reinforced in ads. Risk communications should add critical missing information to a person's mental model that will, in the end, aid in the decision making process that will ultimately determine if a person is exposed to a hazard or not (NRC, 1989).

Atman et al. (1994) suggested that risk communications should cover the basic facts that are relevant to the recipient's decisions and that in risk communication design. The first step is to

create an expert model of the decisions that the recipients can make. The discrepancies that arise from the recipient's mental model and the expert model will elicit the contents of communication thus indicating where the flaws and gaps are in the communication process.

Risk communication research in the area of safety and warnings has examined the design of warning signs and the ways in which the hazard is communicated through pictorials and through written communications. Walker (1965) compared American and international road signs to investigate the recognition and understandability between symbols and text. The results of the study concluded that symbols were recognized more than words (Walker, Nicolay, & Stearns, 1965). Symbols, as Hofstede (1997) defines them, are words, gestures, pictures or objects that carry a particular meaning, which is only recognized by those who share the culture. Symbols can often mean different things to different people and different cultures in particular.

In more recent research, it has been found that the combination of symbols and words produce a greater understanding and a better way of communicating risks (Braun & Shaver 1999; Kalsher, Wogalter, Brewster, & Spunar, 1995; Leonard, 1994). Leonard (1994) examined the ability of the general public to understand hazards denoted by symbols that were commonly used. Although many of the participants were able to select correct alternatives when cued with possible hazards, they were not able to give the correct responses without cues in many cases, particularly when the hazard was not pictured (Leonard, 1994).

Kalsher et al. (1995) investigated factors that were associated with various measures of warning effectiveness, including noticeability, comprehension, and compliance. Kalsher (1995) evaluated the ANSI (1991) Z535.2 and Z535.4 standards warning label design and sign design against a proposed design. It was concluded that the signal word DANGER was perceived as more hazardous than the other currently specified signal words (i.e., CAUTION, WARNING).

Communicating risk factors is a growing phenomenon that government agencies and industries have taken steps to improve. In improving risk communications, industries will cut back on the amount of money spent each year in worker compensation claims, worker absenteeism, and consumer litigations. Often manufacturers will use warning signs that protect consumers from product misuse and potential dangers. Consumers themselves will seek risk information to avoid potential injury and harm to their loved ones. Through product liability lawsuits, the legal system compels manufacturers to provide adequate warnings to consumers while government agencies mandate disclosure of health hazards to protect society (Mazis & Morris, 1999). Many researchers have examined how pictorial and color interpretations differ among individuals and across cultures (Chapanis, 1994; Leonard, 1999; Leonard, Hill, & Karens, 1989; Leonard, Karens, & Schneider, 1988; Smith-Jackson & Wogalter, 2000[a]; Wogalter, Fredrick, Herrera, & Magurno, 1997). The need for risk communication has increased due to the concern surrounding hazards such as pollutants in the air and in drinking water; pesticide residues in food and in milk; threats from radiation and toxic chemicals; or the global climate changes, such as the greenhouse effect, acid rain, or ozone depletion (Tanka, 1997).

Wogalter et al. (1987) reported that criteria for a warning should include a signal word, give a description of the hazard, give a statement of consequence and provide instructions for hazard avoidance (Figure 2). Wogalter et al. (1987) also noted the importance of the physical characteristics of durability and ability to attract attention as well as the cognitive aspects of conciseness and comprehensibility as factors in producing appropriate responses to warnings. It is important to create warning designs that will be understood and interpreted by a vast majority of the population. Warnings and risk communications should communicate a universal message that can be understood across cultures.

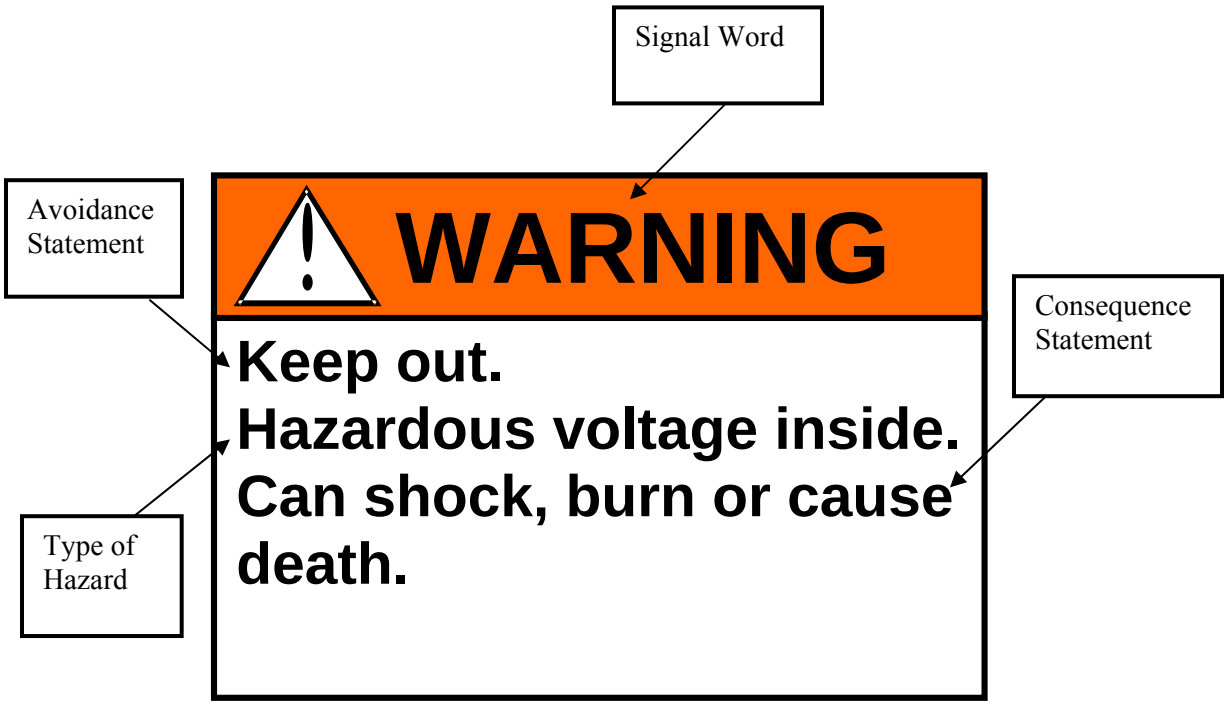

Figure 2: Example of a good warning (ANSI Z535.2, 1998, p. 13)

C-HIP

Researchers have also applied design models to enhance warning effectiveness. One well-known model is the Communication-Human Information Processing model (C-HIP; Figure 3). The C-HIP model consists of three major components: source, channel and receiver (Wogalter, DeJoy, & Laughery, 1999). The third component of the C-HIP model (receiver) consists of a number of information processing stages, which include noticeablility attention, memory comprehension, attitudes beliefs, motivation, and behavior.

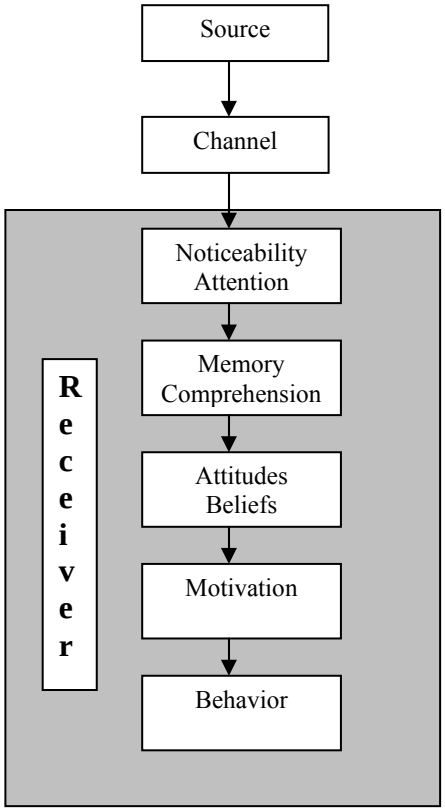

Figure 3: Communication-human information Processing (C-HIP) Model (). "Reprinted from *Warnings and Risk Communication,* Wogalter, M. DeJoy, M., & Laughery, K., (1999), with the permission from Thomson. Publishing"

A major purpose of the C-HIP model is to help identify potential points of failure. Wogalter et al. (1999) used the C-HIP model as an investigative or diagnostic tool for discovering why particular warnings do not fulfill the goal of promoting safe behavior as well as pinpoint the reasons for failure. Ultimately, Wogalter et al. (1999) discovered that this investigative process leads to the desired end result: safe behavior. Although this model seems simple and easy to comprehend, it should be noted that the C-HIP model is complex.

The first component of the C-HIP model is known as the *source.* It is the "originator or initial transmitter of hazard and risk information" (Wogalter, et al, 1999). The *source* can be the individual or entity responsible for initiating the communications intended to protect product

users (Cox, 1999). Possible sources can be the manufacturers, the federal government, nonprofit public service organizations, and industry trade organizations (Wogalter et al., 1999). The characteristics of an effective source are credibility (perceived expertise), likeability (physical attractiveness), power (influence), quantitative aspects (being able to be a part of a group), and demographics (Cox, 1999).

The second component of the C-HIP model is the *channel*. The channel is concerned with the way the message is transmitted from the source to the receiver (Wogalter, et al., 1999). The message can be transmitted through the human senses such as with auditory signals, visual displays, kinesthetic/body language, and olfactory (sense of smell). The channel is an important factor that influences the perception and the way risks are communicated. There are five communication channels across which information can be processed: advertising, product labels, signs and signals, leaflets and owners' manuals, and face-to-face communication (Mazis & Morris, 1999).

The third component of the C-HIP model is the *receiver*. The receiver stage of the model has several mental components: noticeability, attention, memory comprehension, attitudes beliefs, motivation, and behavior (Wogalter, et al., 1999). Each mental stage affects the outcome of how information is processed and how individuals act in response to their interpretation of the information they are processing. This component includes such things as risk perception, culture, individual differences, and outcome behavior.

In studying each stage of the C-HIP model, one can observe potentially dangerous situations, identify where miscommunications take place, and take steps needed to correct the problem. The following information presented will explain the different aspects of the C-HIP model in more detail.

Attention

Signal Words.

Signal words are used to attract attention to the hazard. They call attention to the safety sign and designate a degree or level of hazard seriousness (ANSI Z535.4, 1998). A signal word does not by itself explain what the problem is, but it can alert an individual to a hazardous situation (Leonard, et al., 1989). Research as been conducted on the effectiveness of signal words and the level of risk associated with each word. The most frequently used signal words are DANGER, WARNING, and CAUTION.

DANGER indicates an imminently hazardous situation, which if not avoided, will result in death or serious injury (ANSI Z535.4, 1998). WARNING, according to ANSI Z535.4, indicates a potentially hazardous situation, which if not avoided, could result in death or serious injury. CAUTION indicates a potentially hazardous situation, which if not avoided, may result in minor or moderate injury (ANSI Z535.4).

Chapanis (1994) examined the three aforementioned signal words. In evaluating the signal words, each participant was asked to rate the level of hazard associated with each word by indicting if the term was *most forceful*, *most emphatic* or the *strongest*. The findings of this study were consistent with other research in that DANGER indicated the highest level of hazard. There was a small, but consistent amount of disagreement with WARNING and CAUTION, but overall the two were understood to have the same meaning. WARNING was understood to indicate an intermediate hazard and CAUTION to indicate a low level of hazard.

Wogalter et al. (1997) examined the use of signal words among native Spanish language users and concluded that commonly used English signal words were not well understood by the sample of Spanish speakers in their study. Silver and Wogalter (1989) investigated the use of

signal words, their interpretations, and the level of hazard associated with each word. The results indicated that DANGER is greater in strength than WARNING and CAUTION.

A number of other studies have examined signal words and usefulness in drawing attention to hazards (Chapanis, 1994; Leonard, 1988; Leonard, Hill, & Karen, 1989; Silver & Wogalter, 1989). Other features of risk communications can be equally effective. One particularly effective feature is color.

Color

Color is a determining factor in whether a hazard is communicated properly and understood. In many instances, the determining factor of what level of hazard or risk should be associated with a warning is communicated by the color of the sign being displayed. Color, like many other features, can have a different meaning for different people and thus create mixed impressions or observations of the level of risk associated with a hazard. A great deal of research has been conducted on color and its use in communicating hazards (Chapanis, 1994; DeTurck, Goldhaber, & Richetto, 1991; Hupka, Zaleski, Otto, Reidl, & Tarabrina, 1997; Leonard, 1999; Smith-Jackson & Wogalter, 2000[b]; Wogalter, Fredrick, Herrera, & Magurno 1997).

Smith-Jackson and Wogalter (2000[b]) examined color and symbol hazard ratings among participants whose primary language was English. The participants were asked to rate their perceived hazards of ten ANSI safety colors and six symbols. The study concluded that RED, followed by YELLOW, BLACK, and ORANGE were given the highest hazard ratings. Wogalter et al. (1997) examined native Spanish speakers and their interpretation of ANSI standard colors. It was concluded, consistent with other studies, that RED indicated the greatest hazard among the other colors tested.

DeTurck et al. (1991) examined if the color of text used in a warning and the level of fear that the participants felt in the hazard statement jointly affected the perception of danger associated with alcoholic beverages. The participants in the study perceived alcoholic beverages to be most dangerous when the color RED was associated with the drink where as GREEN received the lowest rating (DeTurck, 1991)

Although the focus was general color impressions and not hazard levels, Hupka (1997) examined cross-cultural differences in color associations. Hupka (1997) examined five different colors (red, black, purple, green, and yellow) and their association with four different emotions (anger, envy, fear, and jealousy) among five different ethic groups (German, Mexican, Polish, Russian, and American). Hupka (1997) found that the colors BLACK and RED were associated with anger across all nations and that fear was associated with the two colors across all nations with the exception of Mexico.

The ANSI Z 535.1 Standard recognizes 10 colors that are commonly used to communicate hazards. The colors are red, orange, yellow, green, blue, purple, white, gray, black, and brown. Smith-Jackson and Wogalter (2000[b]) tested the perceived hazards of the 10 ANSI safety colors along with six symbols among monolingual participants where English was their primary language. The findings of the study were compared to Wogalter, Fredrick, Herrera, and Magurno (1997) study in which the participants' primary language was Spanish.

The findings from Smith-Jackson and Wogalter (2000[b]) were consistent with Wogalter et al. (1997) in that RED was given the highest hazard rating in both studies. BLACK and YELLOW did not differ significantly in the hazard rating, although English speakers perceived YELLOW to be the second highest hazard color, while Spanish speakers rated ORANGE as the second highest hazard color. Based on the ANSI Z535.1 standard, ORANGE is used to show

intermediate level of hazard and is used with the signal word WARNING and YELLOW is more often used with the signal word CAUTION. Thus, there are cross-cultural similarities in the ways in which some colors are interpreted, but there are also differences that warrant further exploration.

In a 1986 study conducted by Dunlap, Granda, and Kustas, participants rated seven signal words and six colors on the basis of the degree of PERSONAL hazards that were associated with each item. The actual color name was presented and not the color itself. The mean ratings for the colors from the highest to the lowest perceived hazard were as follows: RED, ORANGE, YELLOW, BLUE, GREEN, and WHITE. The order in which ORANGE and YELLOW were rated was consistent with the ANSI Z535.1 standard. To date, the majority of risk communication focuses on signal words and colors. Because of the complexity, and thus, the ability to trigger a variety of meanings, symbols have not received sufficient research attention.

Symbol

Symbols are figures or objects that convey a message without using words (ANSI Z535.3, 1998). To date, little research has examined symbols and how their interpretations can affect the level of risk associated with hazards across cultures. Symbols have been researched to determine general interpretations and comprehensibility. Results have indicated that symbols do not always communicate the information they intend.

Studies have examined different symbols and how the general population interprets them, most commonly the (Figure 4) SKULL, SHOCK symbol, PROHIBITION symbol, MR. YUK symbol, ALERT symbol, HAND-IN-GEAR and ASTERISK symbols (Calitz, 1994; Leonard, 2000; Leonard, 1994; Leonard, 1988; Smith-Jackson & Essuman-Johnson 2002; Smith-Jackson & Wogalter 2000[b]; Wogalter, Fredrick, Herrera, & Magurno, 1997). In one particular study in

which the participants were primarily Spanish speakers, it was found that the skull symbol rated the highest in regards to hazard level followed by the electric shock symbol and then the prohibition symbol (Wogalter, et al. 1997).

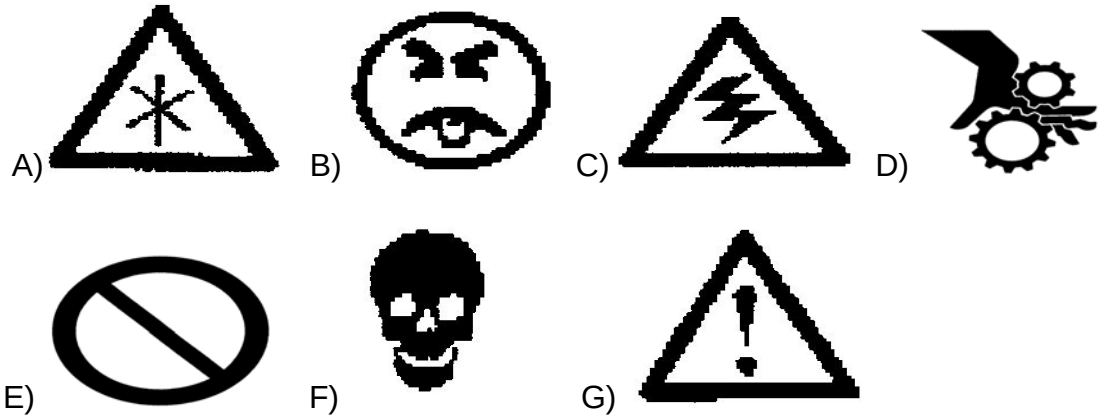

Figure 4: Common symbols used in safety research. A) Asterisk, B) Mr. Yuk, C) Shock, D) Hand in Gear, E) Prohibition, F) Skull, and G) Alert (ANSI Z535.3, 1998).

Smith-Jackson and Essuman-Johnson (2002) examined six symbols from the ANSI Z535.3 Standard and the International Organization for Standardization (ISO) 3864 Standard. The symbols were identical to those used in the Wogalter et al. (1997) study. Smith-Jackson and Essuman-Johnson (2002) used participants from Accra-Tema Ghana, in their study. They found that 81% of the respondents reported that the SKULL symbol (See F in Figure 4) communicated danger, poison, or deadly. It was tentatively stated that the SKULL symbol seemed to elicit a high level of hazard among the Ghanaian population. This was consistent with other populations and their interpretations of the symbol.

The SHOCK symbol (See C in Figure 4), which means electric hazard, did not elicit any association or meanings with the majority of the participants interviewed. Their interpretations ranged from lightning and power to rough and winding roads. The ALERT symbol (See G in

Figure 4), which is used to trigger an individual's attention, yielded roughly the same results as the SHOCK symbol in this study. Sixty-two percent of the participants could not attach a meaning to the symbol nor could they relate the symbol to something with a relatively minimal hazard.

Leonard (1994) observed the general public and their ability to understand hazards denoted by symbols that were commonly used and designed for the study. The symbols that were used in the study were a range of designs depicting biomedical hazards, explosives, flammable objects/substances, irritants, corrosive substances, and electrical shock. The results of the study were quite disturbing in that the participants were unable to appropriately describe the hazards represented by the pictograph. Leonard (1994) suggested that more effort needs to be exerted in the development of symbols, and that more training must be given to the public concerning the meaning of the symbols that are used to denote hazards.

Calitz (1994) observed 16 randomly selected symbols presented to undergraduate commerce students. The results of the study demonstrated that several symbols were too abstract and should be redesigned. Smith-Jackson and Wogalter (2000[b]) examined hazard ratings for six symbols among Spanish-speaking and English-speaking participants. The findings indicated that the SKULL, PROHIBITION, and the SHOCK symbols produced the top three hazard ratings when compared to the MR. YUK, ALERT, and ASTERISK symbols.

The interpretation of symbols, colors and signal words play a large role in how a hazardous situation will be handled and ultimately how the situation will be perceived. An individual's perception of a situation can be the difference between an injury and a possible life-threatening situation. Risk perception, which is the next section that will be discussed, is an

important factor in how hazards are communicated and what type of action an individual will take in response to different hazards.

Risk Perception

Risk perception has been defined in many different ways and for many different reasons. Wogalter et al. (1999) defined risk perception as a broad notion of safety awareness and the overall awareness and knowledge regarding hazards, likelihoods, and potential outcomes of a situation or set of circumstances that could cause potential harm. Risk perception has also been used to describe a person's beliefs, attitudes, judgments and feelings about hazards, danger and risk-taking, within the wider context of social and cultural values (Mearns & Flin, 1995[a]). Mearns and Flin (1995 [b]) stated that it is not "risks" that are perceived, but hazards or various features of decision problems, which lead to feelings of danger or safety.

The C-HIP model, introduced earlier, included three components. The third component, called the *receiver,* included a number of subcategories that all influence risk perception (Figure 3, p.19). Noticeability/attention is one substage of the receiver stage. Noticeability and attention are both important factors that contribute to risk perception. The first operation of the receiver based on the C-HIP model is attention. Attention has two stages, capture and maintenance.

The capture or switch stage is the stage in which the warning must capture the attention of the individual by standing out from other stimuli in cluttered or noisy environments (Wogalter & Leonard, 1999). The second stage of attention is supposed to maintain or hold attention while and until information from the warning is extracted. Wogalter and Leonard (1999) listed some factors that influence attention and maintainability in visual situations including environmental

conditions, duration/flash rate, brightness contrast, color contrast, highlighting boarders, size, signal word panel and multiple feature combinations, pictorial symbols, and location.

The second receiver stage is the comprehension and memory stage. In this stage, the factors that influence the understanding and retention of the warning messages being presented are introduced. Leonard, Otani, and Wogalter (1999) list several guidelines that should be considered when designing warnings to facilitate comprehension and memory (Table 2):

Table 2: Guidelines to facilitate Comprehension and Memory

Comprehension	Memory
Use simple language	Use textual and pictorial materials that are meaningful and organized
Verify that the text and symbols convey the intended meaning to the target population at risk	Provide cues to assist retrieval
Describe carefully and explicitly the nature of the hazard, the instructions on how to avoid the hazard, and the consequences of failing to avoid the hazard	Provide training when considerable amounts of hazard-related information need to be learned
Test the best prototypes with at-risk individuals who may be least knowledgeable about the hazard	Change the warnings occasionally so that the effects of habituation are reduced.
Redesign a warning when testing reveals the target audience does not acquire the message intended	

The third receiver stage that influences the perception of risk is the attitudes and beliefs stage. This stage influences how the individual will approach and interact with a hazardous situation (DeJoy, 1999). DeJoy (1999) refers to beliefs as convictions about phenomena or

objects that are accepted as true (regardless of actual truth), and often beliefs are viewed as the building blocks of attitudes. Rokeach (1966) defines attitudes as a relatively enduring organization of beliefs about an object or situation predisposing one to respond in some preferential manner (DeJoy, 1999). Attitudes and beliefs are influenced by a persons learned behavior. Culture, as mentioned earlier, is a learned behavior that is derived from a person's social environment that encompasses their beliefs, religious, and moral values.

The fourth stage is the motivation stage and deals with factors that energize users to comply with warnings. The factors include cost of compliance, explicit consequences, and anticipated injury severity (Wogalter et al., 1999). In studying risk communications and human behavior, motivation influences how an individual will handle a hazardous situation and ultimately influences the outcome.

The fifth and final stage is the behavior stage. The behavior stage includes the actions that the individual decides to take in response to the previous stages. A number of different personal factors affect behavior including familiarity, perceived risk, gender, and locus of control (Silver & Braun, 1999). Situational variables such as time pressure and cost of compliance have also been shown to affect the extent to which warnings influence behavior (Silver & Braun, 1999).

In summary, the C-HIP model presents characteristics of effective warnings. Effective risk communications should be noticeable, understandable, convey the appropriate message, and take into account the various characteristics of the target audience (such as their beliefs, attitudes, and motivation). These criteria must be met to have a chance at influencing safety-related behavior (Silver, et al., 1999). Each stage of the receiver component focuses on mental operations in which the individual must process and in the end act on. Each component

influences the final actions in which an individual will take and thus contributes to the individual's perception of risk in many instances.

Mearns and Flin developed a similar risk perception model in 1995. Mearns and Flin's (1995 [a]) model was called the elaborate Socio-Cognitive model for risk perception (Figure 6). The model outlined the various phases of the risk perception process and identified some social and cognitive factors, which contribute to safe and unsafe behavior (Mearns & Flin, 1995[b]).

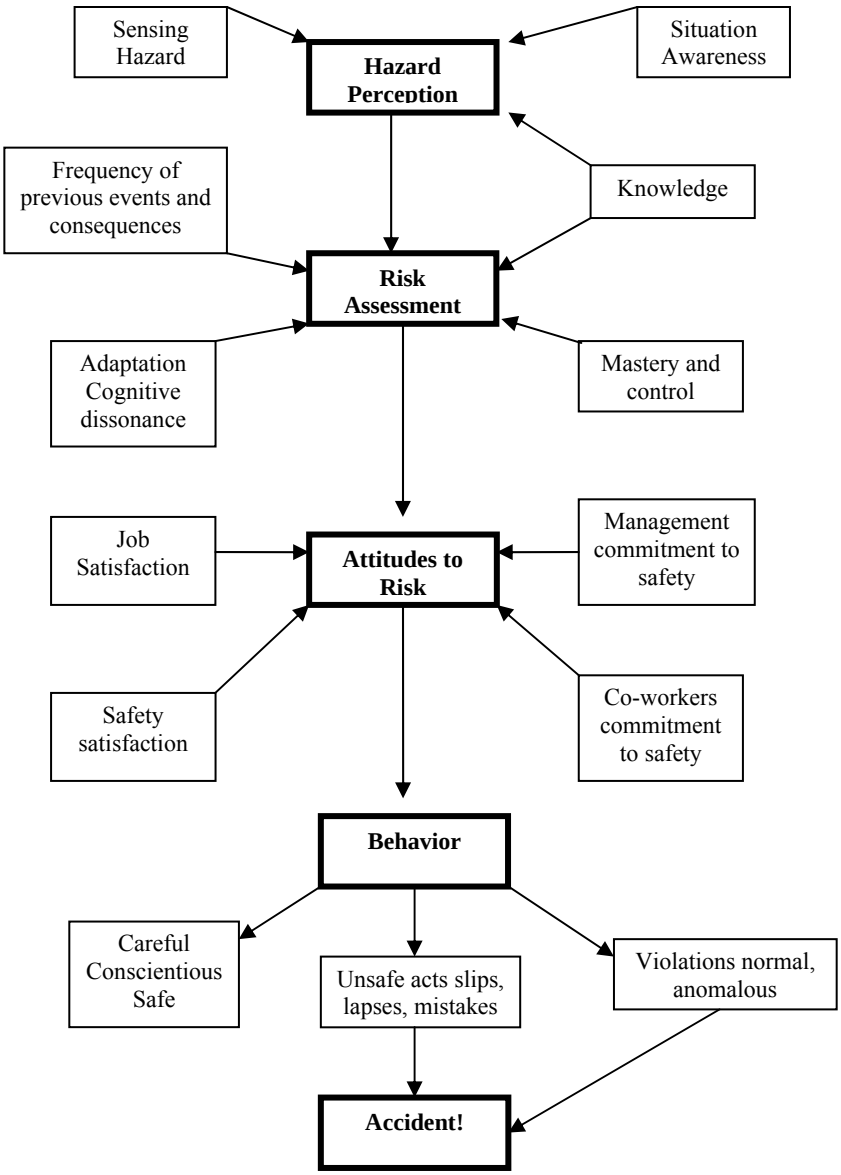

Figure 5: Socio-Cognitive model for risk perception in hazardous work environments

"Reprinted from *The Journal of Loss Prevention in the Process Industries,* Vol. 8, Risk perception and attitudes on safety by personnel in the offshore oil and gas industry: a review, pp 299-305., Copyright (1999), with permission from Esevier".

The model suggests that it is important to determine whether the worker is aware of the hazard and this includes the worker actually sensing the hazard and being aware of his or her situation. General knowledge about risk may be a determining feature of the attitude the individual holds in relation to the risk, although attitudes are also likely to be influenced by

social and cultural factors, such as the commitment of management and co-worker to safety, job satisfaction, and safety satisfaction (Mearns, 1995[b]). Mearns (1995[b]) states that attitudes towards safety in the workplace will be constrained by the values, norms, rules and regulations that the system has in place. In combination, all these factors will reflect the "safety climate" or "culture" of the organization in question. As mentioned in previous sections, culture affects the behavior, attitudes and beliefs of individuals and ultimately affects the way an individual will act and react in hazardous environments. The Mearns and Flins model takes into account the aspects of attitudes, behavior, hazard perception and risk assessment and suggest that they are beneficial to know in accident prevention.

Risk Perception Theories and Methods

A number of different theories and methods have been used to measure risk perception such as cluster analysis, the psychometric paradigm, multi-dimensional scaling, self-administered questionnaires, five-item self-report, risk involvement scales, risk perception questionnaires, comparative risk analysis and the fearful/not fearful measuring scale (Leonard, 1989; Marris, 1998; Sjoberg, 2000; Tanka, 1997). Each of these methods or techniques has been used to measure risk either subjectively or objectively. Subjective measures are the most common methods used to measure risk perception. Current research in the area of risk perception has examined environmental exposure to hazardous chemicals, product warning labels, financial risk and ethnicity and how these phenomena can affect an individual's perception of risk.

When is something considered a risk? Risk is the uncertain degree to which one might be exposed to an undesirable consequence. Risk is measured in different ways according to the environment and the person taking the risk. For example, when dealing with economic

situations, a person is not going to make the same type of decisions or judgments, as would someone working in an industrial setting. Risk is defined differently when assessed within different contexts.

In economic settings, risk is defined as the probability or chance of a loss occurring. For example, individuals demonstrate biases when assessing the risks inherent in deciding to start a business (Simon, 1999). Simon (1999) stated that there are three cognitive biases that previous research has suggested to lower risk perception. The first bias, overconfidence, is the failure to know the limits of one's knowledge. Illusion of control, the second bias, occurs when individuals overemphasize the extent to which their skills can increase performance in situations where chance plays a large part and skills are not necessarily a deciding factor. The third and final bias, belief in the law of small numbers, occurs when an individual uses a limited number of informational inputs to draw firm conclusions.

Simon (1999) surveyed 191 MBA students on their willingness to start a venture, their perception of the venture's riskiness and the extent to which they exhibited cognitive basis in their decision process. Simon (1999) concluded that there are variations in risk perception associated with the decision to start a business as well as stating that cognitive biases do lead individuals to perceive different levels of risk. There are many theories and methods that are used to solve and to conclude why situations of high risk occur and how to reduce the risk in many situations. The signaling theory is one of them.

The signaling theory is a theory that is most often used in economic and finance situations (Levy, 1995). The signaling theory provides a framework for demonstrating how objectively assessed risk can be communicated to improve subjective evaluations of risk. Objective risk, which can be defined as the ratio of a measure of loss, deals with concrete objects

or material rather than mental concepts which are associated with subjective risk (Weegles, 2000). Managers of various businesses possess more information than outsiders regarding a project's viability, expected profits and risk exposure, and therefore can signal the information to outsiders by various means. They can go about doing this by choosing a particular divided policy or by selecting a particular structure (Levy, 1995). The risk in signaling information is that it can be costly or it can be costless to the business depending on the outcome (Levy, 1995).

Other areas in which risk has been studied include the decision sciences, public policy, psychology, and engineering. Different methods and strategies have been used to reduce risk in these areas of study. For example, in the field of engineering research has been conducted in nuclear power environments and in chemical environments to measure the risk employees have in association with their jobs.

In the area of psychology, researchers have attempted to understand the choices and decisions that people make in the work environment regarding color. The use of certain colors to indicate the presence of a hazard increases the amount of attention a person will pay to the situation. Research has revealed that the use of the colors like red, orange, and black indicate hazards and draws more attention to a situation than the use of colors such as white, blue, or green (Leonard, 1999). It has been also suggested that people associate colors with single words related to hazards such as associating red with "danger," orange with "warning," and yellow with "caution." The warmer colors such as red and orange are associated with words that display a greater risk or hazard in the environment than cool colors such as blue or white.

When dealing with the factors that play a part in determining risk, one must understand or attempt to understand how risk adverse or risk accepting a person might be. When something is

said to be objective, it usually focuses on or deals with material objects rather than mental concepts. It is based on fact rather than opinion.

Objective risk deals with concrete objects or materials rather than mental concepts, which are associated with subjective risk. The processes of identifying, measuring, comparing, and representing risks are completely and unavoidably based on judgment, which is something that objective risk does not focus (McDaniels, 1998). Determining whether something is called a risk is based on a variety of social, cultural, and organizational values. When something is said to be objective, it is having or making the best or most necessary judgment regarding a situation. Subjective risk on the other hand is much different.

Subjective risk deals with the biases and opinionated ideas about certain situations that individuals may develop through prior knowledge or experience. Much research related to subjective risk focuses on individual perception about a specific subject or matter. Subjective risk is defined as the perception and awareness of risk loss by the person or person's involved (Weegels, 2000). Whether something is considered to be a risk or how risky a situation is depends on the perception of the person taking the risk and that person's risk assessments, which are often referred to as subjective risk. Risk perception is the same thing as subjective risk, in that it is based on past learning experiences, exposure to information, attribution to groups and personality of individual perceivers (Tanaka, 1991).

Risk perception is how an individual sees a situation. Many studies have suggested that risk perception may differ because of certain types of cognitive biases. Cognitive biases are common types of mental shortcuts used to make judgments (Simon, 1999). Perception is an important factor in determining the level of risk in a situation because what is considered to be a major risk to one person may be perceived as a small risk to another.

An individual's assessment of a situation is the determining factor in labeling a situation as risky or not. If one person sees something one way and another sees it another way, then their perception of the situation is different and they may go about approaching it in a different way. It is important to understand risk perception when dealing with individuals and things such as job placement and culture. Someone who is considered to be high-risk might be quick to do a task without thinking versus someone who is considered to be low risk. Attempting to know the level of risk that someone is willing to take is what is called risk assessment.

Risk assessment, much like risk perception, deals with individual judgment. It is concerned with how far or how willing a person will go to do the task that lies ahead or to what extent the individual will be exposed to a hazard. The level of assessment often determines if a person is a high-risk taker or not. Risk assessments are essential to managing the level of risks and are conducted in everyday activities. Individuals use outside sources of information to prepare them for things to come whether it is dressing for bad weather or packing for a trip. Risk assessments are things that come naturally with preparation for any activity. It is something that cannot be measured on a scale or evaluated and it depends on the individual and the knowledge that the individual has about the situation.

Locus of Control

As mentioned earlier, both risk perception and locus of control are personal factors that play a role in the effectiveness of a warning on behavior (Silver, 1999). Locus of control is a personality measure that is used to moderate the relationship between an individual's perception that events in life are due to the influence of outside forces versus internal forces or factors. It refers to the extent to which an individual believes that events are under his or her control (Silver, 1999). Internal locus of control is the degree to which individuals interpret

reinforcement as contingent upon their own action and external locus of control is the degree to which individuals interpret reinforcement as contingent upon external forces (Rotter, 1966). Locus of control and risk perception have been linked to product safety, sexual risk-taking behavior, and driving behavior and drug use, to name a few examples. In the context of safety, internal locus of control would mean that an accident was under personal control and that it is the individual's fault. External locus of control in terms of safety would indicate that the accident would have happened regardless of what was done to try to prevent the accident.

Laux and Brelsford (1989) examined individual differences in locus of control for consumer product related accidents and the degree to which individuals' perceived risk and sought to understand the hazard. The research concluded that the individual perceptions about accident causalities and controllability, and precautionary behavior are relatively distinct dimensions of consumers' accident locus of control beliefs (Laux, 1989). It was suggested that consumers who believe that accidents are unavoidable and that precautionary behaviors have no effect on the outcome are less likely to seek information about the product or evaluate the value of engaging in risk reducing behavior (Laux, 1989).

Crisp and Barber (1995) examined the relationship between risk perception, sexual risk-taking and locus of control among intravenous drug users. It was found that locus of control mediated the participants' relationship between risk perception and behavior. The participants who were classified as having internal locus of control were more likely to make more accurate assessment of risks associated with the possible infection that could be caused by using needles.

Dunckley and Smith (2000) examined locus of control and how it relates to software design and the effects that cultural differences can have on the development of software. The study concluded that internal/external locus of control could be related to cultural differences

that affect responses to user centered design and teamwork. The study consisted of five different ethnic groups (English, European, Caribbean, African, and Asian participants). The European group had the overall highest internal locus of control and the Caribbean participants were the most external group (Dunckley, 2000).

Locus of control is an influencing factor that contributes to the way individuals interpret and perceive risks, as well as their attitudes about safety. Locus of control as it is known differs by culture and therefore should be considered in international/global safety research.

Globalization

Globalization lies in the heart of modern culture; cultural practices lie at the heart of globalization (Tomlinson, 1999). Culture, globalization, and technology transfer are all three very important factors that play a role in the trade industry between the United States and smaller developing countries. Cultural values and behavioral patterns have a direct bearing upon people's willingness and ability to adapt and absorb technology (Shahnavaz, 2000). Culture, as mentioned earlier, is a determining factor in the way in which individuals think, perceive, and react to different situations. With the developing and growing trade industry among larger first-world countries and smaller second- and third-world countries, there is a need to examine the many factors that affect globalization and the transfer of technology.

The purpose of globalization is to improve the overall quality of life through economic growth (Shahnavaz, 2000). Larger technology-driven countries are the producers of a large portion of high-tech equipment and often times determine the characteristics of that technology. When technology is transferred to an Industrially Developing Country (IDC), which may have different requirements and characteristics, some adaptation is needed to fit the transferred technology to the recipient country. Technology creating countries do not make any adaptation

changes to fit the IDC, which results in a series of problems that in turn hamper their progress. Increased accidents and injuries, low productivity and low work quality are all problems that are associated with IDCs and the transfer of technology among these countries (Shahnavaz, 2000). These problems that arise in IDC all have human factors implications and can be solved through intervention processes that consider ergonomic inputs (Shahnavaz, 2000).

Technology transfer is the diffusion of new technology equipment, practices, and knowledge from one region to another (Forsyth, 1998). It can also be used to provide opportunities to develop improvements in safety, operations, products and services (Argabright, 1999). Failure of technology transferring in IDCs is due to or lack of a safety-conscious culture, low educational standards, inadequate training for operating and maintaining the new technology, and inappropriate organizational structure (Shahnavaz, 2000). Education and training are the cornerstones in technology transfer (Ong, 1991). Education standards in most IDCs are relatively low and therefore no real improvements in the practice of technology transfer or economic growth are likely to occur (Ong, 1991).

Shahnavaz (2000) states that the emphasis of technology is focused on the engineering aspect and as a result many factors necessary for a successful technology transfer are not considered. The factors include user characteristics, organization, information, and both internal and external environments in which the technology will operate. Ong (1991) identified factors that are related to education and training in IDCs which need to be addressed when looking at the rate of technology transfer. It was noted that educational curricula in IDCs are usually imported directly from developed countries, and are rarely adapted to local need. Second, a multiplicity of languages in one country makes it almost impossible to translate technical literature. Third, local people generally do not speak the language of the foreign experts. The language factor is

something that should be taken into consideration in dealing with any type of design and safety situation and more so in risk and hazard communication.

It is necessary to understand the physical, physiological, and anthropometric dimensions of individuals in which jobs and equipment are designed (Ong, 1991). It is necessary to understand the psychological factors that affect individuals and how culture has a role in their psyche. Industrial guidelines and standards for one country may not be the same as they are in another. Design guidelines need to be taken into consideration when designing for the world population. Product designers and manufacturers need to consider every possible concern or discrepancy that might arise with the use of that product or system. This is a very important concern in safety and risk communication. Safety and risk communication and the roles that they play in globalization and the transfer of technology among smaller less industrialized countries are very important in successful transfer of information.

RESEARCH PURPOSE

The purpose of this research was to explore cultural differences in risk perception and hazard ratings of warning signs, signal words, colors, and symbols. In identifying factors that contribute to the different perceptions and interpretations of warning signs, attention would be drawn to the need for globalizing safety signs and hazard and risk communication for jobs and systems designed for diverse populations. The results from this research will help to create training programs and guidelines that will assist in dealing with technology transfer as well as design recommendations for jobs, machinery, and hazard signs that will be used internationally across cultures.

Pilot Study

Purpose

The purpose of the pilot study was to identify differences between components of warnings across two different cultures. The study was conducted to determine if there were any distinct cultural differences in the way individuals perceive risk of hazardous situations, signal words, colors, and symbols in order to justify reasons for further research. Participants rated hazardous situations based on their perception of risk and rated a number of different symbols, colors, and signal words using nine-point Likert-type scales. The findings from the preliminary study gave some indication as to how the two cultures being studied perceived these different components as well as the direction the follow up study should take in examining color and signal word combinations.

The two countries that were examined in this study and in the thesis study differ greatly on the basis of culture (Hofstede's dimensions) and their economy. The United States of America is considered to be a highly industrialized country that manufactures and produces large numbers of merchandise each year to export and trade. The Republic of Ghana on the other hand is considered to be a developing country, to have a subsistence economy and is highly dependent on its agricultural development. The GNP per capita for the two countries differs as well with the United States' GNP equaling nearly $30,000 per year and the Republic of Ghana GNP equaling $309 per year.

In considering the research perspective, it is important to compare these two cultures because of the different cultural influences associated with each group (Hofstede, 1997) and the fact that globalization is increasing between countries from different economic backgrounds and

sizes. In studying these two cultures, the potential to gain a large amount of information associated with risk perception and the perception of different hazard sign components increases the body of literature in these key areas and sets the ground for the potential design and redesign of warnings and risk communications used internationally.

Method

Participants

A total of 73 people participated in this study. The participants were industry workers from both the USA (*n*=34) and the Republic of Ghana (*n*=39). The mean age for the sample of participants was 38.23 years. Of the 34 USA citizens that participated, 13 were female with a mean age of 39.29 years (*SD*= 13.14) and 21 were males with a mean age of 38.29 years (*SD*= 11.79). Of the 39 Ghanaian participants, 4 were female having a mean age of 29.50 years (*SD*= 5.20) and the remaining 35 were males with a mean age of 38.43 years (*SD*=8.70). Each participant had a minimum of six months work experience in industry prior to participating in this study. The mean number for total years of working in industry was 17.37 for the 23 participants from the USA who responded to this question and 11 years for the 32 Ghanaian participants who responded to this question.

Variables

The independent variable of culture had two levels in this study. In addition to culture, symbols (10 symbols), signal words (six signal words), and colors (seven colors) were also independent variables in this study. The independent variable, culture, was selected on the basis of ethnicity. The independent variables color, signal word, and symbol were chosen based on past research and the ANSI Z535 standard. The dependent variables for the study are listed in Table 3.

Table 3: Dependent Variables of Preliminary Study

Dependent Variables
Risk Perception
STRENGTH of injury implied by symbol, signal word, or color
SEVERITY of injury implied by symbol, signal word, or color
LIKELIHOOD of injury implied by symbol, signal word, or color
How ATTENTION-GETTING the symbol, signal word, or color appeared
How CAREFUL one would be after seeing the symbol, signal word, or color
How UNDERSTANDABLE the symbol or signal word appeared

The dependent variables that were chosen in this study all had some relationship to one of the five components in the receiver stage of the C-HIP model with the exception of CAREFULNESS. CAREFULNESS, which is a measure of behavioral intent, reflects the varying degrees of how an individual will act and perform (Wogalter & Dingus, 1999). The components of the receiver stage were examined on two levels of culture. Figure 6 illustrates the dependent variables and the relationship to the receiver stage of the C-HIP model.

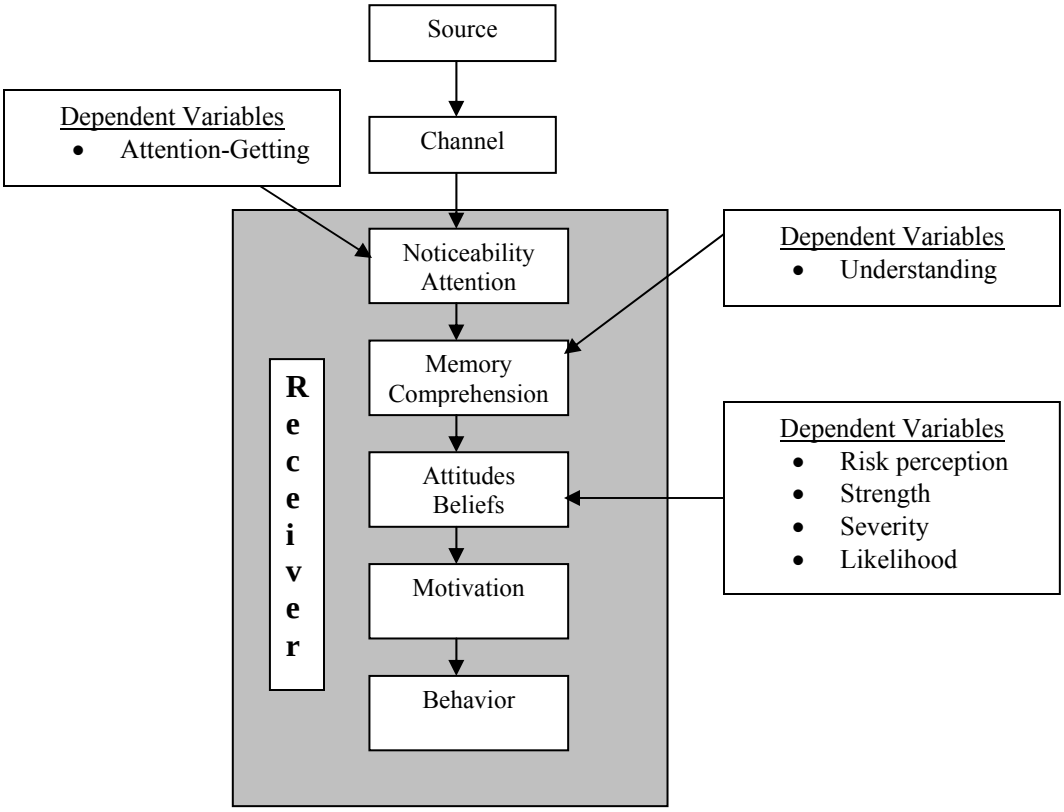

Figure 6: Relationship of dependent variables to C-HIP Model

Questionnaire

One questionnaire with four different sections was administered to the participants. The first three sections requested that the participants evaluate the strength, severity of injury, likelihood of injury, attention-getting, the carefulness, and the understandability of 10 symbols, six signal words, and seven colors on a 9-point Likert type scale taken from the ANSI Z535 Standard. These Sections were developed using Silver and Wogalter's 1989 study of broadening the range of signal words (Appendix A). The fourth section of the questionnaire was used to evaluate the level of risk associated with general statements about work practices in industrial and home settings. This section was a modified version of a risk perception scale (Leonard, 1989). The section consisted of 20 items pertaining to general everyday activities related to

work and home (Appendix E), and was rated on a 9-point Likert-type scale with the anchors ranging from “not risky at all” to “extremely risky”. The questionnaire was modified by adding eight additional items that were more industry related and by using a 9-point scale versus a 5-point scale.

Procedure

Participants were initially given a verbal and written description of the purpose and procedures of the study and completed informed consent documents approved through the Virginia Tech IRB (Appendix F). Participants were given a demographic questionnaire to complete containing questions pertaining to the participant’s age, gender, education level, and work experience (Appendix G). Following the administration of the demographic questionnaire, the participants were given the three sections of the questionnaire in which they were to evaluate 10 symbols (Appendix B), seven colors (Appendix D) and six signal words (Appendix C) using a 9-point Likert-type scale. Following the symbol, signal word and color evaluation, the participants were given the fourth part of the questionnaire, which asked them to rate the level of risk associated with each statement using a 9-point Likert-type scale. Table 4 displays the stimuli that were evaluated in the study.

Table 4: Stimuli

Symbol		Color	Signal Word
	Biohazard	RED	WARNING
	Hot Surface	BLUE	DANGER
	Skull and cross-bones	WHITE	DEADLY
	Radiation	YELLOW	NOTICE
	Laser	BLACK	CAUTION
	Pinch	GREEN	
	Prohibition	ORANGE	
	Cut/Sever		
	Entanglement		

Results

Part 1: Symbols

Results were analyzed using independent-sample t-tests. The analyses revealed significant differences between the USA and Ghanaian populations on five of the 10 symbols evaluated in the study.

The biohazard symbol that was evaluated in the study revealed a significant difference on two of the dependent variables that were measured. A significant difference was found on the SEVERITY of injury implied by the symbol (t (66) = 2.25, $p < .05$) and how CAREFUL a person would be after seeing the symbol (t (66) = 2.22, $p < .05$). The hot surface symbol revealed a significant difference on the dependent variables STRENGTH of the symbol (t (70) = 2.07, $p < .05$), how CAREFUL a person would be after seeing the symbol (t (70) = 3.41, $p < .001$), and the UNDERSTANDING of the symbol (t (70) = 2.37, $p < .05$). The skull symbol revealed a significant difference on ATTENTION-GETTING with a t-value of (t (71) = -2.66, $p < .01$). The radiation symbol revealed a significant difference with SEVERITY of injury (t (66) =2.32, $p < .05$), and how CAREFUL a person would be after seeing this symbol (t (65) < 2.43, $p = .05$). The final symbol that revealed a significant difference between the two cultures was the laser symbol showing significant differences among all six dependent variables measured (STRENGTH, t (55) = 3.67, $p < .0001$; SEVERITY of injury implied by the symbol, t (55) = 3.37, $p < .001$; LIKELIHOOD of injury implied by the symbol, t (54) = 2.35, $p < .05$; how ATTENTION-GETTING the symbol is, t (55) = 5.05, $p < .0001$; how CAREFUL a person would be after seeing this symbol, t (54) = 3.57; $p < .001$; and how UNDERSTANDING the symbol is, t (55) = 4.94, $p < .0001$). Table 5 lists the p-values and t-values for the significant symbols.

Table 5: Symbol t-test results

Dependent Variables	Biohazard 		Hot Surface 		Skull 		Radiation 		Laser 	
	t-value	p-value	t-value	p-value	t-value	p-value	t-value	p-value	t-value	p-value
Strength			2.07	.0421					3.67	.0006
Severity	2.25	.0282					2.32	.0236	3.37	.0014
Likelihood									2.35	.0227
Attention-getting					-2.66	.0098			5.05	.0001
Careful	2.22	.0297	3.41	.0011			2.43	.0180	3.57	.0008
Understanding	2.37	.0205							4.94	.0001

Of all the significant items reported for this portion of the study, the Ghanaian participants rated each item higher than did the participants from the USA except with the dependent variable of ATTENTION-GETTING for the skull symbol. It can be noted that although not significant, the participants from the USA rated each dependent variable associated with the skull symbol higher than did the participants from Ghana, while the Ghanaian participants rated each dependent variable associated with the hot surface symbol higher than the participants from the USA. Appendix H lists the means and standard deviations of each

dependent variable for each symbol and for each group, while Appendix I illustrates the differences between the means using bar graphs. Table 6 lists the means and standard deviations for the significant items in the symbol portion of the pilot study.

Table 6: Symbol Mean and Standard Deviation for Significant Items (Pilot Study)

Dependent Variables		Biohazard 		Hot Surface 		Skull 		Radiation 		Laser 	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Strength	USA			4.14	2.20					2.00	2.05
	Ghana			4.85	2.03					4.09	2.13
Severity	USA	3.42	2.61					3.71	2.58	1.94	1.95
	Ghana	4.79	2.32					4.79	2.32	3.96	2.49
Likelihood	USA									2.06	2.15
	Ghana									3.59	2.61
Attention-getting	USA					7.24	1.13			1.75	1.67
	Ghana					5.95	2.61			4.17	1.88
Careful	USA	4.09	2.83	4.32	2.45			4.06	2.52	2.23	2.13
	Ghana	5.52	2.35	6.06	1.74			5.52	2.35	4.45	2.21
Understanding	USA	3.18	2.95							1.41	1.89
	Ghana	4.00	2.54							4.30	2.46

Part 2: Signal Words

Part two of the questionnaire, which examined six signal words, was analyzed the same way using an independent sample t-test. The results of the analysis revealed significant differences for two of the six signal words.

DEADLY revealed a significant difference with the dependent variables SEVERITY of injury implied by the term (t (67) = -2.55, $p < .01$), ATTENTION-GETTING of the term (t (68) = -2.86, $p < .01$) and UNDERSTANDING of the term (t (68) = -2.34, $p < .05$). CAUTION revealed a significant difference with the dependent variable UNDERSTANDING (t (65) = -2.24, $p < .05$). Table 7 lists the t-values for the signal words that were significant.

Table 7: Signal Word t-test

Dependent Variable	DEADLY	CAUTION
	t-value	t-value
Severity	-2.55**	
Attention-Getting	-2.96**	
Understanding	-2.34*	-2.24*

Note. t significant at *$p < .05$, ** $p < .01$, *** $p < .001$

The Participants from the USA rated each significant item higher than did the participants from Ghana for this portion of the study. Of the remaining non-significant items, the participants from the USA rated every dependent variable higher for all signal words evaluated except for the signal words NOTICE and ATTENTION. The Ghanaian participants rated every dependent variable higher for these two signal words except for LIKELIHOOD. Appendix J lists the means and standard deviations for each dependent variable and for each group, while Appendix K illustrates the difference between the means using bar graphs. Table 8 lists the means and standard deviations for the significant items in the signal word portion of the pilot study.

Table 8: Signal Word Means and Standard Deviations (Pilot Study)

Dependent Variable	Country	DEADLY		CAUTION	
		Mean	Standard Deviation	Mean	Standard Deviation
Severity	USA	7.53	1.08		
	Ghana	6.46	2.19		
Attention-Getting	USA	7.50	1.80		
	Ghana	6.27	2.23		
Understanding	USA	7.53	1.08	6.61	1.54
	Ghana	6.62	2.00	5.69	1.77

Part 3: Color Evaluation

Part three of the questionnaire required participants to evaluate seven colors from the ANSI Z535.1 Standard. The results of the participant's evaluation of the colors were analyzed using an independent t-test.

Three of the seven colors evaluated revealed a significant difference on at least one of the dependent variables measured. The color white revealed a significant difference on the dependent variables STRENGTH (t (59) = 2.66, $p < .01$), ATTENTION-GETTING (t (59) = 3.27, $p < .01$) and CAREFUL (t (59) = 2.84, $p < .01$). The color orange revealed a significant difference on the dependent variables SEVERITY of injury implied by the color (t (56) = 2.13, $p < .05$) and how CAREFUL a person would be after seeing the color (t (56) = 2.96, $p < .01$). The color blue revealed a significant difference on all five of the dependent variables that were evaluated by the two cultures [STRENGTH revealed a t-score of (t (58) = 2.07, $p < .05$), SEVERITY of injury implied by the color (t (58) = 3.20, $p < .01$), LIKELIHOOD of injury implied by the color (t (58) = 2.01, $p < .05$), ATTENTION-GETTING of the color (t (58) = 3.49, $p < .001$), and CAREFULNESS that that the individual would display after seeing the color (t (58) = 2.8, $p < .01$)]. Table 9 displays the t-values and the significant p-values for the colors.

Table 9: Color t-test Results (Pilot Study)

	White		Orange		Blue	
	t-value	p-value	t-value	p-value	t-value	p-value
Strength	2.66	.01			2.07	.05
Severity			2.13	.05	3.20	.01
Likelihood					2.01	.05
Attention-getting	3.27	.01			3.49	.001
Careful	2.84	.01	2.96	.01	2.8	.01

The Ghanaian participants rated each significant item higher than did the participants from the USA for this portion of the study. For the non-significant items, the participants from Ghana rated every dependent variable higher for each color except for the dependent variables of STRENGTH, LIKELIHOOD and ATTENTION-GETTING for the colors YELLOW and GREEN. The USA participants also rated the dependent variable of LIKELIHOOD higher than the Ghanaian participants for the color RED. Table 10 lists the means and standard deviations for the significant color items in the pilot study.

Table 10: Means and Standard Deviations for Significant Color Items (Pilot Study)

		White		Orange		Blue	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Strength	USA	2.90	2.63			3.00	2.16
	Ghana	4.77	2.71			4.19	2.20
Severity	USA			3.44	2.33	2.39	2.22
	Ghana			4.75	2.21	4.22	2.14
Likelihood	USA					2.55	2.38
	Ghana					3.70	1.94
Attention-getting	USA	2.46	2.54			3.16	2.05
	Ghana	4.46	2.06			4.85	1.56
Careful	USA	2.52	2.64	3.84	1.95	2.77	2.32
	Ghana	4.46	2.58	5.38	1.86	4.41	2.31

Part 4: Risk Perception

Part four of the questionnaire used in this study was a modified version of a risk perception scale (Leonard, 1989). The scale contained 20 items in which the first eight were changed to cater to industry/work related events. A t-test was conducted on the data collected from the two groups revealing a significant difference on five of the 20 items.

Item seven, which asked the participants to rate the level of risk associated with placing their hand on a hot surface revealed a t-value of $t\ (66) = -2.8$, $p < .01$. The second significant item was item eight which asked the participants to rate the level of risk associated with not wearing gloves while handling hot objects revealed a $t\ (65) = -2.39$, $p < .05$. Item 12, which was the third significant item from the questionnaire, asked participants to rate the level of risk

associated with pulling an electric plug out of the socket by the cord reported a t (63) = 2.45, p < .05. The forth significant item was item 16, which asked the participants to rate the level of risk associated with flying a small private plane revealed a t (65) = -3.62, p < .001. The final significant item was item 17 of the questionnaire which asked the participants to rate the level of risk associated with flying in a commercial airplane revealed a t (64) = -2.83, p < .01. Table 11 lists the results of the analysis for the significant items as well as the mean and standard deviation for each.

Table 11: Risk Perception Results

T-Test Risk Perception	t-value	Mean USA	SD USA	Mean Ghana	SD Ghana
Q7 Placing your hand on a hot surface	-2.82**	7.118	1.149	6.219	1.431
Q8 Not wearing gloves when handling hot objects	-2.39*	7.088	1.215	6.355	1.253
Q12 Pulling an electric plug out of the socket by the cord	2.45*	4.618	2.582	6.000	1.732
Q16 Flying a small private plane	-3.62***	5.824	1.946	3.581	2.643
Q17 Flying in a commercial airplane	-2.83**	5.059	2.486	3.226	2.714

Note. t significant at *p < .05, ** p < .01, *** p < .001

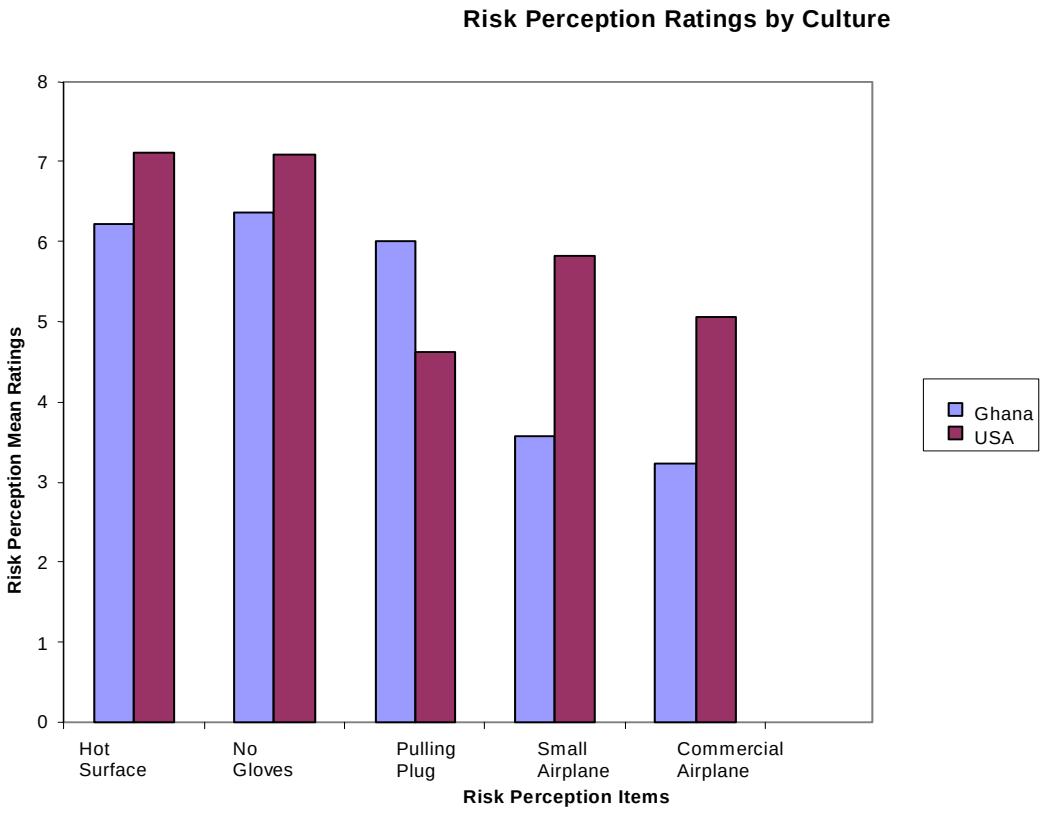

Figure 7: Pilot Study Risk Perception Means

The participants from the USA rated four out of the five significant items higher than the participants from Ghana for this portion of the study (Figure 7). Of the remaining non-significant items, the participants from the USA had a higher overall mean score for 10 out of the 15 items.

Discussion and Conclusions

Based on the results from the data collected in the symbol portion of the questionnaire, the Ghanaians tended to have higher mean ratings on all the symbols that proved to be significant in the study (Appendix H). The United States participants rated the SKULL higher in all categories of the dependent variables measured including the non-significant items. The

Ghanaians overall mean ratings were higher than the USA participants for all other symbols except when evaluating the *likelihood of injury* associated with the biohazard symbol. The total mean and standard deviation scores for all symbols evaluated in the study can be viewed in Appendix H along with the graphs in Appendix I.

Part two of questionnaire one revealed significant difference with two of the six signal words evaluated in the study. The USA participants rated the dependent variables higher for both DEADLY and CAUTION in this section of the study. Of the remaining non-significant items, the participants from the USA rated each item higher except on the dependent variables of STRENGTH, SEVERITY, ATTENTION-GETTING, CAREFUL and UNDERSTANDING for NOTICE and ATTENTION. The total mean scores and standard deviation scores for all signal words examined in this study can be viewed in Appendix J along with graphs for each in Appendix K.

In part three of the questionnaire, the Ghanaians rated every significant item higher than the participants from the USA. For the remaining non-significant items, the participants from Ghana had an overall higher mean score on just about all colors and dependent variables with the exception of STRENGTH, LIKELIHOOD and ATTENTION-GETTING for the color yellow, LIKELIHOOD for the color red and STRENGTH, LIKELIHOOD and ATTENTION-GETTTING for the color green. The means and standard deviation scores for all colors evaluated in this study can be viewed in Appendix L along with the corresponding graphs in Appendix M.

The risk perception questionnaire revealed a significant difference on five of the twenty items presented. The Ghanaian participants had an overall lower mean risk perception score than the U.S. participants on 15 of the 20 questions. Only one of the questions in which the U.S.

citizens rated lower in their perception of risk proved to have a significant difference between the two cultures. The total mean scores and standard deviations can be viewed in Appendix N.

The outcomes from this preliminary study reveal that there are differences between the two cultures on many of the items measured. Of the significant items that were evaluated for the symbol portion of the study, the U.S. participants only rated one item higher than the Ghanaian participants and that was the *"level of attention-getting"* for the SKULL symbol. For every other significant item that was measured in the symbol portion of the study, the Ghanaian participants rated the item higher. The higher ratings by the Ghanaian participants could indicate that regardless of knowledge and what the symbol represents or what it is trying to communicate, the Ghanaian participants may take extra caution and assume that the symbol dangerous. The results could also indicate that the participants from the USA are experiencing habituation and are overexposed to these symbols on a regular basis and do not take the caution needed when the symbol is present.

The signal word portion of the study was just the opposite of the symbols. The U.S. participants, with the exception of NOTICE and ATTENTION, rated all signal words higher than the Ghanaians. In regards to the Ghanaian populations, this could suggest that signal words such as DANGER, DEADLY, CAUTION and WARNING have little meaning in regards to hazards in Ghana as well as indicate in Ghana that there are fewer ways to communicate risk.

The color portion of the study revealed that the Ghanaian participants rated every color higher than did the American participants regardless of significance. The higher ratings by the Ghanaian participants could indicate that Ghanaians put more emphasis on colors than do the participants from the USA when trying to communicate both verbally and nonverbally. The risk perception portion of the study only revealed significant differences on five of the items

evaluated, but out of the nonsignificant items, the American participants rated every item higher. The significant differences among the five items suggest that there are differences between the two cultures and their perception of risk on the items. Although significant, the ratings on the five items may not be cause to say that the Ghanaians have an overall lower perception of risk than the American participants, but it does indicate that the perceptions between the two groups differ on the items measured. Although there were many items that proved to be significant in the preliminary study, further research still needs to be conducted in the area of risk communication and culture. Further research should examine the use of signal word and color combinations as presented in a hazard sign well as reexamine the perception of commonly used safety symbols.

The preliminary study has justified the need to further examine risk communication and hazard components across cultures. The results from the preliminary study indicate that there are differences between the two cultures, but further research could indicate that additional differences do exist and that more research and time should be spent on the development of ways to communicate risk effectively across cultures. In examining the effectiveness of combined hazard components versus single components, there might be cause to standardize certain combinations for use internationally. In examining the use of different color/signal word combinations, there might be a greater chance that individuals from different cultures would better understand the intended message because there will be an additional cognitive cue to capture the individual's attention. As the preliminary study shows, risk perception and the perception of different hazard components tend to differ across cultures. The thesis study was designed expand the preliminary study further by examining combinations of hazard components along with locus of control. Locus of control was included in the thesis study to provide a

personality measure to compare the participants and the two cultures. Locus of control is also the individual difference variable that is most closely associated with causal attribution and the way an individual takes responsibility for the outcome of a situation (Weiner, 1986). Previous research has suggested that locus of control and risk perception do differ by culture and both can have an effect on the safe or unsafe behavior that an individual displays in a hazardous situation (Laux & Breisford, 1989; Neff & Hoppe, 1993; Zackowitz, 2001).

Research Objectives of thesis study

The objective of this research was to determine if there are distinct cultural differences in the way individuals from different cultures perceive risk and to determine if there are differences in the way individuals perceive hazards associated with combinations of signal words and colors. The research will expand previous studies by examining the combination of hazard components versus single components. It is important to examine forms of risk communication as a whole versus examining the individual parts, as different combinations of information may relay different meanings. Gestalt Psychology suggests that individuals perceive information differently based on the way in which the information is presented (Quinn, 1984). "The whole is greater than the sum of its parts." The same information, whether presented in single components or as a group can have an entirely different meaning and understanding to an individual or group of individuals. The way in which information is presented has a great deal to do with how the information will be understood. It is better to present information as a whole, and in one entity versus in individual components because, meaning is lost when information is broken up into components (Quinn, 1984).

Research Questions

1. What is the difference in risk perception associated with different hazardous situations among industry workers from the USA and Ghana?

   Hypothesis 1: There will be a difference in the perceived risk associated with the different hazard situations among USA and Ghanaian industry workers.

2. What is the difference in the locus of control between industry workers from the USA and Ghana?

   Hypothesis 2: There will be a difference in locus of control associated with the different statements between USA and Ghanaian industry workers.

3. What is the difference in the level of hazard conveyed, severity of injury implied, likelihood of injury implied, how attention-getting, the level of understanding and how careful and individual will be after seeing a symbol between USA and Ghanaian industry workers?

   Hypothesis 3: There will be a difference in the level of hazard conveyed, severity of injury implied, likelihood of injury implied, how attention-getting, the level of understanding and how careful an individual will be after seeing a symbol between USA and Ghanaian industry workers.

4. What is the difference in the level of hazard conveyed and how attention getting a hazard sign is perceived by USA and Ghanaian industry workers?

   Hypothesis 4: There is a difference in the level of hazard perceived and how attention-getting a hazard sign appears between USA and Ghanaian industry workers.

5. What effect will different comparisons of color/signal word combinations have on the level of hazard/risk perceived by industry and trade workers from the USA and Ghana?

Hypothesis 5: There will be a difference in the level of hazard/risk perceived with different color/signal word combinations of hazard signs among industry workers from the USA and Ghana.

Rationale

The rationale behind each of these hypotheses is that, despite the information or stimuli presented to the participants partaking in this research, there are going to be a number of differences between the two groups, but the reason for these differences has a great deal to do with culture. Hofstede (1997) suggest that there are differences between the USA and West African societies (includes the Republic of Ghana) on the dimensions of individualism versus collectivism, power distance, uncertainty avoidance, and masculinity versus femininity, while others have found differences in the interpretations of safety symbols between the two cultures (Smith-Jackson & Essuman-Johnson, 2002) and locus of control (Smith, Trompenaars, & Dugan, 1995). Cultural differences in risk perception, hazard perception of different symbols and hazard sign combinations, and locus of control, make it necessary to further research these components in order to better communicate warnings and risk communications internationally on the global market.

Hypothesis one and two suggest that there will be differences in risk perception and locus of control between the two groups and based on previous research, differences have been found with regard to gender and when comparing other cultural groups (Bontempo, Bottom., &Weber, 1997; Brenot, Bonnefous, & Marris, 1998; Crisp & Barber, 1995; Flynn, Slovic, & Mertz, 1994; Laux, & Breisford, 1989; Reimanis & Posen, 1980; Smith, Trompenaars, & Dugan, 1995). It is expected that there will be differences between the USA and Ghana on risk perception and locus of control because the two countries differ greatly on Hofstede's dimensions individualism

versus collectivism and power distance as well as the other two dimensions. The rationale behind testing these two hypotheses is that little research has examined the effects that culture can have on the way warnings and risk communications are presented and understood. By understanding how these two groups perceive risk and their locus of control, alternative ways to communicate hazards can be created.

Hypothesis three suggests that there will be differences in the way the two cultures perceive the different levels of hazard associated with the symbols presented. Previous research has suggested that individual differences as well as cultural differences do exist on the ways in which individuals understand and perceive the level of hazard associated with different safety symbols (Calitz, 1994; Leonard, 1994; Leonard, 2000; Leonard, Karens, & Schneider, 1988; Smith-Jackson & Essuman-Johnson, 2002). It is expected that they way in which each group perceives each symbol in regards to the dependent variable will differ and thus lead to alternative ways and suggestions for using symbols to present a hazard.

Hypotheses four and five suggest that there will be differences between the two groups and the way they perceive different hazard sign combinations and the level of attention-getting and hazard conveyed displayed by each sign. It is expected that there will be differences between the two cultures and how they perceive each hazard sign in terms of attention-getting and hazard conveyed and on the basis of signal words and color, but little research has examined the effects that different combinations colors and signal words will have on individual's perception.

EXPERIMENTAL METHOD

As mentioned previously, the intent this study was to determine if there are any distinct cultural differences in the way individuals from different cultures perceive hazardous situations as well as determine if different combinations of colors and signal words will affect the level of hazard conveyed by a sign and how attention-getting a sign appears. The study also examined the perceived level of hazard by individuals when one sign is compared to another. In addition to sign comparisons, the study also examined the use of six commonly used symbols to determine if there are any cultural difference in the way symbols are perceived based on hazardousness, understanding, likelihood of injury implied by the symbol, how attention getting the symbol appears, the level of caution that an individual would proceed with after seeing the symbol and the severity of injury implied by the symbol.

Method

Participants

A total of 96 industry workers from both the USA and Ghana took part in this study (46 American, 50 Ghanaian). The participants from the USA were Trade-Act students recruited from a community college in Southwestern Virginia. Trade Act is a program in which individuals who have been laid off are given the opportunity to learn a trade through college courses and training. The Ghanaian participants were recruited through the assistance of industry and trade groups in Ghana, West Africa, and through print media. Each participant had worked in industry for at least a year. The majority of the participants who participated in this research had work experience in manufacturing and textile companies. There were some participants who held clerical and janitorial positions. Table 12 details the general demographics of the participants. Additional demographic information can be found in Appendix O.

The uneven balance between male and female participants cannot be accounted for with the American participants or the Ghanaian participants. It can be suggested and as mentioned earlier that the differences between the two countries as far as the economy is concerned can be a contributing factor associated with the uneven balance of female and male participants between the two groups. Women from countries that have subsistence economies are often left to work in agriculture environments and in markets trading and selling goods.

Table 12: Demographics

Demographics	USA	Ghana	Total
Male	7	46	53
Female	39	4	43
Mean Age	40.04 (*SD* =11.92)	37.56 (*SD* = 7.30)	38.75 (*SD* = 9.83)
Mean Work Experience in years	12.03 (n = 36; *SD* = 9.59)	8.94 (n = 47; *SD* = 5.42)	

Equipment and Questionnaires

A questionnaire consisting of three parts was given to each participant to complete. The first part of the questionnaire included 30 questions (Appendix P). The first 21 items of the questionnaire were modified risk perception items from Leonard's 1989 study. Each participant was asked to rate the level of risk they felt was associated with a hazard statement using a nine-point Likert-type scale. The remaining nine questions attempted to measure locus of control by having participants state whether they strongly agree, agree, disagree, or strongly disagree with a statement. The Locus of control statements that were used for this study came from a web-based locus of control test developed by Pettijohn (2002). Pettijohn (2002) developed the test based on Rotter's 1966 locus of control test. The web based survey consisted of a total of 20 questions, but only nine were chosen to include in the study based on random selection.

The second part of the questionnaire consisted of six commonly used symbols in which each participant was asked to rate the level of hazard conveyed by the symbol, how attention-getting the symbol appeared, the likelihood of injury implied by the symbol, the severity of injury implied by the symbol and how careful they would be after seeing the symbol (Appendix Q and Appendix R). Each symbol was rated on the aforementioned dependent variables using a 9-point Likert-type scale.

The third part of the questionnaire required participants to evaluate and rate how attention-getting a hazard sign appeared and the level of hazard conveyed by the sign using a 9-point Likert-type scale. The 16 signs differed by signal word and color (Appendix S).
The variables that were measured in the second and third parts of the questionnaire relate the different components of the receiver stage of the C-HIP model. As can be viewed in Figure 3 (page 19), the receiver component of the C-HIP model includes five sub-components that are characteristic of information human processing. Each stage has an effect on the interpretations and responses that individuals have on the item or situation with which they come into contact. In this case, it has an effect on the level of hazard conveyed by a hazard/warning sign and how attention getting the sign appears.

The final part of the research entailed participants viewing 120 different hazard sign combinations. The 120 different hazard sign combinations were presented one at a time with two different hazard signs labeled “A” or “B” on an 8 ½ x 3 ½ flash card. Each participate was instructed to circle the letter of the sign that appeared to be the most hazardous. Figure 8 illustrates an example card used in the study.

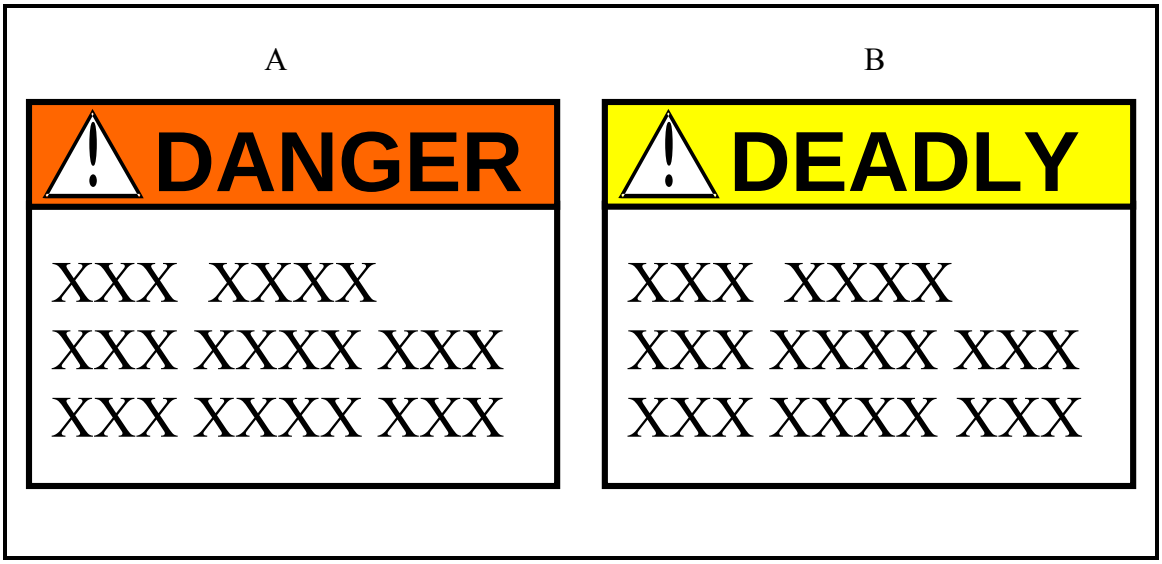

Figure 8: Pair Wise Comparison Example (Orange DANGER and Yellow DEADLY)

A pair wise comparison was used for this portion of the research to make use of information retrieved and to yield better results from the study. The pair wise comparison was used to see what sign combination was chosen over another. A pair wise comparison is often used in the absence of a measuring scale. The advantage of using a pair wise comparison is that it compares only two things at once and the individual assessment of an item is triggered by his or her bias and thus produces a weight on the items chosen more often. Hart and Staveland (1988) used a pair wise comparison in the development of the NASA-TLX to assess workload factors.

Procedure

Each participant was given an informed consent detailing and explaining the purpose and procedures of the experiment (Appendix T). Upon consent, each participant completed the three-part questionnaire and the hazard sign comparison.

Part 1

Hypothesis 1: There will be a difference in the perceived risk associated with the different hazard situations among USA and Ghanaian industry workers.

Part one of the questionnaire consisted of two sets of statements for a total of 30 items. The first set of items asked participants to rate the level risk they felt was associated with the statement using a 9-point Likert-type scale. The 21 statements used for the questionnaire reflect potentially hazardous situations in which an individual might come across in an industrial work environment or at home.

Variables

The dependent variable that was measured in this part of the study was risk perception.

Data Analysis Part 1

An independent t-test was used to analyze the results of part one of the questionnaire along with a Cronbach's alpha to measure internal consistency.

Hypothesis 2: There will be a difference in locus of control associated with the different statements between USA and Ghanaian industry workers.

Variables

The dependent variable that was measured in this part of the study was locus of control.

Data Analysis Part 2

An independent sample t-test was used to analyze the results for this part of the questionnaire along with a Cronbach's alpha to measure internal consistency. A Pearson's r-correlation was conducted to determine the relationship between the risk perception scale and the locus of control scale.

Part 3

Hypothesis 3: There will be a difference in the level of hazard conveyed, severity of injury implied, likelihood of injury implied, how attention-getting, the level of understanding and how careful and individual will be after seeing a symbol between USA and Ghanaian industry workers.

Part two of the questionnaire consisted of participants viewing six commonly used symbols (Appendix Q). Each participant was asked to rate the level of hazard conveyed by the symbol, how attention-getting the symbol appeared, the likelihood of injury implied by the symbol, the severity of injury implied by the symbol, the level of understanding of the symbol and how careful they would be after seeing the symbol using 9-point Likert-type scales (Appendix R). The independent variables in this portion of the study were the six symbols.

Variables

The dependent variables that were measured in this part of the study were, level of hazard conveyed, severity of injury implied, likelihood of injury implied, attention-getting, understanding, and carefulness.

Data Analysis Part 3

A MANOVA was used to analyze the results of part two of the questionnaire with the dependent variables being hazard conveyed, attention-getting, carefulness, likelihood of injury, carefulness and severity of injury implied by the symbol. The MANOVA produced both multivariate and univriate statistics for this portion of the study.

Part 4

Hypothesis 4: There is a difference in the level of hazard perceived and how attention-getting a hazard sign appears between USA and Ghanaian industry workers.

Part three of the questionnaire consisted of participants viewing 16 different warning signs and rating the level of hazard conveyed by the sign and how attention-getting the sign appeared using a nine point-likert-type scale. Each sign differed either by color (orange, green, yellow, red) or signal word (CAUTION, DANGER, DEADLY, WARNING).

Variables

The independent variables that were manipulated in this part of the study were color and signal word. The dependent variables that were measured in this study were attention-getting and level of hazard conveyed by the signs.

Data Analysis

A MANOVA was used to analyze the results for part three of the questionnaire. The MANOVA produced both univariate and multivariate statistics for this portion of the study. The univariate statistics revealed that there are significant differences between the two populations and their perception of hazard associated with the sixteen different hazard signs and how attention-getting the hazard signs appear.

Part 5

Hypothesis 5: There will be a difference in the level of hazard/risk perceived by industry and trade workers from the USA and Ghana on different comparisons of signal word and color combinations.

Part four of the study consisted of participants viewing 120 different hazard sign combinations and selecting the sign that appeared the most hazardous between the two signs that were presented at that time. Each sign was paired with every other possible sign.

Variables

The Independent variables that were manipulated in this part of the study were color and signal word. The dependent variable that was measured in this study was hazard perception.

Data Analysis

A 2 x 16 chi-square test of independence was used to analyze the data from the pair wise comparison.

RESULTS

Risk Perception

Internal consistency was measured using Cronbach's alpha for both risk perception and locus of control. The overall scale reliability for the 21 risk perception items was $r_{alpha} = 0.88$, indicating a high degree of consistency across the items. Five items were removed from the analysis due to low correlation with the total. The five items that were removed included *"not wearing protective goggles while welding," "not wearing steel toe safety shoes in high risk environments where objects are known to fall," "exceeding the speed limit by 10 mph," "pulling an electric plug out of the socket by the cord"* and *"jump starting a car without wearing protective goggles.*" Removing the five items resulted in a $r_{alpha} = 0.92$. The overall scale reliability for the nine locus of control items was $r_{alpha} = 0.37$. Due to the low reliability of the locus of control items, two items were removed to increase the reliability of the scale. The two items that were removed were removed due to low correlations with the total. The two items were *"persistence and hard work usually lead to success"* and "*leaders are successful when the work is hard*." Removing the two items increased the reliability to $r_{alpha} = 0.50$. A significant positive correlation was found on the risk perception scale and the locus of control scale [r (95) =0.61, $p < .0001$].

Separate independent sample t-tests were used to analyze the data from the risk perception portion and the locus of control portion of the study. The results of the analysis are listed in Table 13 for the risk perception and Table 14 for the locus of control. Table 13 and Table 14 also list the means and standard deviations for the risk perception and locus of control portion of the study.

Table 13: Risk Perception Results

Risk Perception Items	**T-Value**	**USA Mean**	**USA SD**	**Ghana Mean**	**Ghana SD**
Q1. Not wearing protective goggles while welding.	3.28***	7.64	.96	6.94	1.12
Q2. Not wearing ear plugs in a high intensity noise environment	3.23**	7.11	1.28	6.18	1.52
Q3. Not wearing steel toe safety shoes in high risk environments where objects are known to fall.	-3.75***	6.84	1.43	7.77	.95
Q4. Not wearing a hard hat in construction areas where posted signs state that they are required.	3.01**	7.31	1.18	6.48	1.47
Q5. Removing a cutting guard from a cutting machine.	4.42****	7.56	1.13	6.37	1.43
Q6. Not reporting a machine malfunction	3.02**	7.02	1.53	6.02	1.68
Q7. Placing your hand on a hot surface	3.97****	7.58	.97	6.63	1.33
Q8. Not wearing gloves when handling hot objects	2.61**	7.07	1.23	6.43	1.15
Q9. Having sex with a partner that you have known for a very brief time.	5.70****	7.16	1.45	4.71	2.54
Q10. Being in the outdoors, away from shelter, during an electrical storm	4.82****	6.76	1.42	5.08	1.92
Q11. Using an electric power tool without protective goggles	2.02*	6.41	1.45	5.73	1.80
Q14. When driving, passing when the solid yellow line is nearest you	6.17 ****	6.64	1.75	4.52	1.61
Q15. Not wearing your seatbelt while you are driving a distance of over 20 miles (32 kilometers)	3.73 ***	6.33	1.83	5.04	1.56
Q16. Driving the wrong way on a one-way street.	7.99****	7.76	.77	5.54	1.70
Q17. Flying a small private plane	3.25**	5.18	2.41	3.65	2.06
Q18. Flying in a commercial airplane	5.45****	4.84	2.50	2.42	1.75
Q19. Not wearing your seatbelt while you are a passenger riding a distance of over 20 miles (32 kilometers).	3.63***	5.98	1.99	4.61	1.64
Q20. Not wearing you seatbelt while you are a passenger riding a distance less that 3 miles	3.23**	5.18	2.33	3.90	1.47

Note Significantly different *p < .05, ** p < .01, *** p < .001, **** p < .0001

The analysis revealed significant differences between the two groups on 18 of the 21 risk items presented, with all items except one (Question 11) showing differences with p-values of .01 or lower. The USA participants rated the items higher than the Ghanaian participants on all items that were significant except one. The Ghanaians rated *"not wearing steel toe safety shoes in high risk environments where objects are known to fall"* higher than the participants from the USA. This item was removed when calculating the reliability of the questionnaire along with five other items. Of the five items that were removed, only one additional item was significant. The item addressing *"not wearing protective goggles while welding"* was the other.

Total risk perception was analyzed for both groups using an independent sample t-test. The analysis revealed that there was a significant difference between the two groups in total risk perception (t (84) = 6.43, $p < .0001$). The participants from the USA had an overall higher risk perception mean equaling 6.39 (SD = .85) and the Ghanaian participants equaling 5.28 (SD = .74). Figure 8 illustrates the individual means of the risk perception items between the two groups.

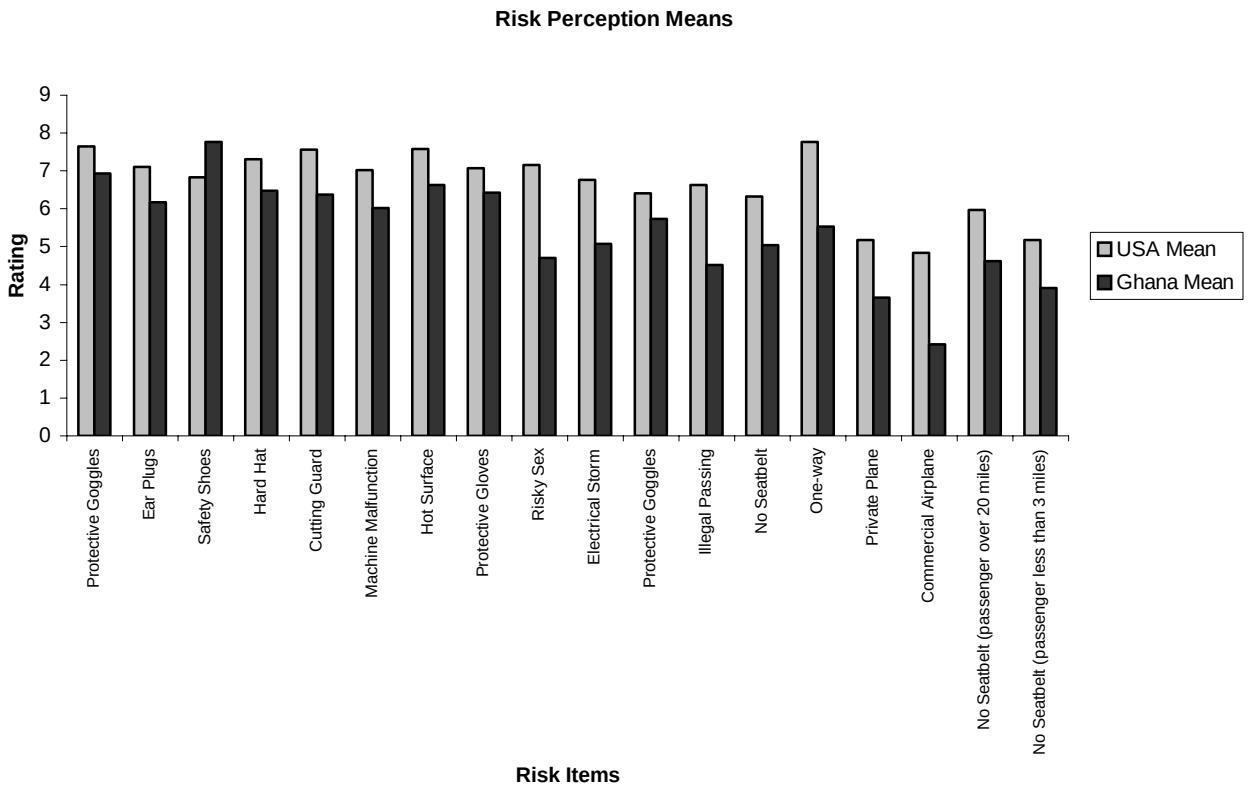

Figure 9: Risk Perception Means

Locus of Control

The results from the locus of control portion revealed that there were significant differences on 5 of the 9 items examined. Reverse order scoring was used for the items that measured internal locus of control. The mean values for the five significant items were higher for the participants from the USA than the participants from Ghana indicating that the participants from the USA reported a higher internal locus of control. Of the five items that were significant, one was removed originally to increase reliability. The item that was removed was *"persistence and hard work usually lead to success."*

The scale that was used to measure the locus of control items was a 4-point scale with the anchors labeled as one being "strongly agree" to four labeled as "strongly disagree." The total

locus of control score was calculated and did reveal a significant difference between the two groups using the independent sample t-test to analyze the data (t (93) = 3.53, $p < .001$). The mean value for the participants from the USA was 2.95 (SD = .27) and the mean value for the participants from Ghana was 2.78 (SD = .19). The mean and standard deviation values are listed in Table 14. Figure 8 illustrates the mean comparisons between the two groups on the individual significant items.

Table 14: Locus of Control Results

LOC	T-Value	USA Mean	USA SD	Ghana Mean	Ghana SD
Q1. I am in control of what happens to me	2.57**	2.82	.83	2.43	.65
Q4. Persistence and hard work usually lead to success	3.19**	3.49	.55	3.14	.53
Q5. Other people usually control my life	2.20*	3.20	.67	2.96	.40
Q6. I usually get what I want in life	3.60***	2.76	.68	2.29	.58
Q7. If I do not succeed in a task, I usually give up.	2.03*	3.20	.66	2.96	.49

Note Significantly different *p < .05, ** p < .01, *** p < .001, **** p < .0001

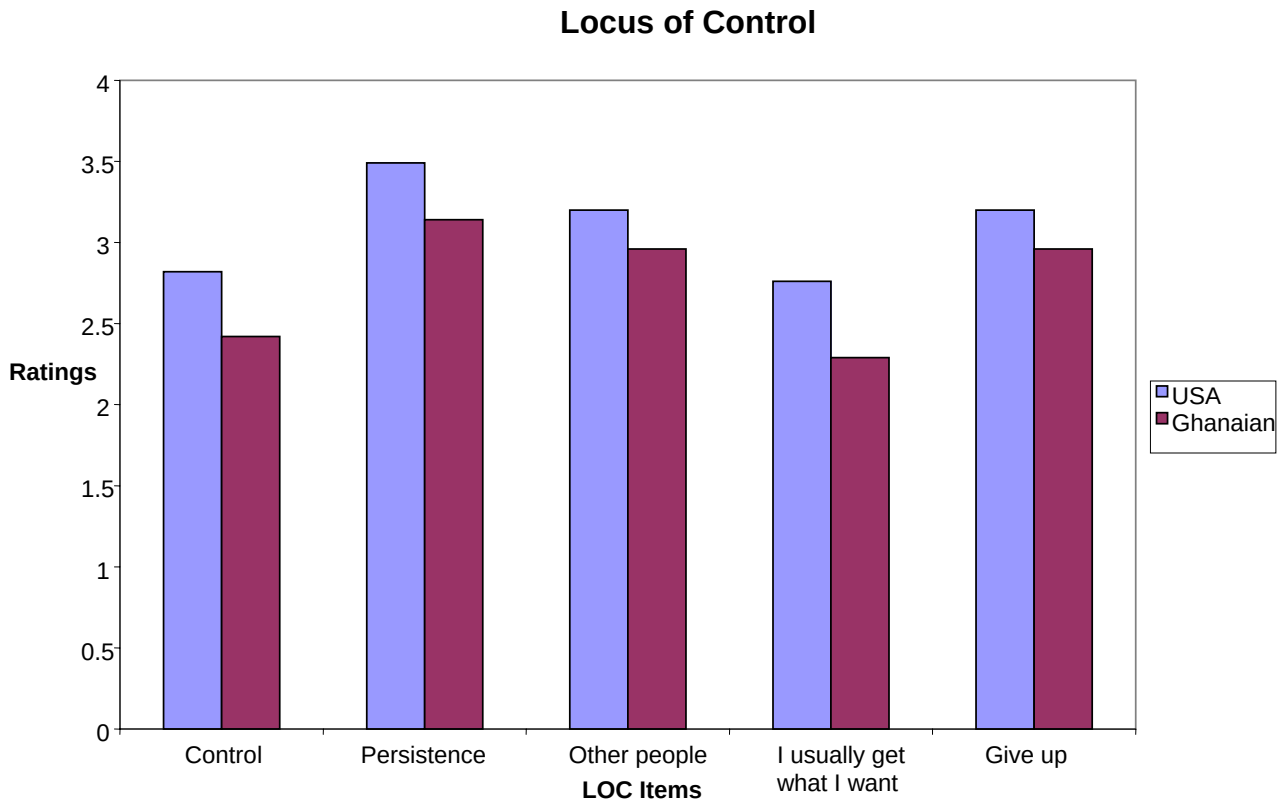

Figure 10: Locus of Control Means

Symbols

A one-way MANOVA was used to analyze the data for the symbol portion of the study. A MANOVA was used to analyze the data due to the multiple variables measured in the study. The multivariate analysis revealed significant differences between the two groups on five of the six symbols examined. The results reveal that there is an overall culture effect for the MR. YUK, SKULL, EXCLAMATION, ELECTRIC SHOCK, and ELECTRIC BOLT symbols between the two groups, thus indicating that the two groups differ on their perceptions of symbols. Table 15 displays the multivariate results from the analysis.

Table 15: Symbol Multivariate Statistics

	Wilks' Lambda	F-value	DF	P-values
	.5176	8.39***	6, 54	.0001
	.8519	2.58*	6, 89	.0238
	.8032	2.65*	6, 65	.0230
	.8453	2.59*	6, 85	.0235
	.7755	3.43**	6, 71	.0050

Note Significantly different *p < .05, ** p < .01, *** p < .001

The univariate statistics indicate that there are significant differences between the two groups on five of the six dependent variables that were measured for the MR. YUK symbol, four of six for the SKULL symbol, and one of six for the EXCLAMATION symbol. Tables 16 and 17 display the univariate statistics and means and standard deviations from the analysis. Graphs illustrating the means can be found in Appendix U as well as additional information on familiarity of symbols in Appendix V.

Table 16: Symbol Univariate Statistics

	Mr. Yuk 		Skull 		Exclamation 	
	F-value	P-value	F-value	P-value	F-value	P-value
Hazard Conveyed	40.52***	0.0001	6.73**	0.0110	----	----
Severity implied	20.90***	0.0001	11.03**	0.0013	----	----
Likelihood of Injury	19.18***	0.0001	----	----	----	----
Attention-getting	19.18***	0.0001	10.76**	0.0015	----	----
Careful	22.52***	0.0001	4.32*	0.0404	----	----
Understanding	----	----	----	----	3.98*	0.0498

Note Significantly different *p < .05, ** p < .01, *** p < .001

Table 17: Symbol Mean and Standard Deviation

	Mr. Yuk				Skull				Exclamation			
	US		Ghana		US		Ghana		US		Ghana	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hazard Conveyed	4.98	2.15	1.24	1.79	7.71	.69	6.94	1.88	----	----	----	----
Severity implied	4.41	2.29	1.17	2.15	7.73	.65	6.73	1.94	----	----	----	----
Likelihood of Injury	4.34	2.21	1.65	2.43	7.02	1.51	6.30	2.43	----	----	----	----
Attention-getting	4.34	2.54	6.47	2.00	7.55	1.01	6.47	2.00	----	----	----	----
Careful	4.52	2.33	6.94	1.54	7.49	.92	6.94	1.54	----	----	----	----
Understanding	----	----	----	----	----	----	----	----	2.79	2.64	3.97	2.13

Based on the results from the univariate statistics, there is evidence that the two populations have different perceptions on the degree of hazard associated with each symbol evaluated. The participants from the USA had a higher mean score than the participants from Ghana on three of the five significant variables measured for the MR. YUK symbol and all five significant variables measured for the SKULL symbol. The participants from Ghana had a

higher mean value for the one significant variable measured for the EXCLAMATION symbol. Of the remaining items that were not significant, the participants from the USA tended to have a higher mean score than the participants from Ghana on the majority of the items.

Hazard Sign Comparison

A total of 16 hazard signs were presented in which participants were asked to rate the level of hazard conveyed by the sign and how attention-getting the sign appeared. The overall MANOVA for culture effect revealed significant differences on all 16 signs presented with Wilk's Lambda and *f*-values ranging from .93 to .59 and $f\,(2, 91) = 3.67$ to $f\,(2, 91) = 33.10$. The multivariate statistics suggest that there are differences between the two cultures and the way they perceive the degree of hazard associated with each combination. The complete results from the multivariate analysis are displayed in Table 18.

Table 18: Hazard Sign Multivariate Statistics

Hazard Sign	Wilks' Lambda	F-value	DF	P-value
Red DEADLY	.79	11.49	2, 88	.0001
Red DANGER	.93	3.67	2, 91	.029
Red WARNING	.8295	9.35	2, 91	.0002
Red CAUTION	.7966	11.74	2, 92	.0001
Orange DEADLY	.7969	11.72	2, 92	.0001
Orange DANGER	.8297	9.44	2, 92	.0002
Orange WARNING	.7357	16.53	2, 92	.0001
Orange CAUTION	.7828	12.62	2, 91	.0001
Yellow DEADLY	.7210	17.41	2, 90	.0001
Yellow DANGER	.6501	24.75	2, 92	.0001
Yellow WARNING	.6275	27.30	2, 92	.0001
Yellow CAUTION	.5788	33.10	2, 91	.0001
Green DEADLY	.8089	10.74	2, 91	.0001
Green DANGER	.7665	14.01	2, 92	.0001
Green WARNING	.6999	19.51	2, 91	.0001
Green CAUTION	.7164	17.41	2, 88	.0001

The univariate statistics reveal the same results as the multivariate statistics with significant differences being found on all 16 hazard signs evaluated and on the two dependent variables of attention-getting and hazard conveyed. The univariate statistics suggest that the participants from both the USA and Ghana perceive the level of attention-getting and hazard conveyed differently for each of the sixteen hazard signs. Based on the means, the participants from the USA rated each sign higher than the participants from Ghana for both dependent variables. Table 19 displays the *f*-values along with the means and standard deviations for the two groups. Graphs illustrating the mean comparison can be found in Appendix W.

Table 19: Hazard Sign Mean and Standard Deviation

Hazard Sign	Conveyed					Attention-getting				
		USA		Ghana			USA		Ghana	
	F-Value	Mean	SD	Mean	SD	F-Value	Mean	SD	Mean	SD
Red Deadly	21.24****	7.53	1.14	6.17	1.56	17.14****	7.22	1.53	6.04	1.33
Red Danger	7.41**	7.2	1.39	6.42	1.25	4.54*	6.80	1.75	6.10	1.42
Red Warning	16.39****	6.61	1.60	5.1	1.97	9.94*	7.41	5.46	4.84	1.73
Red Caution	13.93***	6.40	1.51	5.30	1.36	23.58****	6.49	1.83	4.84	1.48
Orange Deadly	21.90****	7.44	1.18	6.12	1.53	18.63****	7.15	1.48	5.84	1.49
Orange Danger	16.59****	6.96	1.35	5.60	1.83	15.70****	6.67	1.69	5.42	1.43
Orange Warning	27.81****	6.56	1.55	4.78	1.72	30.16****	6.49	1.74	4.70	1.43
Orange Caution	20.54****	6.09	1.69	4.59	1.51	24.87****	6.13	1.85	4.37	1.57
Yellow Deadly	33.53****	7.55	1.21	5.92	1.47	27.84****	7.33	1.48	5.69	1.47
Yellow Danger	35.11****	7.20	1.18	5.28	1.86	48.83****	7.24	1.30	5.12	1.62
Yellow Warning	26.46****	6.58	1.64	4.70	1.89	54.89****	6.82	1.70	4.50	1.30
Yellow Caution	53.18****	6.50	1.58	4.16	1.53	60.34****	6.84	1.58	4.3	1.58
Green Deadly	21.55****	7.27	1.63	5.56	1.90	10.98***	6.89	1.94	5.58	1.87
Green Danger	18.81****	6.91	1.53	5.32	1.98	27.98****	6.91	1.76	5.04	1.69
Green Warning	29.83****	6.47	1.63	4.23	1.82	39.35****	6.20	1.90	4.26	1.51
Green Caution	34.74****	6.36	1.57	4.40	1.60	11.13***	6.91	4.56	4.43	1.53

Note Significantly different *p < .05, ** p < .01, *** p < .001, **** p < .0001

Tables 20 and 21 list the mean ratings between the two groups based on level of hazard conveyed and how attention-getting the sign appeared in regard to signal word and color. Both groups appeared to be consistent in the rating of level of hazard conveyed and level of attention-getting for each sign in regard to color and signal word. Although the groups were consistent in ratings among themselves, the participants from Ghana were consistent with the normal protocol

for communicating a hazard on the basis of both color and signal word while the participants from the USA were only consistent with signal words.

Table 20: Average Rank Order Based on Color

Hazard Conveyed (average rating)		Attention-Getting (average rating)	
USA	**Ghana**	**USA**	**Ghana**
Yellow	Red	Yellow	Red
Red	Orange	Red	Orange
Green	Yellow	Green	Yellow
Orange	Green	Orange	Green

Table 21: Average Rank Order Based on Signal Word

Hazard Conveyed (average rating)		Attention-Getting (average rating)	
USA	**Ghana**	**USA**	**Ghana**
Deadly	Deadly	Deadly	Deadly
Danger	Danger	Danger	Danger
Warning	Warning	Warning	Warning
Caution	Caution	Caution	Caution

Pair wise Comparison

A total of 120 different hazard sign combinations were presented to each participant. Each combination consisted of two identical signs (one labeled “A” and the other labeled “B”) in shape and size differing only by the signal word presented and/or color (Figure 8). Each participant was asked to mark the sign that was perceived to be the most hazardous between each sign combination presented.

A 2 x 16 chi-square test of independence was used to analyze the data from the pair wise comparison. The results from the data analysis indicated that there is a significant difference

with χ^2 (15, N=96) = 350.39, $p < .0001$ between the two groups and the frequency in which a combination was chosen. The results indicate that the participants from the USA and Ghana differ on their overall perception of hazard associated with different signal word and color combinations when compared to another combination. The participants from Ghana had a higher overall frequency on nine of the sixteen combinations as compared to the participants from the USA who had a higher frequency the remaining seven combinations. The results from the 2 x 16 chi-square frequency are listed in Table 22.

Table 22: 2 x 16 Chi-Square Frequency Count

Signal Word Color Combination	USA	Ghana
Red Deadly	422	376
Red Danger	270	334
Red Warning	394	284
Red Caution	457	233
Orange Deadly	377	422
Orange Danger	267	370
Orange Warning	343	330
Orange Caution	364	245
Yellow Deadly	269	492
Yellow Danger	292	490
Yellow Warning	293	400
Yellow Caution	338	317
Green Deadly	259	501
Green Danger	354	440
Green Warning	365	400
Green Caution	430	353

In addition to the 2 x 16 chi-square test, a 2 x 4 chi square test of association was conducted on the four different colors presented with the sign combinations and the two different ethnic groups. The results from the chi square test revealed a χ^2 (3, N=11506) = 186.95, $p < .001$ for the color and ethnic association. The results of the chi square indicate that there is an association between culture and the selection of color with the hazard signs. This suggests that the two cultures differ on the level of hazard associated with color and the frequency in which

one particular color was chosen over another. The participants from Ghana had an overall higher frequency on three of the four colors as compared to the participants from the USA who only had a higher frequency with the color green. The frequency in which a color was chosen for this 2 x 4 chi-square is listed in Table 23.

Table 23: 2 x 4 Chi-square Color Frequency Count

Color	USA	Ghana
Red	1362	1814
Orange	1170	1615
Yellow	1395	1414
Green	1588	1148

An additional 2 x 4 chi square was conducted in which signal word and ethnic group were associated. The results from the chi square test of association revealed a χ^2 (3, N=11506) = 127.27, $p < .001$ for the signal word and ethnic association. The results indicated that there is an association between the individual selections of a hazard sign based on the signal word presented. The 2 x 4 chi square test of association on signal word and ethnic group suggest that the two cultures differ in their perceptions of the level of hazard associated with a signal word and the frequency in which one signal word was chosen over another. Table 24 lists the frequency for which a signal word was chosen for each ethnic group.

Table 24: 2 x 4 Chi-square Signal Word Frequency Count

Signal Word	USA	Ghana
DEADLY	1407	1694
DANGER	1216	1713
WARNING	1305	1357
CAUTION	1542	1227

Individual 4 x 4 chi square test of associates were conducted between color and signal word for each ethnic group. The chi square test of association between color and signal word revealed a $\chi 2$ (9, N=5515) = 61.19, $p < .001$ for the USA participants. The association between color and signal word did not reveal a significant difference among the Ghanaian industry workers who participated in this study. The 4 x 4 test of association suggest that there are inter-group differences in the way individuals from the USA perceive the level of hazard associated with different signal word and color combinations.

Individual 2 x 2 one-way chi square test of association were conducted on each signal word and color combination between the two ethnic groups. Of the 120 different signal word and color combinations presented, 72 of the combinations revealed a significant difference between the two groups. The results from the individual 2 x 2 chi square analysis can be viewed in Appendix X. The explanation in the right hand column explains the proportion in which one ethnic group chose a combination over another.

As mentioned, the individual 2 x 2 chi square test revealed significant differences on 72 of the 120 combinations evaluated. The proportion to which one group chose one combination over another for the 72 significant items is explained in Appendix X. As Appendix X suggests, proportionally more Ghanaians chose the winning combination on 71 out of the 72 times as compared to the participants from the USA. Overall, the winning combinations were consistent with those recommended by the ANSI Z 535.1 and ANSI Z 535.4 Standards and other research findings.

The color in which a signal word was paired with did have some effect on the overall level of hazard displayed by the signal word and the final choice of the participants. For example only twice was the color “green” selected as most hazardous when paired with another

color (yellow). Green WARNING was chosen over Yellow CAUTION and Green WARNING was chosen over Yellow DEADLY. There were a few discrepancies with the colors orange and yellow as would be expected from the results of previous research. Of the 10 times in which the colors orange and yellow were paired against each other, the color yellow was selected most hazardous three out of the 10 trials. Yellow DANGER was chosen over Orange CAUTION, Yellow DANGER was chosen over Orange DANGER and Yellow DANGER was chosen over Orange WARNING. Appendix Y gives a more detailed break down of the winning combinations based on color and signal word.

Summary of Results

This research resulted in a number of significant findings. First, the results suggest that there are cultural differences in risk perception on 19 of the 21 items measured as well as on total risk perception between the two groups. The results imply that the participants from the USA that participated in this study had an overall lower perception of risk than the Ghanaian participants who took part in this research. Second, the results from the locus of control portion of the study suggested that there are differences between the two populations and their level of internal locus of control measured on the nine items. The results imply that the participants from the USA have an overall higher internal locus of control on the items measured than the participants from Ghana. Thirdly, the results from the symbol portion of the study suggest that there are differences between the two populations on their perception of five of the six symbols evaluated. The participants from the USA rated every significant dependent variable higher for the MR. YUK symbol and the SKULL symbol than did the participants from Ghana. The participants from Ghana only rated one dependent variable significantly higher and that was for the EXCLAMATION symbol. The forth set of significant findings came from the evaluation of

sixteen different hazard signs in terms of ATTENTION-GETTING and HAZARD CONVEYED. The results revealed significant differences on all sixteen signs with the participants from the USA rating each sign higher than the participants from Ghana. The fifth and final set of results suggested that there are significant differences between the two groups and their choice of one hazard sign over another in the pair wise comparison. The results suggested that the participants from the USA and Ghana differ on their perception of hazard associated with different signal word and color combinations when compared to another.

DISCUSSION

This research resulted in a number of significant outcomes as well as support for all five hypothesis tested. The results from the research revealed that there are significant differences between industry workers from the USA and Ghana and their perceptions of different symbols, how attention getting and how hazardous a sign appears, their perceptions of risk and their locus of control. There were limitations to this research, but they will be discussed later in this document.

Hypothesis1 Discussion

The results of the data analysis indicated that there are differences in the judgments of risk and supports past research in suggesting that differences in risk perception do exist across cultures (Bontempo, 1997; Vaughn, 1991). The results can also be linked to Hofstede's (1997) dimensions of power distance and individualism versus collectivism. As mentioned in previous sections, West African countries such as the Republic of Ghana have a lower individualism index in comparison to the United States. Individualism, as Hofstede explains, is when the ties between individuals are loose. This statement indicates that the United States, an individualistic society, is more concerned with individual self versus a collective society. The lower risk

perception score by the Ghanaian participants may suggest that the Ghanaian's look at the broader picture and see taking greater risks as a benefit to themselves and ultimately to their families and community.

The total risk perception score indicated that the participants from the USA have an overall higher perception of risk, thus indicating that they may be more cautious. The results from the risk perception analysis can be interpreted to indicate that USA industry workers are more cautious of risks and hazards than Ghanaian industry workers. These findings are to some extent consistent with the pilot study conducted for this research. Although the pilot study did not provide significant results for total risk perception between the two groups, it did provide evidence to suggest that there are significant differences on some of the items measured. The items from the pilot study suggested that the participants from the USA had a higher perception of risk than did the participants from Ghana on four of the five significant items as well as on ten of the remaining non-significant items. The results from the risk perception portion of this thesis study suggested the same thing, but with stronger support in that significant differences were found on total risk perception between the two cultures and on 18 of the 21 items measured. Previous research (Wogalter, 1997) has suggested that cultural differences do influence risk perception among other things. The results of the risk perception portion of this study can also be contributed to the participants from the USA that participated in this study. As mentioned previously, the participants from the USA were made up of many occupational backgrounds while the participants from Ghana were from the same type general occupation and thus could be reason for such findings.

The risk perception results as well as the results from other parts of this research not only suggest that there is a difference between the two culture's perception of risk and different

hazards, but they may also suggest that there is a difference in the way individuals' view the overall consequence and take control of the outcomes of a hazardous situation or event. As mentioned previously, there was an unbalance of participants in regard to gender and age among the two groups. These differences in gender and age could also contribute to the outcomes as well as the difference in locus of control between the two cultures which will be discussed later. Another suggestion for such findings could be due to the number of injuries that the participants from the USA reported in comparison to the participants from Ghana. Of the number of participants who responded, 39% of the participants from the USA reported that they had been injured on the job as compared to only 4% of the Ghanaian participants (Appendix O). With the participants from the USA having reported more injuries, this can be suggestive that past experiences with injuries has made the USA participants more cautious in the work environment and more accountable for their actions.

Hypothesis 2

As mentioned in the results section for locus of control, the participants from the USA had an overall higher mean value on all five significant items, thus indicating that the participants from the USA have a higher internal locus of control than the participants from Ghana. It has been suggested that individuals who believe that they encounter most hazards voluntarily and who have a high internal locus of control are more likely to look for and comply with warnings (Young & Lovvoll, 1999). The results from the research are consistent in that Western societies such as the USA score more internally on locus of control measures than do non-western societies (Smith, 1995), thus meaning that the participants from the USA are more likely to try to take control over or at least believe that they have control over the outcome of a

situation than the participants from Ghana who in turn might blame the outcome on some external factor or force which is characteristic of external locus of control.

These findings can be due to the individualistic values that Western societies hold versus those of non-western and collectivist societies. These findings are consistent in that previous research has concluded that a trait variable such as locus of control does differ by culture and indirectly influences attitudes and risk perception (Neff & Hoppe, 1993). The results from the Pearson's correlation support Neff and Hoppe (1993) in that there was a high correlation between the risk perception and locus of control items measured in this study. It has also been suggested that such findings can be perilous in that Rotter's locus of control items are invalid in some settings. This is because particular items are either irrelevant to some cultures or because some sources of control that are important in some cultures are not addressed in Rotter's items (Smith, Trompenaars, & Dugan, 1995). It must also be noted that although Rotter's actual scale was not used in this study, the scale that was used was developed from Rotter's original locus of control scale and these suggestions can hold true for these findings as well. Although the validity of the actual scale used in this study is unknown, this is something that future research should consider.

Hypothesis 3

Hypothesis three stated that there would be a difference between how Ghanaian and USA industry workers interpreted different commonly used symbols. Of the six symbols that were examined by the participants, there were significant differences between the two groups on all of symbols and significant differences on the dependent variables that were measured between the two cultures on three of the six symbols. Participants from the USA had an overall higher mean score on all dependent variables measured for the SKULL symbol and all but attention-getting

and carefulness for the MR. YUK symbol. The Ghanaian participants rated the significant dependent variable understanding, higher than the participants from the USA for the EXCLAMATION symbol.

If one were to examine the dependent variable, UNDERSTANDING, across all symbols that were evaluated, one would note that the average rating for each symbol for both groups was relatively low, more so for the USA population. It is not clear why the rating for the dependent variable UNDERSTANDING was low, but this supports the notion that the combination of signal words with symbols are a better way of communicating risks than by using symbols alone (Braun and Shaver, 1999; Kalsher, Wogalter, Brewster, and Spunar, 1995; Leonard, 1994). It could also mean that the symbols are insufficient at communicating the hazard or hard to understand. This finding contradicts Walker et al. (1965) study, which concluded that symbols were recognized more than words.

In referring back to the results of the symbol portion of the pilot study, the participants from Ghana rated the significant items higher than the participants from the USA except for the dependent variable of UNDERSTANDING for the biohazard symbol. The only symbol that was shown to have a significant difference between the two groups and that was used in both studies was the SKULL symbol. The participants from the USA rated the SKULL symbol higher than the participants from Ghana on all dependent variables except for attention-getting in the pilot study. As mentioned previously, it was suggested that the results from the symbol portion of the pilot study can be contributed to the participants from Ghana regardless of personal knowledge about the symbol, rating it higher and taking extra caution when the symbol is present. If one were to refer back to Hofstede's (1997) definition of a symbol, it is defined as words, gestures, pictures or objects that carry a particular meaning which is recognized by those of a shared

culture. This definition is fitting for this portion of the study in that a symbol such as the MR. YUK symbol is only recognized and has meaning to a particular culture or group as with the USA and not Ghana. A symbol such as the SKULL symbol is recognized by many cultures and can be used internationally.

As the results for the MR. YUK symbol suggest, the participants from the USA rated three of the five significant dependent variables higher than the participants from Ghana for the MR. YUK symbol as well as 43% of the USA participants indicating that they had seen the symbol before in comparison to only 16% of the Ghanaian participants (Appendix V). Smith-Jackson and Essuman-Johnson (2002) found that only 10% of the respondents in their study reported that the MR. YUK symbol was related to something hazardous while others could not elaborate or provide enough information for further questioning. This again suggests that a symbol such as the MR. YUK symbol is only understood by a small group of people who are usually familiar with and understand the meaning of the symbol. The two dependent variables in which the participants from Ghana rated higher for the MR. YUK symbol were ATTENTION-GETTING and CAREFULNESS. This suggests that regardless of personal knowledge of a symbol, the participants from Ghana are going to proceed with caution when this or any symbol that they do not recognize is present. This type of behavior could also be due to their lower internal locus of control score.

Hypothesis 4

Hypotheses four stated there would be a difference between how Ghanaian and USA industry workers rated the level of hazard conveyed and how attention-getting a hazard sign appeared. The results from the analysis supported this hypothesis. Tables 20 and 21 (Page 80) list the average rating between the two groups based on ATTENTION GETTING and HAZARD

conveyed by the signs. When the signal word was held constant and compared to the mean scores of the dependent variables measured, there was a difference detected in the hazard preference associated with color.

The Ghanaian participants were consistent with the ANSI Z535.1 (1998) Standard in that the assigned level of hazard associated with a color was the same (RED, ORANGE, YELLOW, GREEN). The Ghanaian participants were also consistent with other studies in that RED received the highest average hazard rating (Hupka, 1997; Smith-Jackson & Wogalter, 2000[b]; Wogalter, Fredrick, Herrera, & Magurno, 1997). No conclusions can be drawn as to why the mean score for the USA participants rated YELLOW to be a greater hazard than RED. Other studies have produced similar inconsistencies with the color YELLOW rating higher than the color ORANGE in many cases (Smith-Jackson & Wogalter, 2002[b]; Wogalter, Klasher, Fredrick, Magurno, & Brewster, 1998; Wogalter, Fredrick, Herrera, & Magurno, 1997). It can be suggested that for this portion of the study, participants from the USA were more attracted to color YELLOW than the other colors due to familiarity or personal preference, thus giving a higher rating for the color. It should be again noted the participants from the USA rated each hazard sign higher than the participants from Ghana for both dependent variables. The comparisons of means (Table 21) based on signal words were consistent with ANSI Z535.2 Standards and other research for both cultures (Chapanis, 1994) indicating that signal words are perceived to have the same level of hazard in both cultures.

Hypothesis 5

The fifth hypothesis dealt with the comparison of hazard signs using a pair wise comparison. Table 22 (Page 82) lists the frequencies in which each combination was chosen. The combination "GREEN DEADLY" was chosen more frequently by the Ghanaian

participants, while the USA participants chose “RED CAUTION” more frequently when compared to the other combinations. The combinations of “ORANGE WARNING” and “YELLOW CAUTION” were chosen a relatively equal number of times by both the USA and Ghanaian participants. The multiple chi-square tests that were conducted suggest a number of different things in regard to preference of one combination, color or signal word over another by a particular culture. It can be concluded from these results that the participants from the USA had a preference for the combination of “RED CAUTION” over any other combination while the participants from Ghana preferred the combination “GREEN DEADLY” and that the combinations of “ORANGE WARNING” and “YELLOW CAUTION” were relatively close in the frequency in which each culture chose the combination. In considering color alone (Table 23), it can be suggested that the participants from the USA had an overall preference for the color “GREEN” while the participants from Ghana had a preference for the color “RED.” In regard to signal words (Table 24), the participants from the USA had a preference for the signal word CAUTION while the participants from Ghana had a preference for the signal word DANGER. This could suggest the signal word CAUTION is used more frequently in the USA and that is the reason for frequency in which it was chosen over the other signal words. The same is possible for the use of the signal word DANGER in Ghana.

Each of these signal words could possibly be used or viewed more on a regular basis than another signal word for a particular country or culture. For example, how often does the term CAUTION appear in the USA on a regular basis from day to day? The term is often seen posted on roadways, in supermarkets and department stores and on household products and appliances. The term CAUTION is viewed on a regular basis in the USA and could suggest that the participants from the USA in this study take more caution and view the signal word CAUTION

to be a greater hazard than it actually is in comparison to the other signal words. This to could also possibly be due to the inter group differences that are associated with the participants from the USA. Wogalter et al. (1997) suggested that commonly used English signal words were not well understood by the Spanish participants who participated in the study. This possibly could suggest that there are discrepancies in the understanding of the signal words among the Ghanaian participants who participated in this study.

The pilot study results suggested that the participants from the USA rated every signal word higher than the participants from Ghana on all the dependent variables with the exception of NOTICE and ATTENTION. This could suggest that companies need to spend additional time training employees on how to understand the level of hazard associated with different components of hazard statements and risk communication.

CONCLUSION

Summary and Recommendations

Based on the results of this study, it can be concluded that there are differences in the way individuals from different cultures perceive hazards and different components of warnings. Although there are differences between the two populations examined, one cannot fully conclude that these differences exist across the board.

The findings from this study suggest that industry workers from the USA are more cautious and have an overall higher total risk perception than did the Ghanaian industry workers who participated in this study. The findings from the risk perception study support Bontempo et al. (1997) in that judgment in risk perception differs across culture and not occupation. All participants in the study had worked in an industrial type setting for at least a year prior to

participating in the study. The risk perception findings were also consistent with Kleinhesselink et al. (1991) in that perceptions in risk can differ across culture, but still display similarities between the cultures in certain aspects. Although gender was not examined in this study, it could be a contributing factor as to why the USA participants had an overall higher perception of risk than did the Ghanaian participants in that more of the USA participants were women. Brenot, et al. (1998) states that it is a common for women to rate all risk higher than men in most cases and thus having a higher perception of risk than most men. This along with age could possibly be a contributing factor to the locus of control results, Gomez (1997) found that external locus of control decreases with age for both male and female participants. The USA participants in the study had a higher mean age than did the participants from Ghana thus possibly suggesting that age could be a contributing factor as to why the participants from the USA had a higher internal locus of control than did the participants from Ghana.

The symbol portion of the study, which revealed significant differences on five of the six symbols, supports other research (Smith-Jackson & Essuman-Johnson, 2002; Smith-Jackson & Wogalter, 2000[b]; Wogalter, Fredrick, Herrera & Magurno, 1997) in that the SKULL symbol was more highly recognized with 100% of USA participants and 98% of Ghanaian participants (Appendix V). Although no significant results were found between the two cultures and their perception of hazard associated with the ASTERISK symbol, it too was consistent with other research (Smith-Jackson & Essuman-Johnson, 2002; Smith-Jackson & Wogalter, 2000[b]) with 98% of USA participants and 60% of Ghanaian participants reporting having never seen the symbol before.

Although a number of the symbols that were examined in the study were recognized by one culture or the other, there were also inconsistencies. When asked if they had ever seen the

SHOCK symbol, only 52% of the USA participants who responded to the question indicated that they recognized the symbol while 82% of the Ghanaian participants who responded recognized the symbol. Inconsistencies such as those indicated from the results of the symbol portion of the study further justify the need to study cultural research and safety.

The hazard sign portion of the study justifies the need to study risk communication and culture further especially when designing warnings and risk communications for international use. Based on the results from the analysis, there are differences in the way industry workers from the USA and Ghana perceive hazards on the basis of color and signal words. The results draw the conclusion that participants from the USA perceive warning signs more hazardous and more attention-getting than the Ghanaian participants for all signs measured no matter how they were presented. It can be suggested that the lack of exposure and understanding of different signal words on behalf of the Ghanaian participants could have contributed to these results.

The fifth and final portion of the study further examined warnings and risk communication by comparing 120 possible sign combinations to one another. Again, there were significant difference between the two cultures and the frequency in which a particular color/signal word combination was chosen over another. It was concluded that the signal word CAUTION was chosen more frequently than any other signal word for the USA participants along with the color GREEN. The Ghanaian participants chose the signal word DANGER more frequently along with the color RED in comparison to the other signal words and colors. The most frequently chosen signal word and color combination for the USA participants was RED CAUTION and GREEN DEALDY for the Ghanaian participants. Again, it can be suggested that the lack of or overexposure to certain signal words could have contributed to these results.

The same can hold true for colors used to communicate hazards. No additional conclusions can be drawn as to why these results occurred in the manner that they did.

Careful consideration and thought needs to go into the development and design of warnings and hazards especially when they are being developed for products that are going to be used internationally. Some questions that came out of this research as well as response based on the results from this research are listed in Table 25. Each one of these questions should be considered when communicating hazards and creating warnings that have intentions for use internationally.

Table 25: Warning Design Questions to Consider for International Use

Warning Design Questions to Consider for International Use	
Question to Consider	Research Findings
• Does this color have the same level of hazard intent associated with it in one culture as it does in the other culture?	• As the results from hypotheses 4 and 5 suggest, the level of hazard associated with color is not consistent among the two populations examined.
• Are signal words more so than colors recognized more with this particular culture than in another and vice versa?	• The results for hypothesis 5 suggest that there is a lack of consistency in terms of color preference for the participants in this study. The results suggest that the participants from USA have a greater preference for the color GREEN while the participants from Ghana have a greater preference for the color RED.
• Does this symbol represent or have the same meaning in one culture as it does in another?	• As the results from hypothesis 3 suggest, symbols that are often used to communicate hazards do not always have the same intended meaning or communicated the same level of hazard in one culture as it does in another. An example from the results of the symbol portion of the study would be with the MR. YUK symbol. The participants from the USA rated the *"level of hazard conveyed"* by the symbol higher than did the participants from Ghana and the same is true for the SKULL symbol.
• How often are signal words used and are certain ones used more often than others?	• Based on the results from hypothesis 5, the participants from the USA chose the signal word CAUTION more frequently than any other signal word where as the participants from Ghana chose the signal word DANGER. It was suggested from these results that it is possible that the signal word CAUTION is used more frequently in the USA than any other signal and thus potentially leading the participants from the USA to choose the term more frequently.
• How risk adverse is the target population?	• The results from hypothesis 1 suggest that the participants from the USA have higher risk perceptions than do the participants from Ghana. It can be suggested from these results that the consequences of taking risk or partaking in high risk events need to be addressed more clearly to certain groups of people. Hazard signs need to clearly communicate the dangers of partaking in high risk events more precisely.
• What combinations of signal words and colors have the same intended meaning globally?	• The results from hypothesis 5 suggest that same combination of signal words and colors do not have the same hazard level intention across the two cultures. The study found that the participants from the USA chose the combination of RED CAUTION more frequently than any other combination while the participants from Ghana chose the combination of GREEN DEADLY more frequently than any other combination when asked which combination appeared to be the most hazardous.
• Does the target population have an internal or external locus of control?	• The locus of control portion of the study suggests that the participants from the USA have a higher internal locus of control than the participants from Ghana. This suggest that the participants from the USA are going to feel that they have control over the outcome of a situation where as the participants from Ghana are more likely to believe that the outcomes are controlled by chance or by powerful others.

In addition to these questions, it is recommended that employee training be conducted on a regular basis to keep both employers and employees up to date with the latest in hazard and

risk communication. It should also be noted that the overuse of symbols, signal words, colors and the wrong combination of any of the three can affect the way a hazard is communicated and understood. Individuals develop cognitive models of events and information that are stored in their memories and these are often not complete. When these models of different events or information are developed, memory is formed causing the stimulus to become less salient and thus allowing the individual to become distracted by other events and loose focus or attention on the actual warning (Wogalter & Leonard, 1999). Situations such as this are why hazard sign components should not be overused and used improperly. Culture should be considered in all aspects of training especially in warnings and risk communications. Adams (1995) suggests using cultural filters to help deal with biases that can be contributed to culture. Table 26 lists some training and design recommendations along with the justification for each that have been formulated from the results of this study.

Table 26: Training and Warning Design Recommendations

International Warning Design Recommendations	Justification
An alternate symbol should be used instead of the MR. YUK symbol when communicating hazards in Ghana.	Based on the results from the symbol portion of the thesis study, the MR. YUK symbol does not convey the same level of hazard in Ghana as it does in the USA. The same is true for severity of injury implied by the symbol and likelihood of injury implied by the symbol.
The SKULL symbol, which communicates "poison", should be used to communicate the hazard instead of the MR. YUK symbol.	The results from the symbol portion of the thesis study suggest that the SKULL symbol is a better communicator of "poison" than the MR. YUK symbol when it comes to communicating a hazard. The study showed that although there was a difference, the participants from the USA and Ghana were similar in their ratings of the dependent variables for the SKULL symbol
The BIOHAZARD symbol should not be used alone to communicate a hazard. A text message needs to be used in addition to the BIOHAZARD symbol to communicate the hazard and risk.	The results from the pilot study suggest that there is a difference in the way the two cultures perceive the risk associated with the symbol as well as understand the symbol. It is suggested that the BIOHAZARD symbol not be used alone to communicate a hazard, but be used with a supplementary text message to communicate the hazard.
The RADIATION symbol should not be used alone to communicate a hazard. A text message needs to be used in addition to the RADIATION symbol to communicate the hazard and risk.	The results from the pilot study suggest that the level of hazard associated with the RADIATION symbol is not the same among the two cultures. It is suggested that the RADIATION symbol not be used alone to communicate a hazard, but be uses with a supplementary text message to communicate the hazard.
The LASER symbol should not be used alone to communicate a hazard. A text message needs to be used in addition to the LASER symbol to communicate the hazard and risk.	The results from the pilot study suggest that there is a difference in the way the two cultures perceive the risk associated with this symbol and understand the symbol. It is suggested that the LASER symbol not be used alone to communicate a hazard, but be used with a supplementary text message to communicate the hazard.
The EXCLAMATION symbol is not understood well by either culture and therefore should not be used unless its meaning and purpose is understood and communicated better.	The thesis study showed that the participants from the USA and Ghana rated the level of "understanding" for the EXCLAMATION symbol, relatively low in comparison to other symbols, thus suggesting that the participants did not know the meaning and therefore should not be used unless the meaning is understood by the target population.
The BOLT and ELECTRIC SHOCK symbol can be used interchangeably to communicate electrical hazards for these two cultures.	The thesis study showed that there were no significant differences with the dependent variables measured between the two cultures for the BOLT symbol and the ELECTRIC SHOCK symbol, thus possibly indicating that they are equally understood by each culture. The means for the two symbols were fairly high and fairly equal for each dependent variable.
RED CAUTION might be a better signal word and color combination to use when communicating a hazard in comparison to any other signal word and color combination in the USA.	The results from hypothesis 5 of the thesis study suggest that when asked to choose the combination that appeared the "most hazardous," the participants from the USA chose the combination of RED CAUTION more frequently than any other combination.

GREEN DEADLY might be a better signal word and color to use when communicating a hazard in comparison to any other signal word or color combination in the Republic of Ghana.	The results from hypothesis 5 of the thesis study suggest that when asked to choose the combination that appeared the "most hazardous," the participants from Ghana chose the combination of GREEN DEADLY more frequently than any other combination
The combination of RED CAUTION should not be used to communicate a hazard in the Republic of Ghana.	The results from hypothesis 5 of the thesis study suggest that the combination of RED CAUTION was chosen less frequently than any other combination when ask to select the "most hazardous" combination by the Ghanaian participants.
The combination of GREEN DEADLY should not be used to communicate a hazard in the USA.	The results from hypothesis 5 of the thesis study suggest that the combination of GREEN DEADLY was chosen less frequently than any other combination when ask to select the "most hazardous" combination by the USA participants.
The combinations of ORANGE WARNING and YELLOW CAUTION appear to be best combinations to use when communicating the same hazard in both the USA and in Ghana.	The results from hypothesis 5 of the thesis study suggest that the combinations of ORANGE WARNING and YELLOW CAUTION might be better combinations to use when communicating hazards between the USA and Ghana. Both combinations were fairly close in the frequency in which the two cultures chose them over another.
Warnings should include a symbol to help facilitate the intended message whenever possible.	Based on the results from hypotheses 3, 4, and 5, it is evident that symbols, signal words, and color alone do not communicate hazards that well. A concrete, understandable symbol depicting the hazard's consequence should be used whenever possible.
Concrete symbols that are common to all populations should be used instead of difficult to understand uncommon symbols.	Based on the results of the study, concrete symbols such as the SKULL symbol, the BOLT symbol, and the ELECTRIC SHOCK symbol should be used to communicate the appropriate hazard. The results from the study suggest that they are good communicators of hazards and are understood well by both cultures.

These recommendations, as well as the guidelines to facilitate comprehension and memory listed in Table 2 (p.28), should be considered when designing warnings and risk communications that will be used internationally. The guidelines in Table 2 suggest using simple language and verifying that the text and symbols convey the intended meaning to the target population. The guidelines in Table 2 also suggest that prototypes should be used to test at-risk individuals and groups to make sure that the information is comprehended properly.

Future Research Implications

Future research should investigate the differences in hazard/risk perception across cultures by examining the combination of symbols, text, and color to communicate hazards. The investigations should take a closer look at deciding if different signal word and color combinations used properly along with symbols will relay the same intended message across cultures. Future research should also investigate methods of employee training in risk communication and hazard control. The research should also examine the use and overuse of signal words, colors and symbols in the work environment as well as how employees are taught to evaluate and perceive a hazard. Additional research still needs to examine individual hazard and risk perception associated with hazards and colors across cultures. Further research should also examine risk perception and hazard communication across multiple cultures that differ on multiple personality measures.

Limitations of Research

Although it produced a number of significant outcomes, this research had its limitations. The limitations that were associated with this research could have had a possible effect on the overall outcome of the study. If this study could be repeated these limitations would be considered.

The first limitation was the uneven balance of participants in regard to gender. The balance of male and female participants per culture was significantly different and could have strongly affected the risk perception results. If there was an equal number of male and female participants per culture, the study might have produced different results overall. The second limitation of this study was the poor reliability of the locus of control scale. As discussed earlier, the overall reliability of the scale was poor suggesting that there could be a problem with the

scale and its consistency. The third limitation of this study has to do with the different occupational backgrounds of the participants. As mentioned, each participant worked in an industrial type environment for at least one year, but the jobs and task of the participants were not as consistent as one would have hoped. The level of exposure that the participants encountered on a day to day basis in regard to hazards and warnings and risk communication differed somewhat could have had an effect on the outcome of the study. If the occupations of the participants were more consistent, there might have been different out comes on the hazard sign comparison and symbol portion of the study. The fourth limitation of this study could have possibly contributed to the outcomes of this research have to do with language issues. Although the Ghanaian participants were fluent in English, there could have possibly been some problems in that English is their second language and that some of the words and phrases that were used in the questionnaire may not have been familiar to the participants.

In studies similar to this in the future, scale reliability, sample size and balance, occupational consistency among participants, and language issues need to be considered. All three among other things could have had an effect on the results of the study.

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APPENDIX

Appendix A: Likert- type Scale

Signal words: DANGER, WARNING, CAUTION, NOTICE, ATTENTION, DEADLY

You will be presented with a number if different signal words. For each signal word presented, rate the word using the scale below. (Scale: Silver, N. and Wolgalter, M., 1989)

1. What is the STRENGTH of this term?

not at all strong		slightly strong		strong		very strong		extremely strong
0	1	2	3	4	5	6	7	8

2. What is the SEVERITY of injury implied by this term?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

3. What is the LIKELIHOOD of injury implied by this term?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

4. How ATTENTION-GETTING is the term?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

5. How CAREFUL would you be after seeing this term?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

6. How UNDERSTANDABLE is this term?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

For each color presented, give a brief description of what the color means to you (thoughts, feelings of the color). Next, use the scale below to rate each color.

RED, ORANGE, YELLOW, BLACK, GREEN, BROWN, WHITE

1. What is the STRENGTH of this color?

not at all strong		slightly strong		strong		very strong		extremely strong
0	1	2	3	4	5	6	7	8

2. What is the SEVERITY of injury implied by this color?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

3. What is the LIKELIHOOD of injury implied by this color?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

4. How ATTENTION-GETTING is the color?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

5. How CAREFUL would you be after seeing this color?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

You will be shown a number of different symbols. For each symbol presented give a brief description of your meaning and interpretation of the symbol. Next, rate each symbol using the scale below.

ELECTRIC SHOCK (HAND), HOT SURFACE, CUT/SEVER, ENTANGLEMENT, EYE PROTECTIN, RADIATION, BIOHAZARD, LASER, SKULL

1. What is the STRENGTH of this symbol?

not at all strong		slightly strong		strong		very strong		extremely strong
0	1	2	3	4	5	6	7	8

2. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

3. What is the LIKELIHOOD of injury implied by this symbol?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

4. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

5. How CAREFUL would you be after seeing this symbol?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

6. How UNDERSTANDABLE is this symbol?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

Appendix B: ANSI Symbols

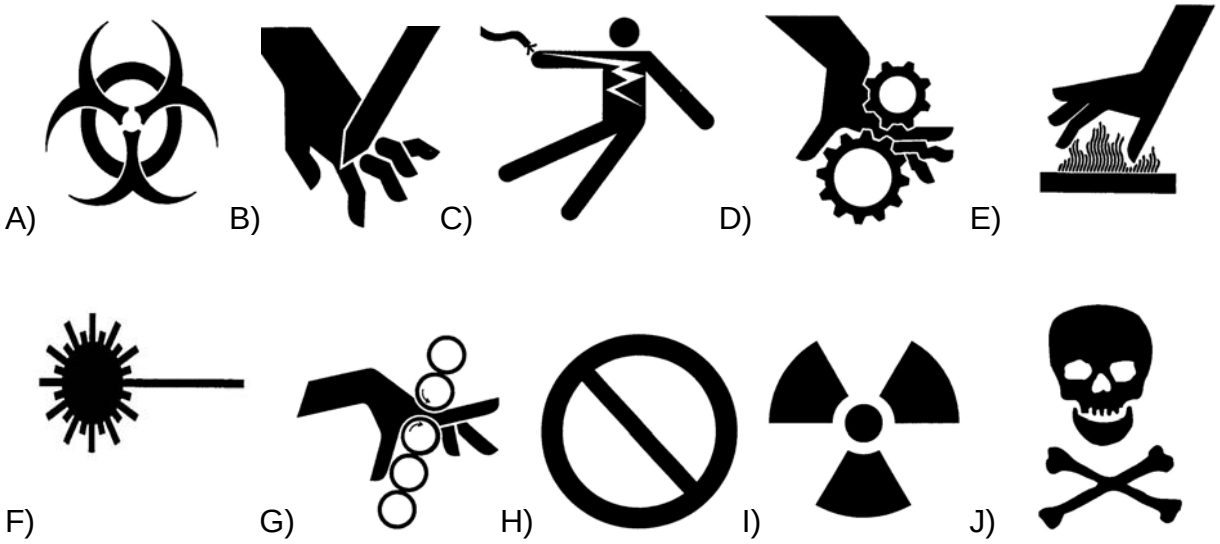

Figure 11: ANIS Symbols: A) Biohazard B) Cut C) Electric Shock D) Entanglement E) Hot Surface F) Laser G) Roller H) Prohibition I) Radiation J) Skull and Cross Bones

Appendix C: Signal Words

DANGER
WARNING
DEADLY
CAUTION
NOTICE
ATTENTION

Appendix D: Colors

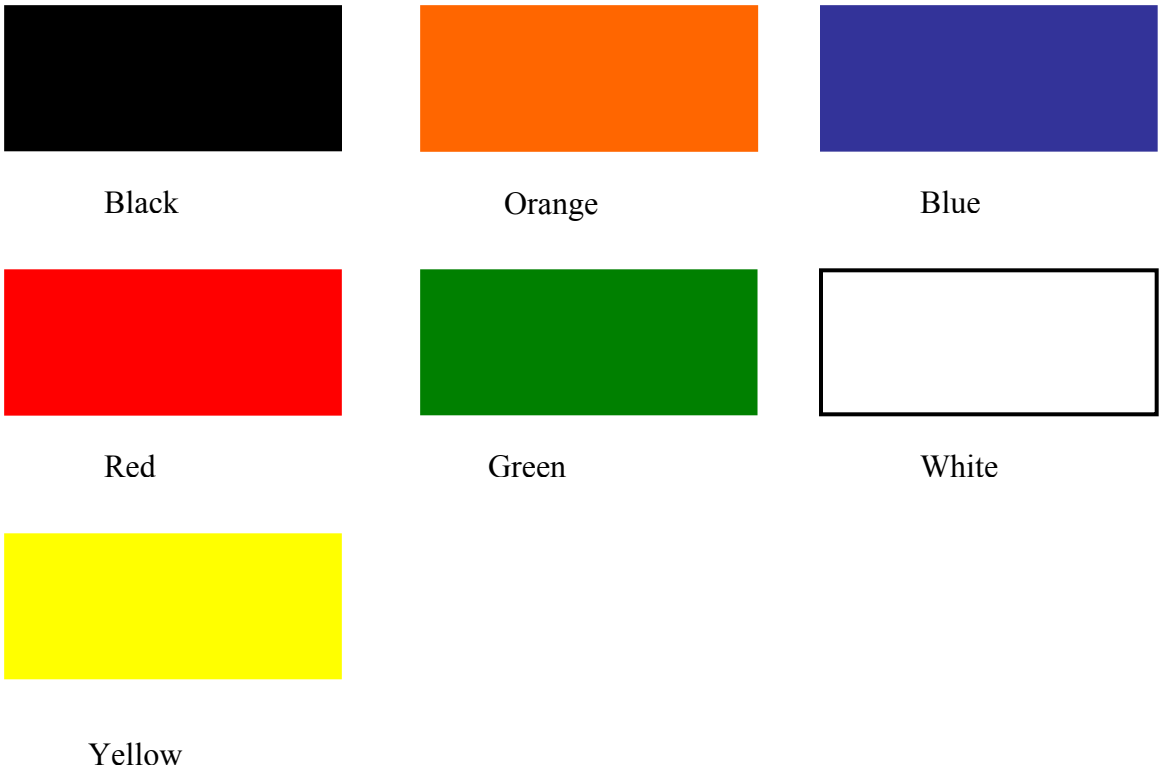

Figure 12: Colors

Appendix E: Risk Perception Scale

Rate the level of risk involved with each statement.

1. Not wearing protective goggles while welding.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

2. Not wearing ear plugs in a high intensity noise environment.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

3. Not wearing steel toe safety shoes in high risk environments where objects are known to fall.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

4. Not wearing a hard hat in construction areas where posted signs state that they are required.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

5. Removing a cutting guard from a cutting machine.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

6. Not reporting a machine malfunction.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

7. Placing your hand on a hot surface.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

8. Not wearing gloves when handling hot objects.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

9. Being in the outdoors, away from shelter, during an electrical storm.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

10. Using an electric power tool without protective goggles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

11. Exceeding the speed limit by 10 mph.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

12. Pulling an electric plug out of the socket by the cord.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

13. When driving, passing when the solid yellow line is nearest you.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

14. Not wearing your seatbelt while you are driving a distance of over 20 miles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

15. Driving the wrong way on a one-way street.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

16. Flying a small private plane.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

17. Flying in a commercial airplane.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

18. Not wearing your seatbelt while you are a passenger riding a distance of over 20 miles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

19. Not wearing you seatbelt while you are a passenger riding a distance less that 3 miles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

20. Jump starting a car without wearing protective goggles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

Appendix F: Informed Consent

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY GRADO DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING ASSESSMENT AND COGNITIVE ERGONOMICS LABORATORY

Informed Consent for Participants of Investigative Projects

Title of Project: Cultural Differences in Risk Perception

Principal Investigators: LaTanya F. Martin, Graduate Student
Dr. Tonya L. Smith-Jackson, Assistant Professor, ISE

Faculty Advisor: Dr. Tonya L. Smith-Jackson, Assistant Professor, ISE

I. THE PURPOSE OF THIS RESEARCH

The purpose of this research is to determine if there are any distinct cultural differences in the way people perceive risk in industrial/hazardous environments.

II. PROCEDURES

First, you will be given a short questionnaire used to obtain general information about yourself. The questionnaire will consist of 10 to 12 questions.

This experiment contains two different studies. Study one contains two parts and study two just contains one part.

Part one of study one will entail you observing a number of different colors, signal words and colors and rating them using a Likert-type scale. You will be also asked to give a brief personal interpretation or description of the stimuli presented to you.

Part two of study one will entail you observing a number of hazard signs. You will be show three different signs at a time. You are to rank order each sign for most perceived hazardous to least perceived hazardous as well as give a personal interpretation of each sign.

Study two will have the same format, except this time you will be given a number of different scenarios to read. Once you have read the scenarios, you will be asked to rate the level of risk you feel is associated with each scenario as well as whether or not you agree with the situation and whether or not you would follow the rules for that particular situation.

If you have any questions related to any of the procedures or purpose of this experiment after reading this document, please feel free to ask them. If you wish to be a participant in this experiment after reading this form, sign your name at the appropriate place at the end.

III. RISKS

There are no factors related to this research experiment that should pose more than minimal risk to you.

IV. BENEFITS OF THIS RESEARCH

Your participation in this research will be used to better understand the different cultural differences that influence the perceptions of risk. Additionally, your participation will contribute to the effort to standardize safety communications such as symbols, signal words, sign text, training protocols, and manuals.

V. EXTENT OF COFIDENTIALITY/ANONYMITY

The results of this study will be kept strictly confidential. At no time will the researchers release the results of the study to anyone other than the individuals working on the project without your consent. The information you provide will have your name removed and only a number will identify you during analyses and any written reports of the research.

VI. COMPENSATION

For participation in this study, you will be compensated $7.50 an hour for hour of participation.

VII. FREEDOM TO WITHWRAW

You are free to withdraw from this study at anytime without penalty. If you choose to withdraw, you will be paid for the time that you participated in the study.

VIII. APPROVAL OF THIS RESEARCH

This research has been approved, as required by the Institutional Review Board for projects involving human participants at Virginia Polytechnic Institute and State University, and by the Grado Department of Industrial and Systems Engineering.

IX. PARTICIPANT'S RESPONSIBILITIES

I voluntarily agree to participate in this study and know of no reason in which I would not be able to participate. I have the following responsibilities:

- Answer each question as openly and as honestly as possible.
- Listen and pay attention carefully
- Express my own opinions and beliefs

_____

Signature of Participant

X. Participant's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I herby consent to participate, with the understanding that I may discontinue participation at any time, being compensated only for the portion of time that I spend in the study.

Signature: _____

Printed Name: _____

Date: _____

Should you have any questions or concerns about this research or its conduct, you may contact:

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Appendix G: Demographic Questionnaire

Please answer each question as accurately and as honest as possible.

1. Age: _____

2. Gender: ☐ Male ☐ Female

3. Ethnicity: ☐ Caucasian ☐ Hispanic ☐ Native American

   ☐ African American ☐ Ghanaian ☐ Other

4. Number of years living in the US/Ghana: _____

5. Highest level of education completed: ☐ High School ☐ 1 Year of College

   ☐ 2 Years of College ☐ Bachelors Degree ☐ Master's Degree

   ☐ Other_____

6. Have you ever worked in an industrial environment?

   ☐ Yes ☐ No

7. Where and how long? _____

8. What were your job responsibilities?_____

   _____

9. Have you ever been injured or involved in an accident while working on your job?

   Yes ☐ No ☐

10. If you answered yes to question #9 please explain:

    _____

    _____

11. Are you aware of all safety guidelines and procedures required to perform your job?

    Yes ☐ No ☐

12. Do you feel that an adequate amount of training was provided to you for the current job that you are working on? Yes ☐ No ☐

13. How long did the training last? _____

14. Are you required to wear PPE (Personal Protective Equipment) while performing the task required for your job? Yes ☐ No ☐

15. If you answered yes to question #14, what types of PPE are you required to wear and do you wear it at all time?

_____

_____

Appendix H: Symbol Means and Standard Deviations

Table 27: Ghana Symbol Mean and Standard Deviation (Pilot Study)

Ghana	Strength		Severity		Likelihood		Attention-getting		Careful		Understanding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cut	5.846	2.621	6.282	1.973	5.079	2.705	5.410	2.552	6.923	1.149	5.410	2.245
Biohazard	4.845	2.029	4.788	2.315	4.697	2.338	4.576	2.398	5.515	2.347	4.000	2.540
Hot Surface	5.250	2.247	5.167	2.145	4.556	2.408	5.056	2.203	6.056	1.739	5.278	2.603
Entanglement	5.969	2.352	6.121	2.247	5.412	2.324	5.818	2.143	6.529	1.692	5.765	2.075
Electric Shock	5.526	2.648	6.158	2.163	5.210	2.440	5.241	2.238	6.579	1.638	5.526	2.190
Skull	6.378	2.722	6.297	2.390	5.486	2.714	5.946	2.613	6.676	1.827	6.514	1.880
Radiation	4.844	2.23	5.093	2.263	4.355	2.534	4.645	2.429	5.387	1.783	4.290	2.466
Roller	5.156	2.302	4.969	2.321	4.563	2.539	4.438	2.257	5.516	2.189	4.839	2.296
Laser	4.087	2.130	3.957	2.495	3.591	2.612	4.174	1.875	4.348	2.208	4.304	2.458
Prohibition	5.700	1.664	4.633	2.428	4.200	2.139	5.267	1.574	5.533	1.569	5.33	3.133

Table 28: USA Symbol Mean and Standard Deviation (Pilot Study)

USA	Strength		Severity		Likelihood		Attention-getting		Careful		Understanding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cut	5.529	2.501	6.6912	1.288	5.794	1.855	5.971	1.447	6.764	1.017	5.794	1.951
Biohazard	3.667	2.734	3.424	2.610	6.636	2.748	4.091	2.578	4.091	2.832	3.182	2.952
Hot Surface	4.147	2.203	4.206	2.058	4.147	2.298	4.00	3.039	4.324	2.471	3.765	2.731
Entanglement	5.788	2.118	6.212	1.916	5.394	1.983	5.939	1.919	6.121	1.916	5.636	2.119
Electric Shock	6.059	1.705	6.026	1.754	5.941	1.722	6.294	1.338	6.765	1.92	6.324	1.492
Skull	7.029	1.291	7.029	1.087	6.265	1.711	7.235	1.129	6.941	1.229	6.882	1.431
Radiation	3.824	2.679	3.7056	2.576	3.882	2.358	3.941	2.473	4.059	2.522	3.471	2.788
Roller	4.424	2.624	5.061	2.135	4.879	2.342	4.788	2.247	4.477	2.205	4.545	2.526
Laser	2.000	2.048	1.938	1.949	2.063	2.154	1.750	1.666	2.226	2.125	1.406	1.898
Prohibition	5.455	2.063	4.548	2.378	4.636	2.191	4.969	2.172	5.121	2.132	5.818	1.793

Appendix I: Symbol Graphs (Means)

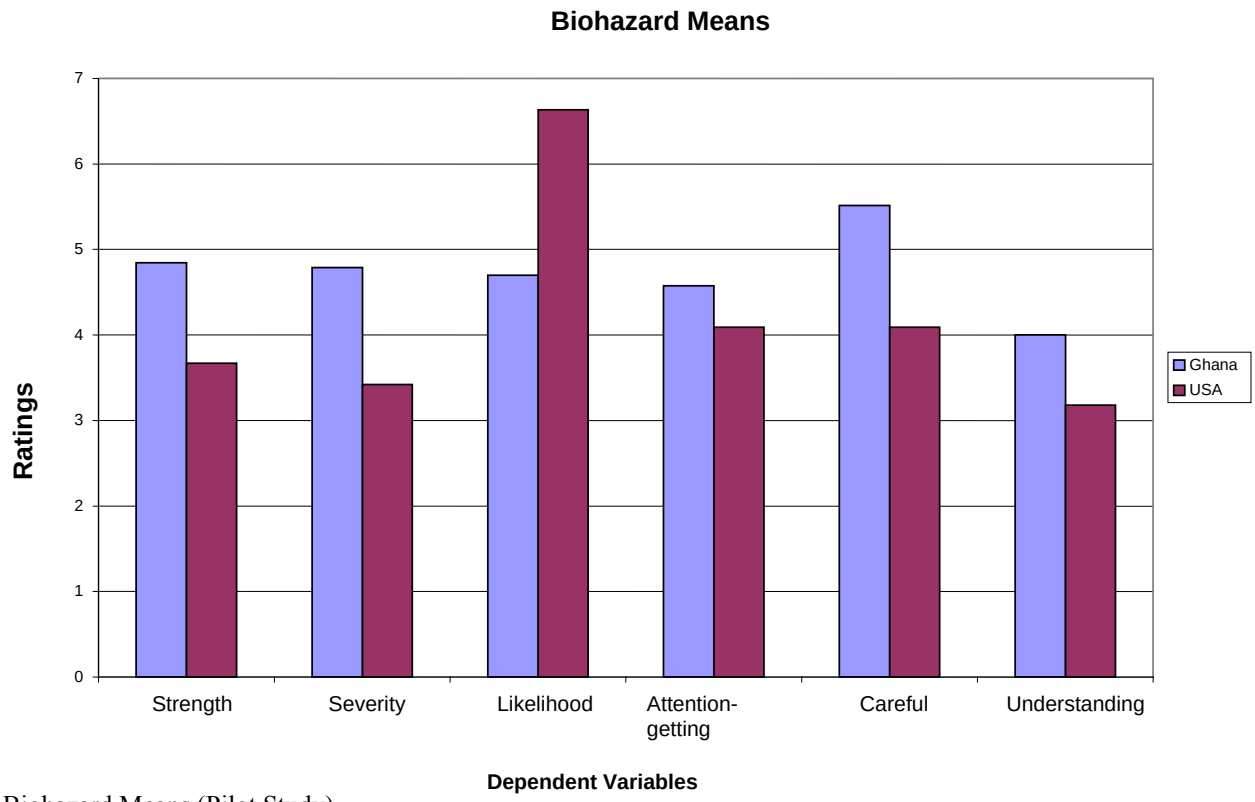

Figure 13: Biohazard Means (Pilot Study)

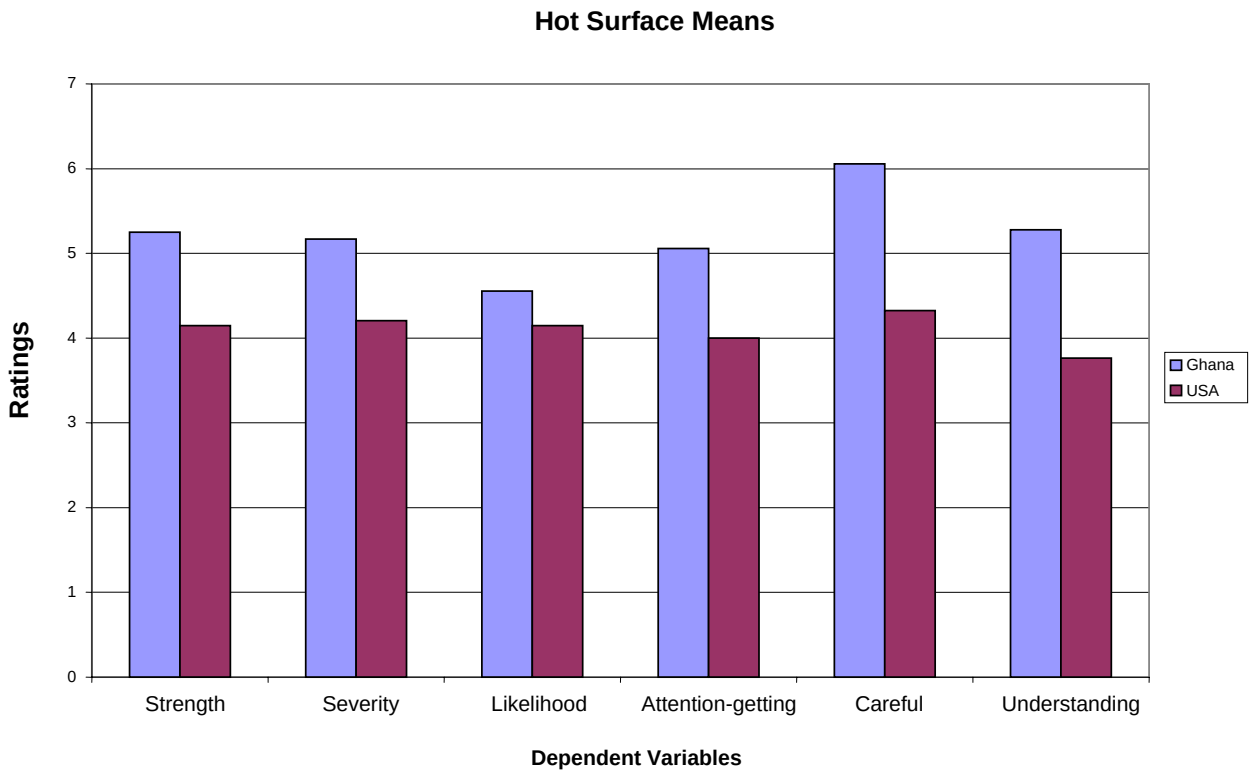

Figure 14: Hot Surface Means (Pilot Study)

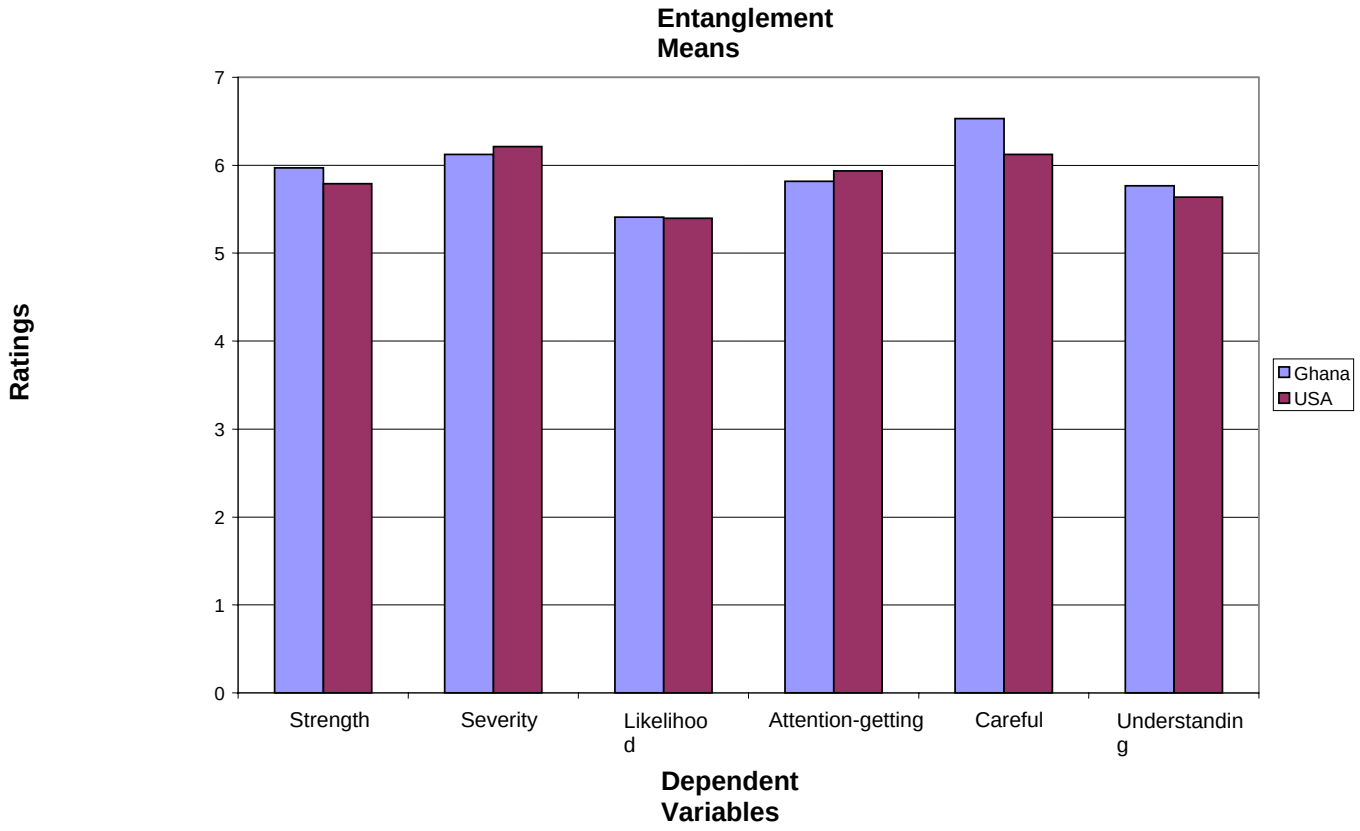

Figure 15: Entanglement Means (Pilot Study)

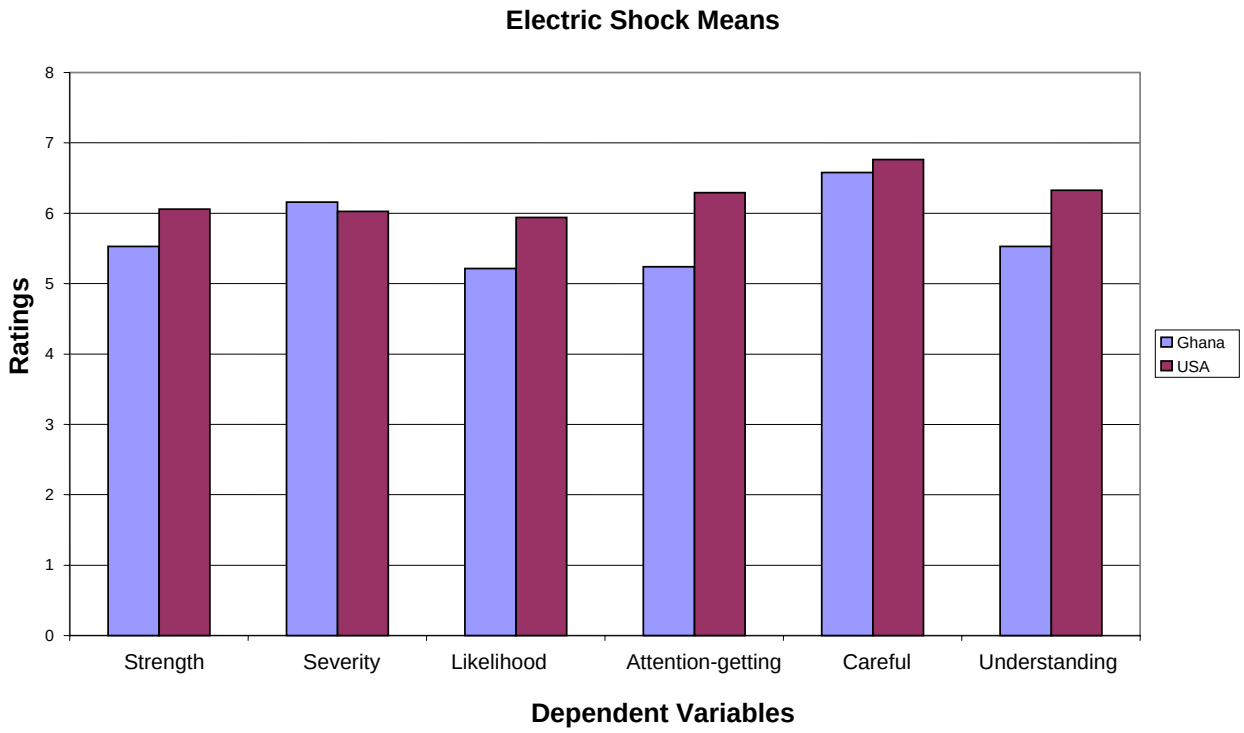

Figure 16: Electric Shock Means (Pilot Study)

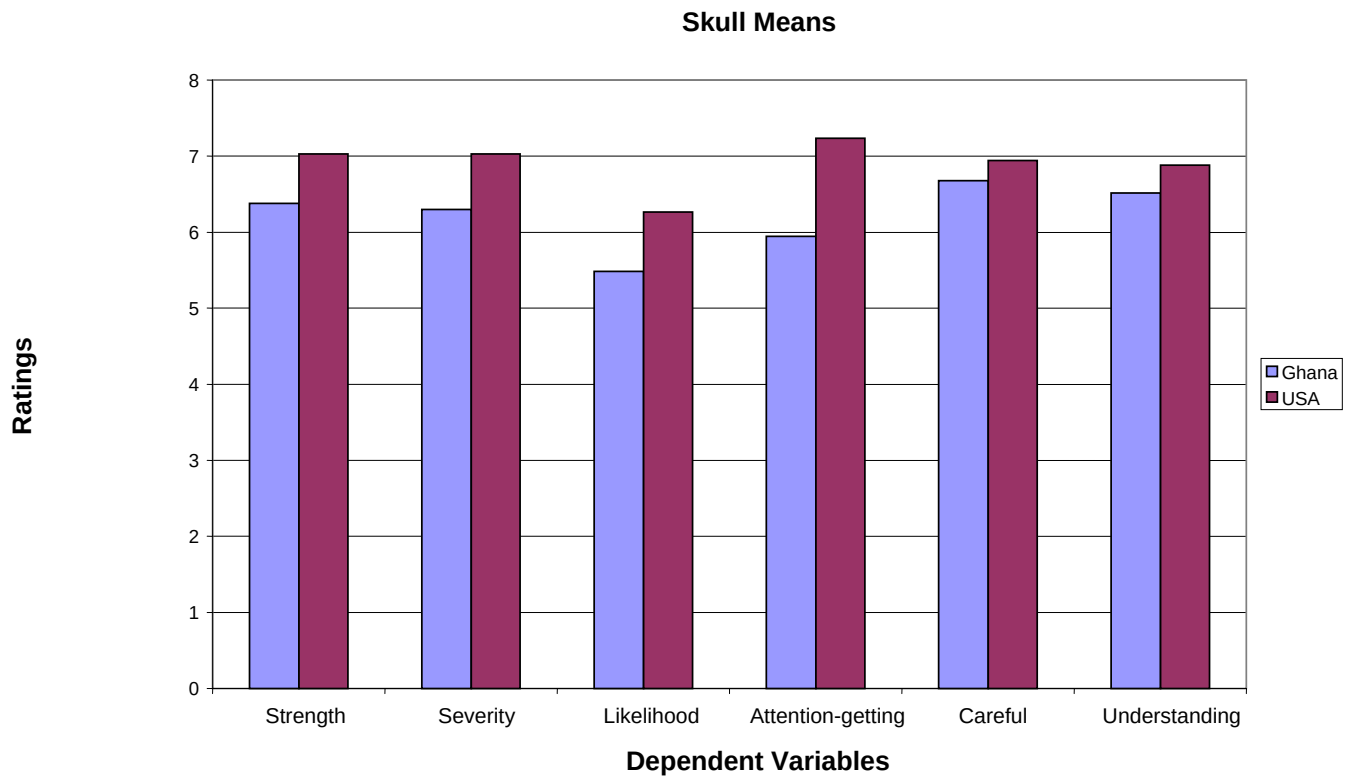

Figure 17: Skull Means (Pilot Study)

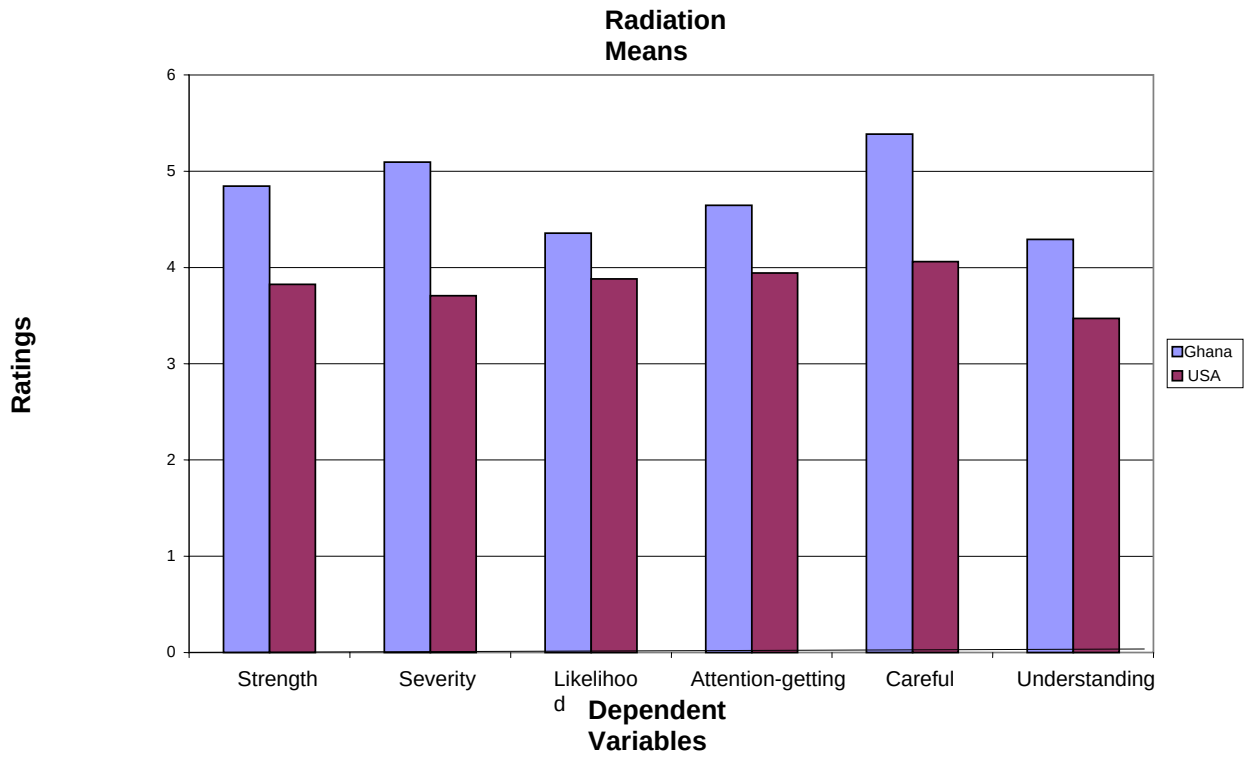

Figure 18: Radiation Means (Pilot Study)

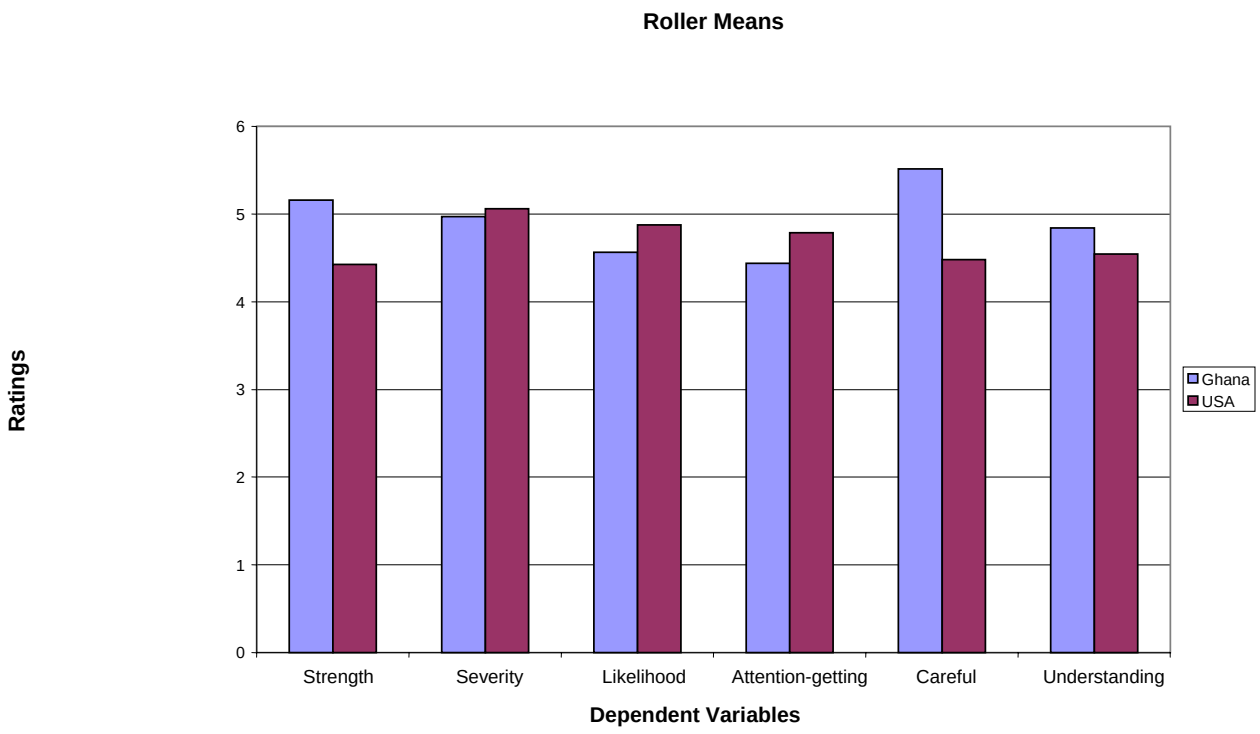

Figure 19: Roller Means (Pilot Study)

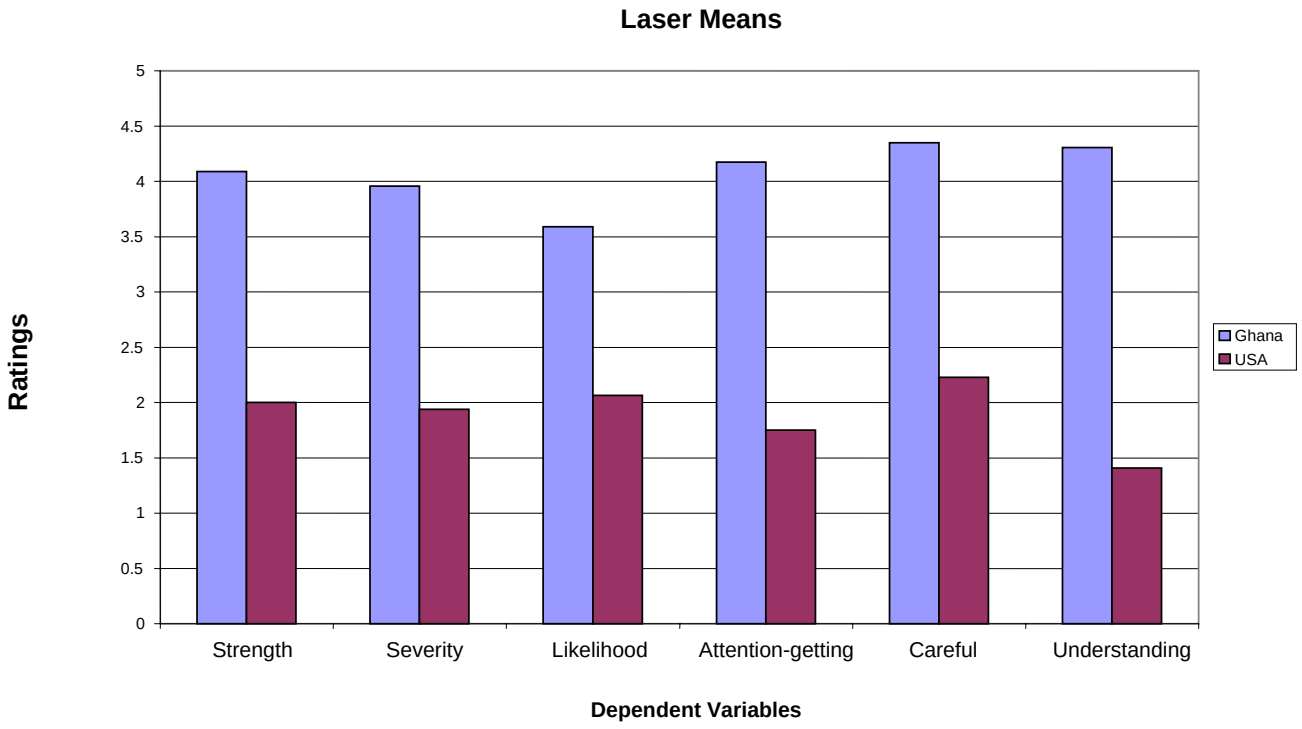

Figure 20: Laser Means (Pilot Study)

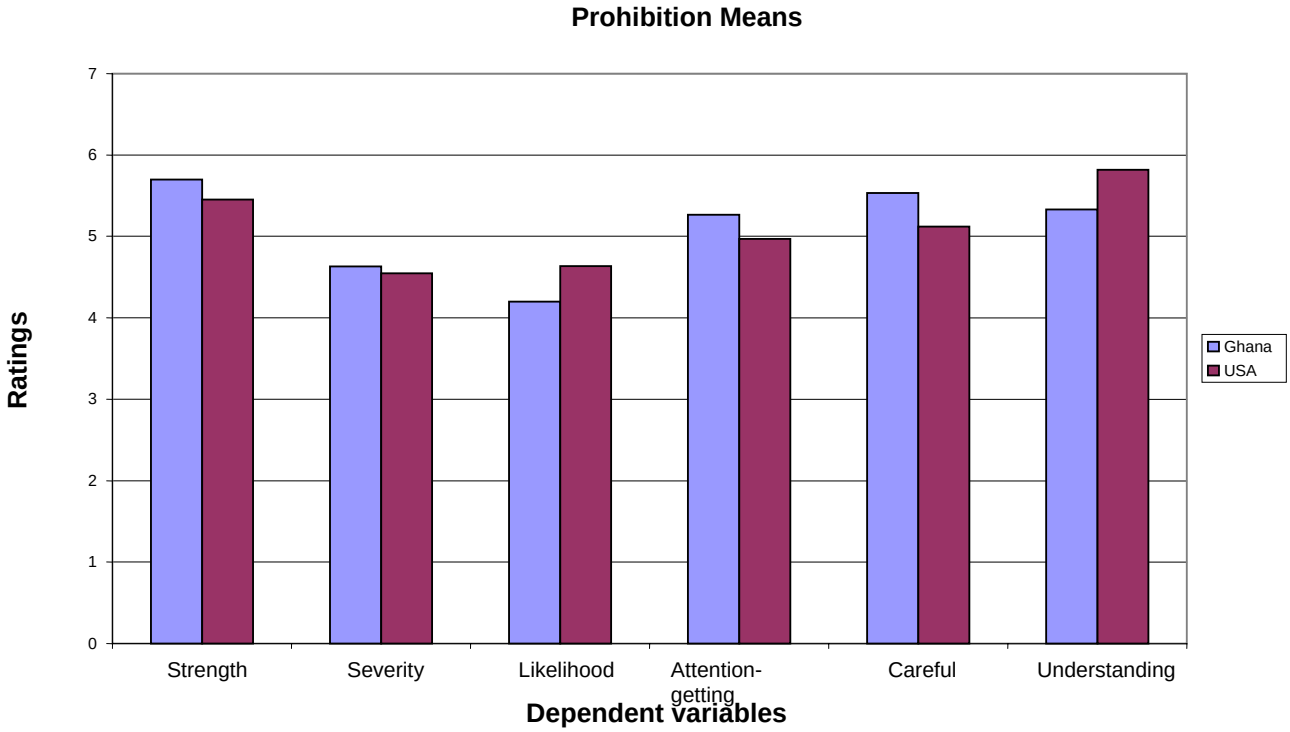

Figure 21: Prohibition Means (Pilot Study)

Appendix J: Signal Word Means and Standard Deviation

Table 29: Ghana Signal Word Mean and Standard Deviation (Pilot Study)

Ghana	Strength		Severity		Likelihood		Attention-getting		Careful		Understanding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Danger	6.412	1.940	6.364	2.162	5.500	2.688	6.424	1.601	6.941	1.205	6.500	1.638
Deadly	6.727	2.066	6.455	2.195	5.758	2.818	6.265	2.274	7.088	1.621	6.618	2.000
Warning	5.257	2.063	5.235	1.970	4.500	2.233	5.714	1.637	6.143	1.396	6.143	1.396
Caution	5.250	1.481	4.645	1.99	4.188	2.361	5.188	1.655	5.656	1.335	5.688	1.768
Notice	4.618	2.334	3.529	2.415	2.941	2.201	4.529	1.862	4.882	1.996	5.676	1.665
Attention	5.000	2.132	3.912	2.745	3.471	2.631	4.971	1.800	4.971	1.930	5.794	1.610

Table 30: USA Signal Word Mean and Standard Deviation (Pilot Study)

USA	Strength		Severity		Likelihood		Attention-getting		Careful		Understanding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Danger	6.735	1.355	6.727	1.464	6.176	1.445	6.941	1.347	7.00	1.55	7.147	1.282
Deadly	7.471	.896	7.529	1.079	6.647	1.952	7.500	1.808	7.559	1.049	7.529	1.079
Warning	6.212	2.012	5.697	2.215	5.250	2.155	5.879	1.965	6.00	1.803	6.424	1.542
Caution	5.697	1.862	5.121	2.342	4.750	2.170	5.788	2.147	5.939	2.120	6.606	1.539
Notice	4.394	2.499	3.212	2.509	3.333	2.569	4.242	2.222	4.091	2.283	5.121	2.118
Attention	4.636	2.547	3.818	2.778	3.848	2.671	4.758	2.562	4.424	2.669	5.515	1.839

Appendix K: Signal Word Graphs (Means)

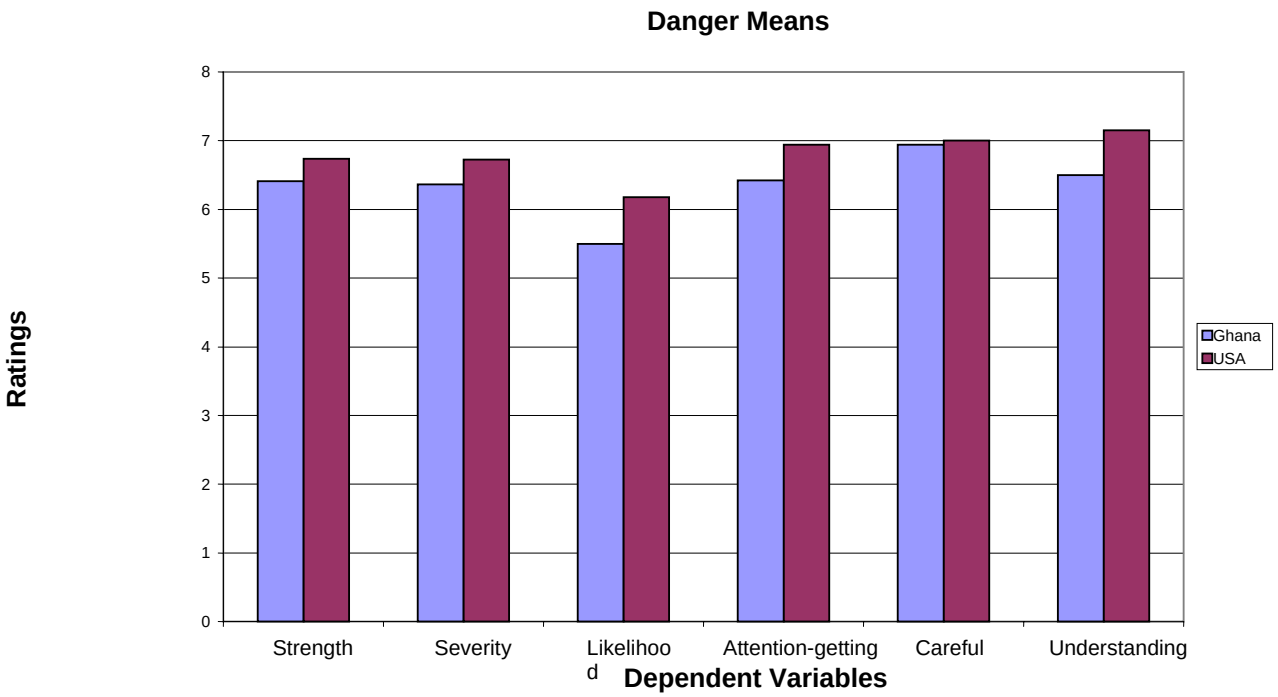

Figure 22: Danger Means (Pilot Study)

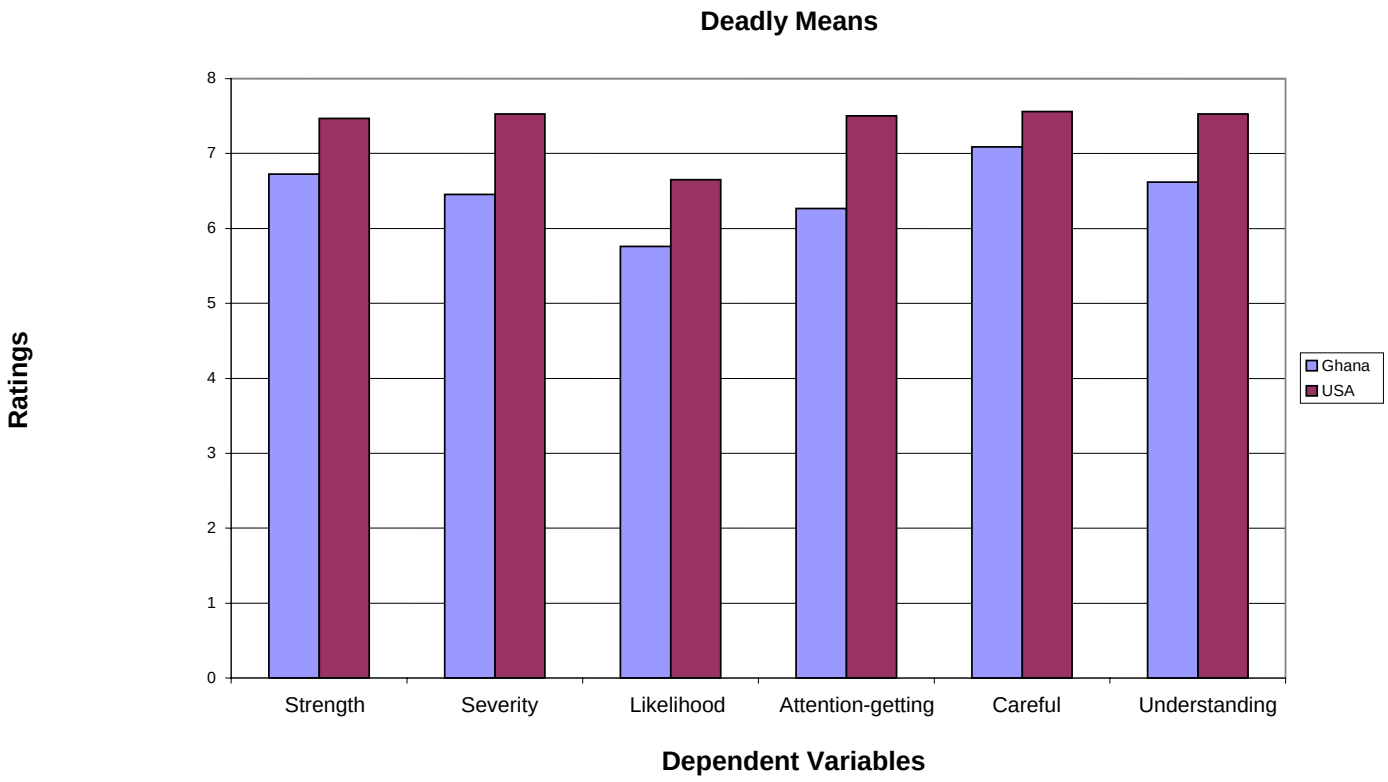

Figure 23: Deadly Means (Pilot Study)

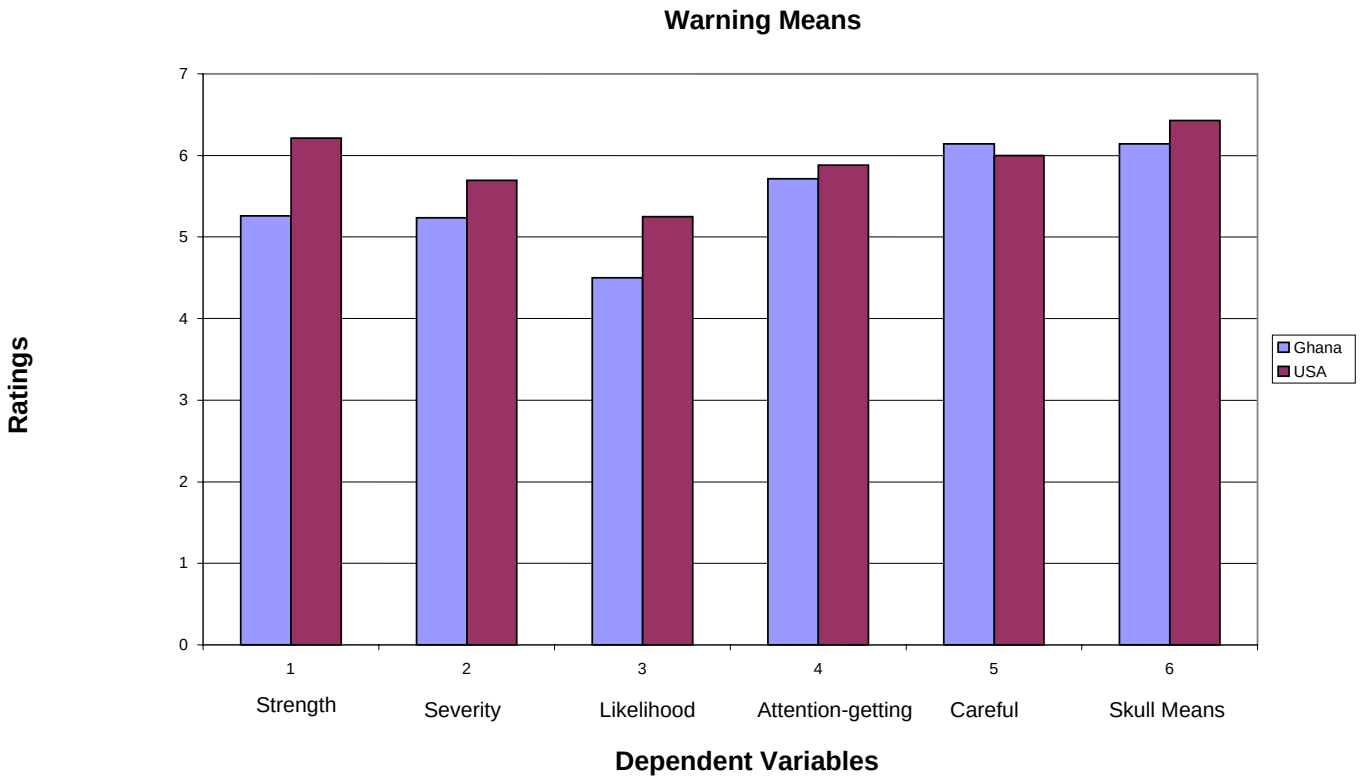

Figure 24: Warning Means (Pilot Study)

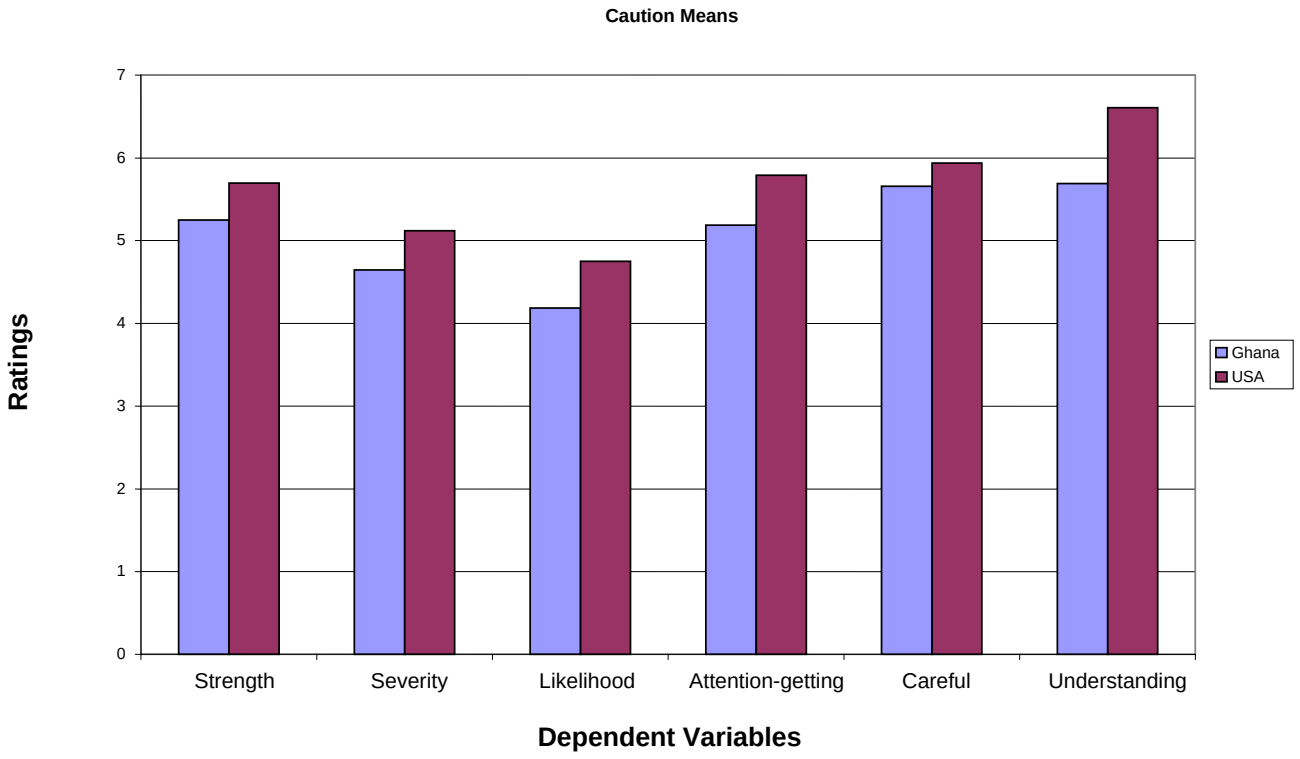

Figure 25: Caution Means (Pilot Study)

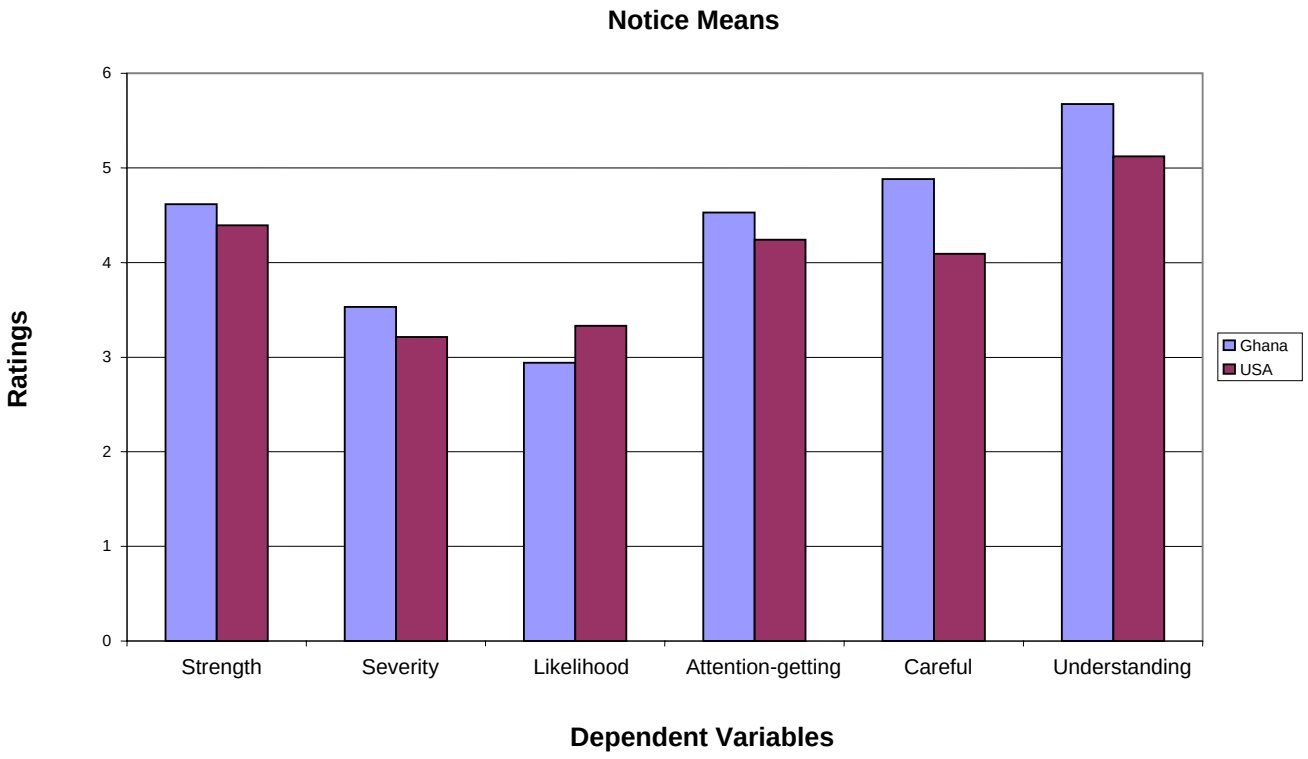

Figure 26: Notice Means (Pilot Study)

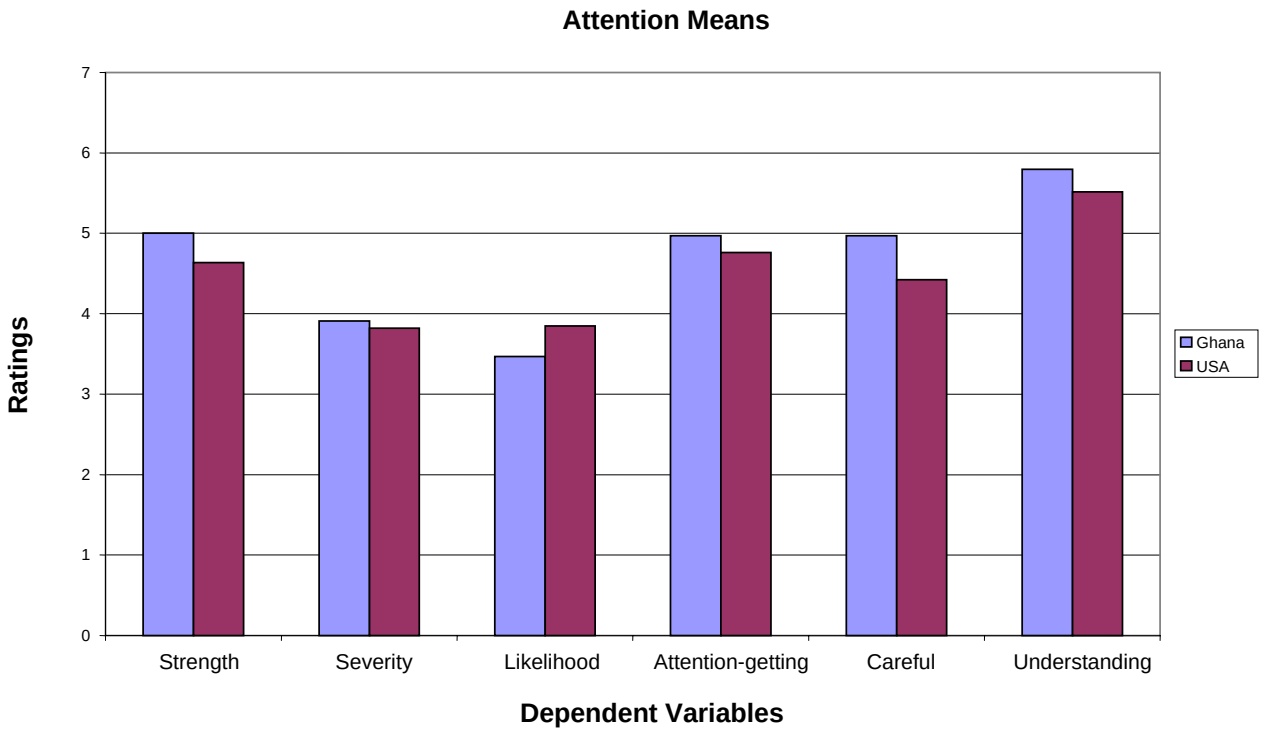

Figure 27: Attention Means (Pilot Study)

Appendix L: Color Means and Standard Deviations

Table 31: Ghana Color Mean and Standard Deviation (Pilot Study)

Ghana	Strength		Severity		Likelihood		Attention-getting		Careful	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Yellow	4.148	2.143	3.963	2.426	4.00	2.166	4.704	1.751	5.556	4.668
White	4.769	2.717	2.692	2.797	2.731	2.765	4.462	2.064	4.462	2.580
Black	5.621	1.934	5.207	2.396	4.897	2.439	5.241	1.864	5.345	2.092
Orange	4.542	1.956	4.750	2.212	4.208	2.377	4.783	1.678	5.375	1.861
Blue	4.185	2.202	4.222	2.136	3.704	1.938	4.852	1.562	4.407	2.308
Red	6.484	1.313	6.097	1.9034	5.709	2.411	6.548	1.546	6.935	1.289
Green	4.400	2.499	3.200	2.483	3.200	2.696	4.567	1.942	4.000	2.084

Table 32: USA Color Mean and Standard Deviation (Pilot Study)

USA	Strength		Severity		Likelihood		Attention-getting		Careful	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Yellow	4.576	1.821	3.697	2.518	4.212	2.190	4.879	1.799	4.455	2.063
White	2.909	2.626	2.000	2.704	2.091	2.492	2.455	2.538	2.515	2.635
Black	5.182	2.053	4.424	2.424	3.939	2.461	4.697	2.186	4.576	2.385
Orange	4.094	1.820	3.438	2.327	3.500	2.185	4.656	1.928	3.844	1.953
Blue	3.000	2.160	2.387	2.216	2.548	2.378	3.161	2.051	2.774	2.319
Red	6.147	1.579	5.941	1.791	5.818	1.895	6.235	1.304	6.559	1.397
Green	4.848	2.063	3.000	2.691	3.333	2.642	4.848	2.209	3.939	2.449

Appendix M: Color Graphs (Means)

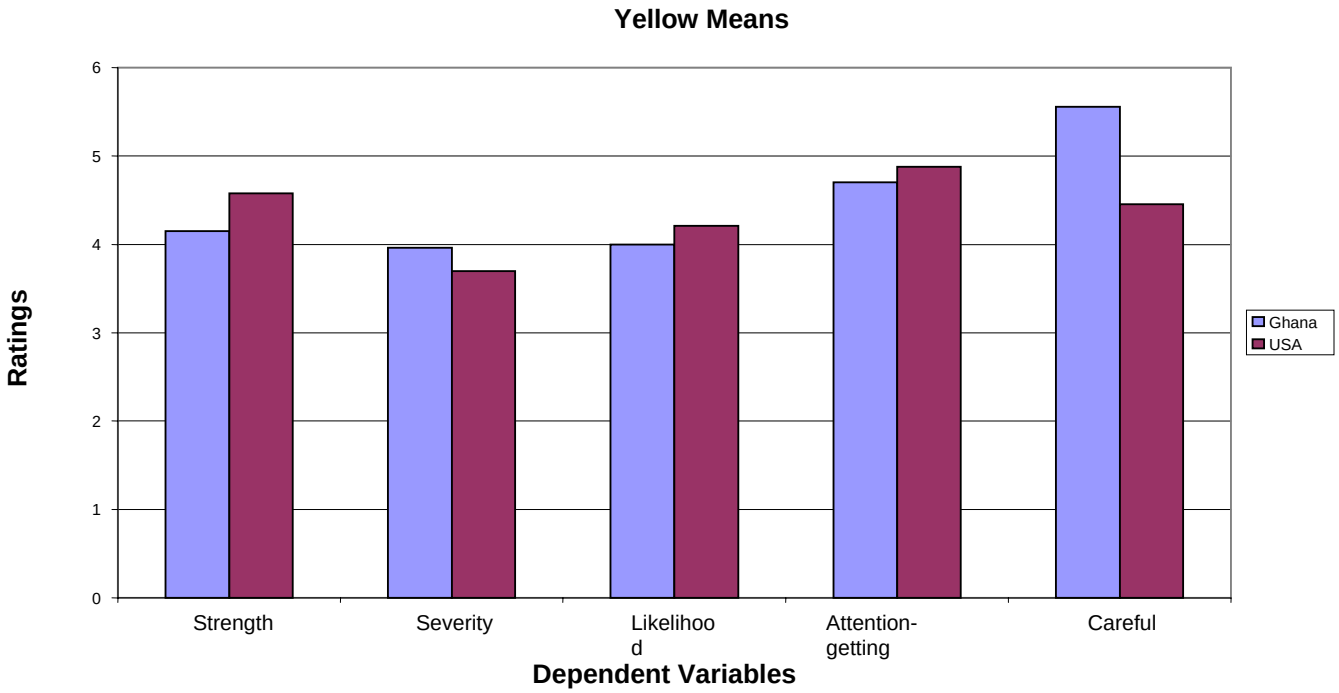

Figure 28: Yellow Means (Pilot Study)

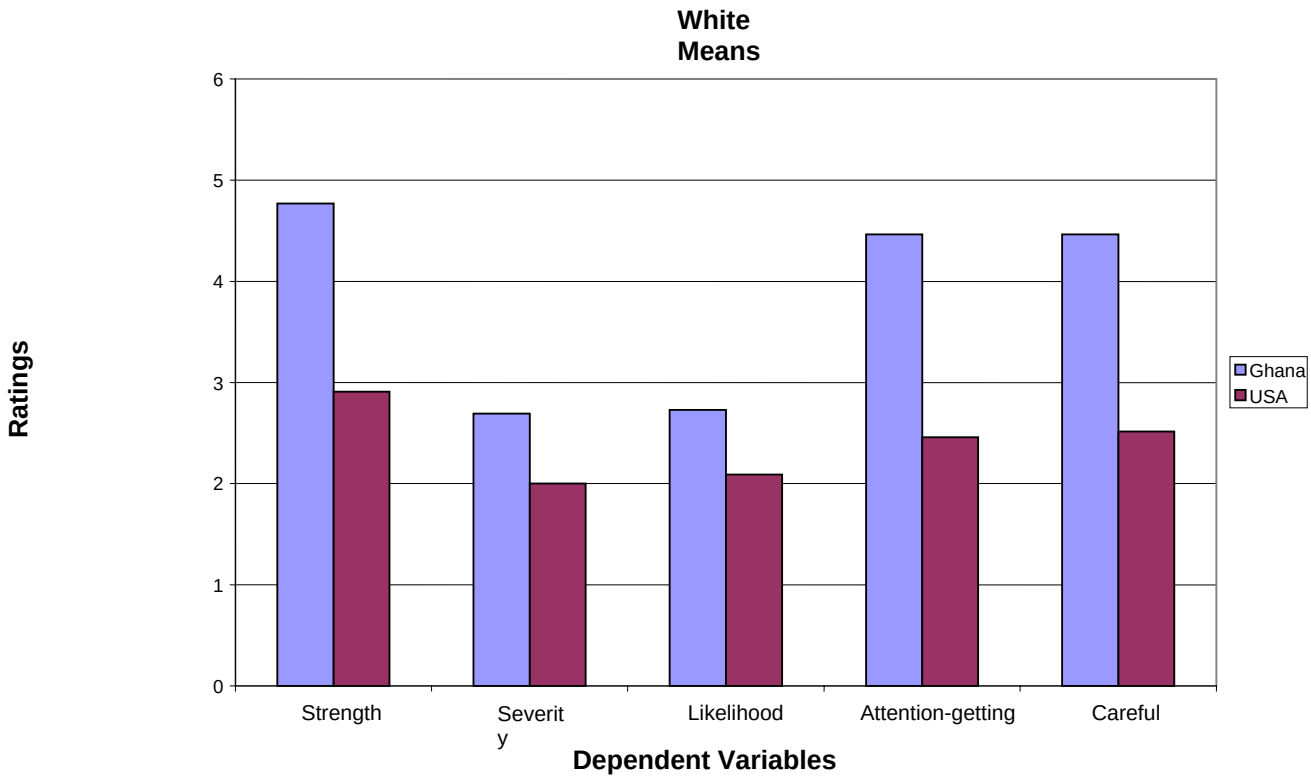

Figure 29: White Means (Pilot Study)

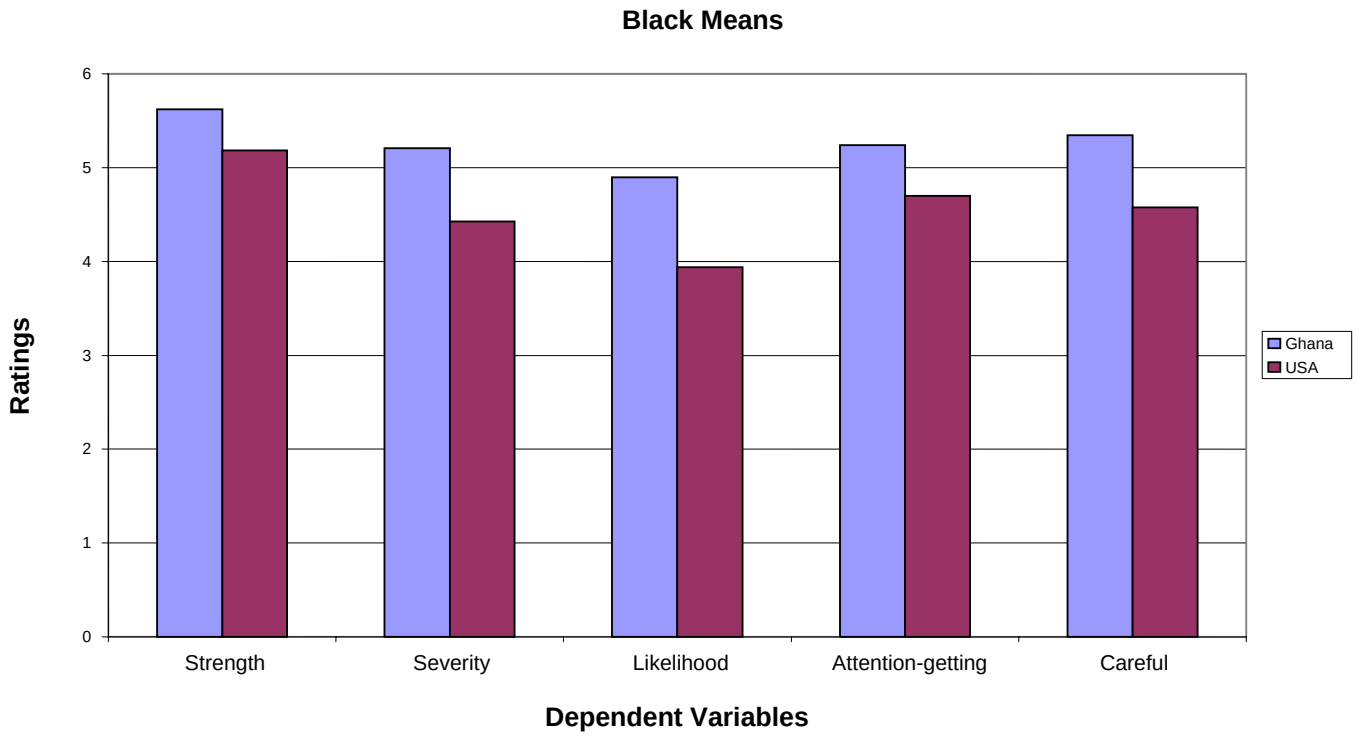

Figure 30: Black Means (Pilot Study)

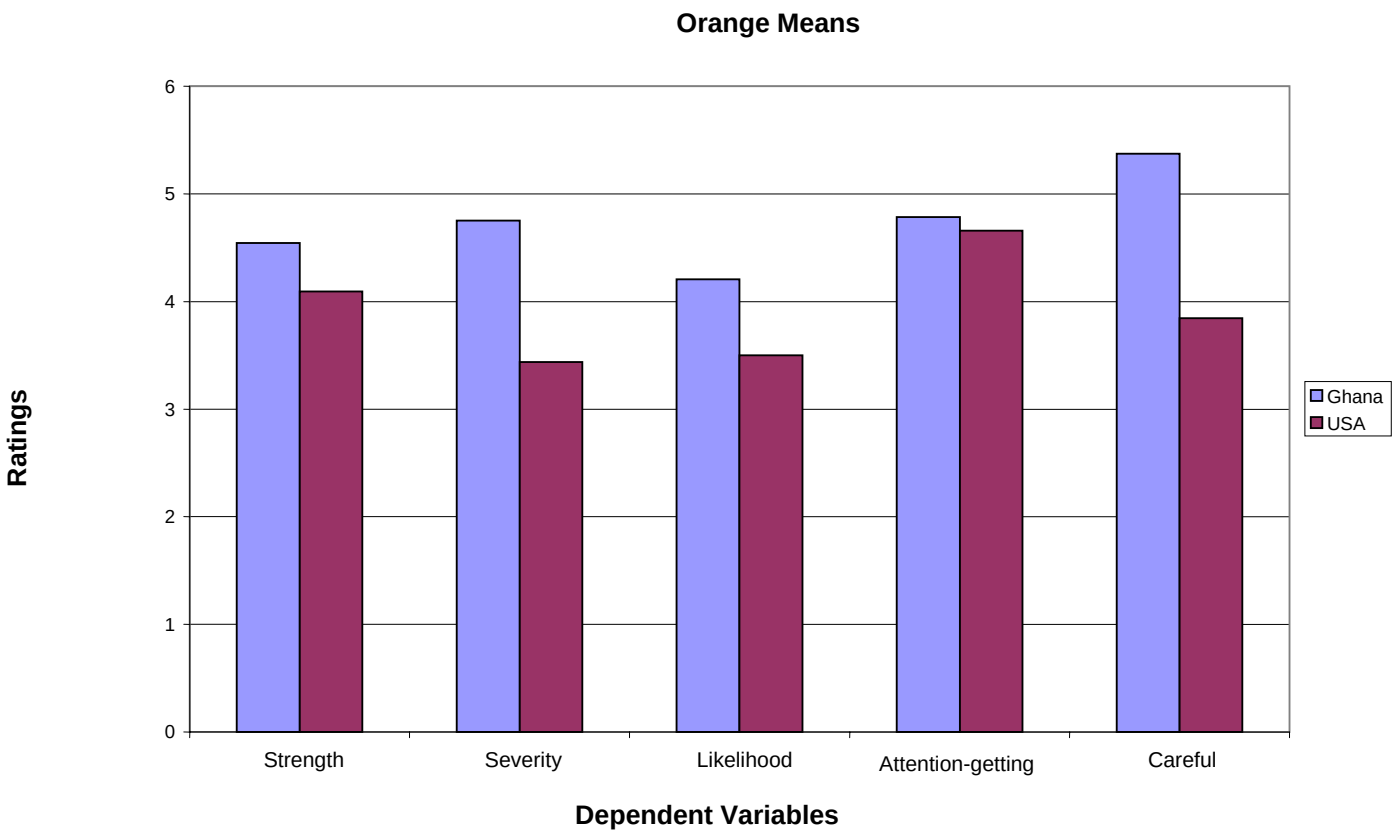

Figure 31: Orange Means (Pilot Study)

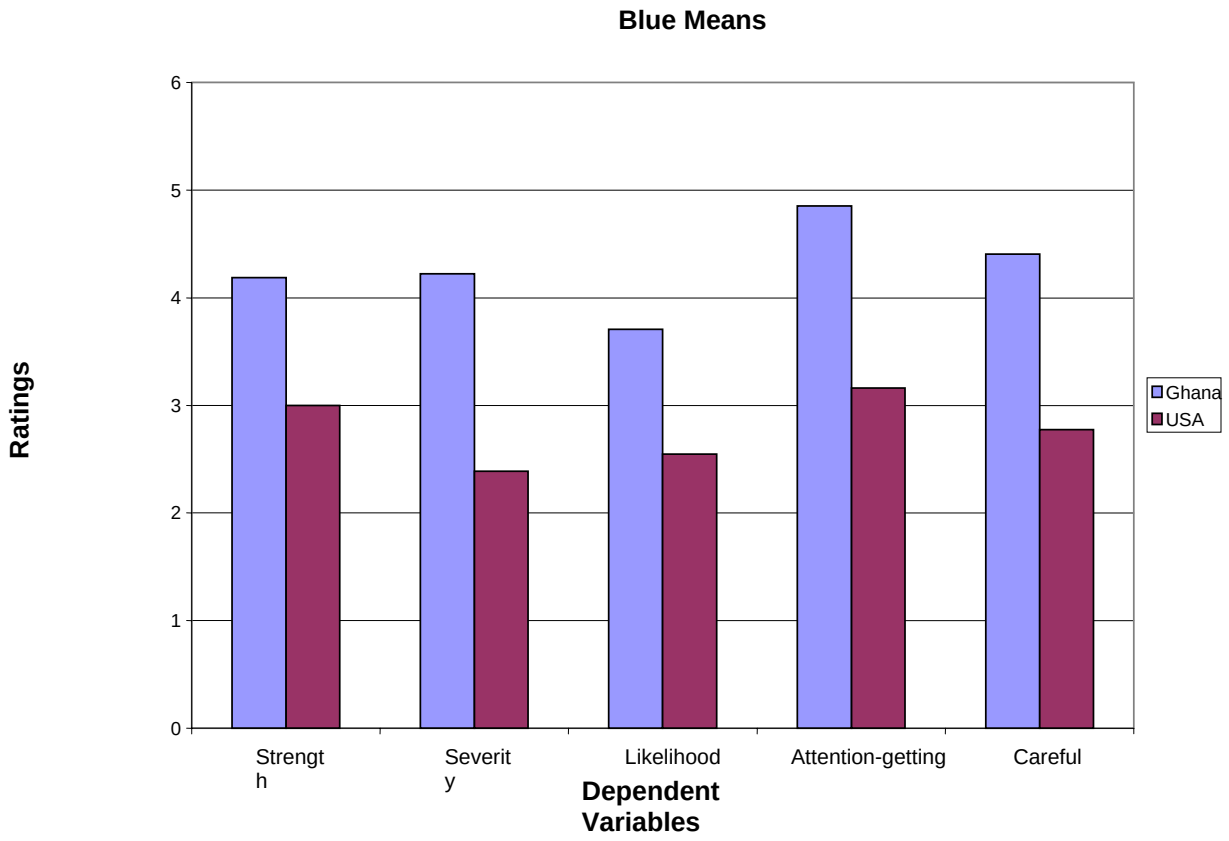

Figure 32: Blue Means (Pilot Study)

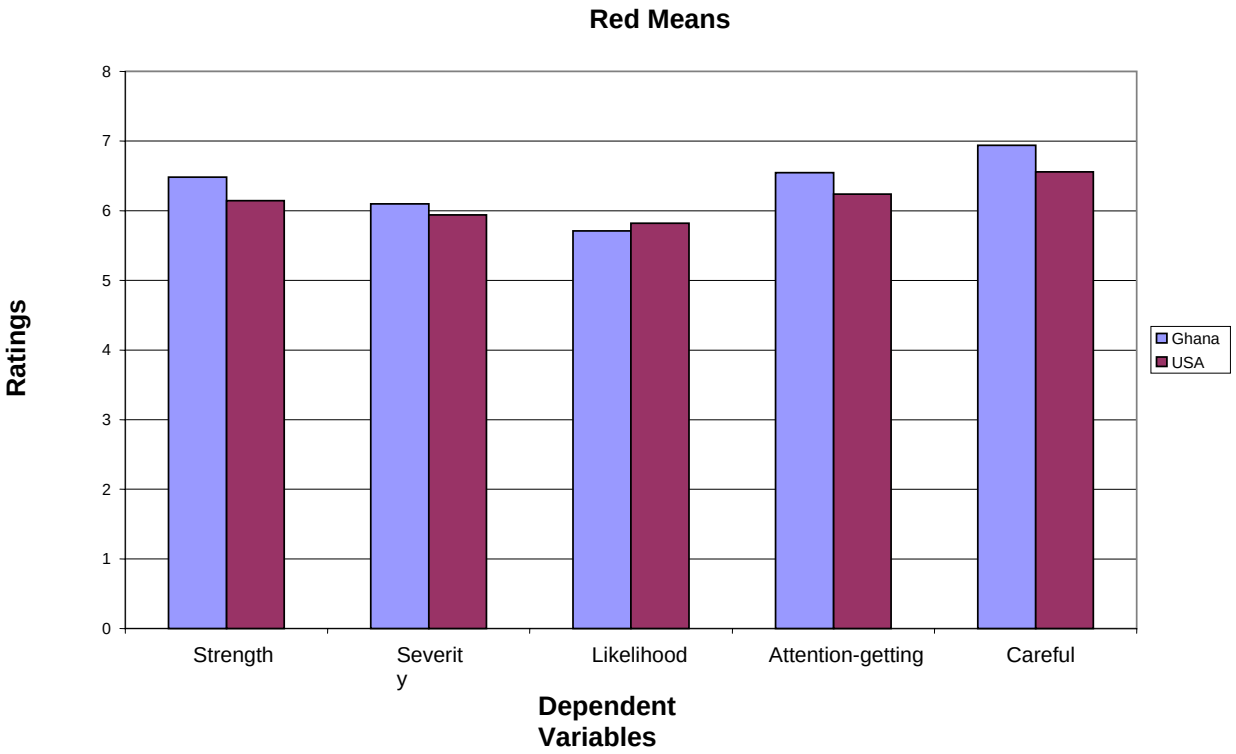

Figure 33: Red Means (Pilot Study)

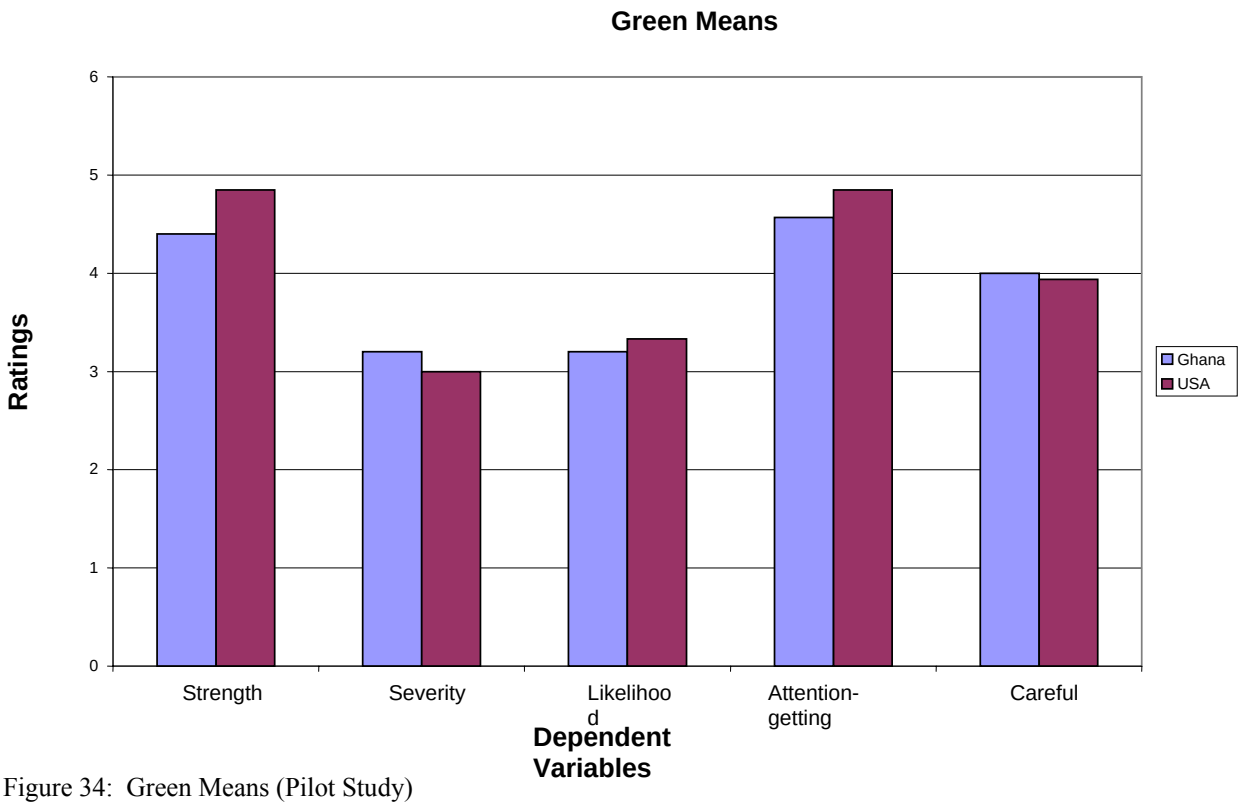

Figure 34: Green Means (Pilot Study)

Appendix N: Risk Perception Means and Standard Deviation

Table 33: Ghana Risk Perception Means and Standard Deviaton (Pilot Study)

Ghana		
	Mean	SD
Q1	6.969	1.551
Q2	6.455	1.459
Q3	6.594	1.720
Q4	6.938	1.523
Q5	6.406	1.720
Q6	6.813	1.595
Q7	6.219	1.431
Q8	6.355	1.253
Q9	5.774	2.261
Q10	6.774	1.230
Q11	5.433	2.254
Q12	6.000	1.732
Q13	5.167	2.198
Q14	5.933	1.766
Q15	6.806	1.108
Q16	3.581	2.643
Q17	3.226	2.741
Q18	5.129	1.928
Q19	4.00	2.463
Q20	2.774	2.629

Table 34: USA Risk Perception Means and Standard Deviation (Pilot Study)

USA		
	Mean	SD
Q1	7.206	1.095
Q2	6.618	1.577
Q3	6.735	1.639
Q4	6.735	1.814
Q5	6.676	1.471
Q6	6.618	1.939
Q7	7.118	1.149
Q8	7.088	1.215
Q9	5.853	2.189
Q10	5.853	2.338
Q11	5.061	2.331
Q12	4.618	2.582
Q13	5.324	2.279
Q14	5.088	2.340
Q15	7.088	1.485
Q16	5.824	2.355
Q17	5.059	2.486
Q18	4.824	1.946
Q19	4.206	2.447
Q20	3.882	2.847

Appendix O: Additional Demographic Information

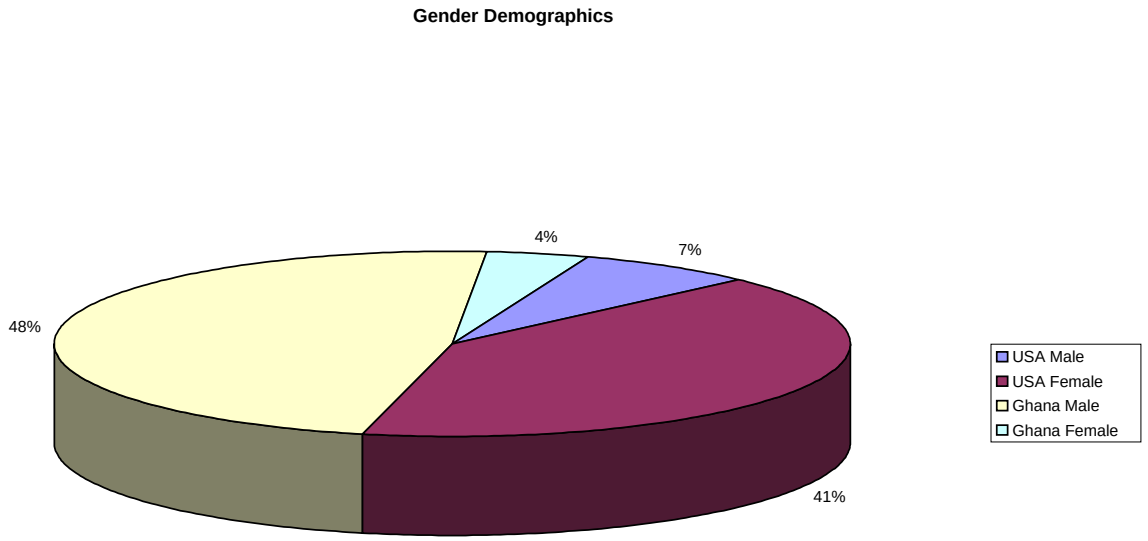

Figure 35: Gender Demographics

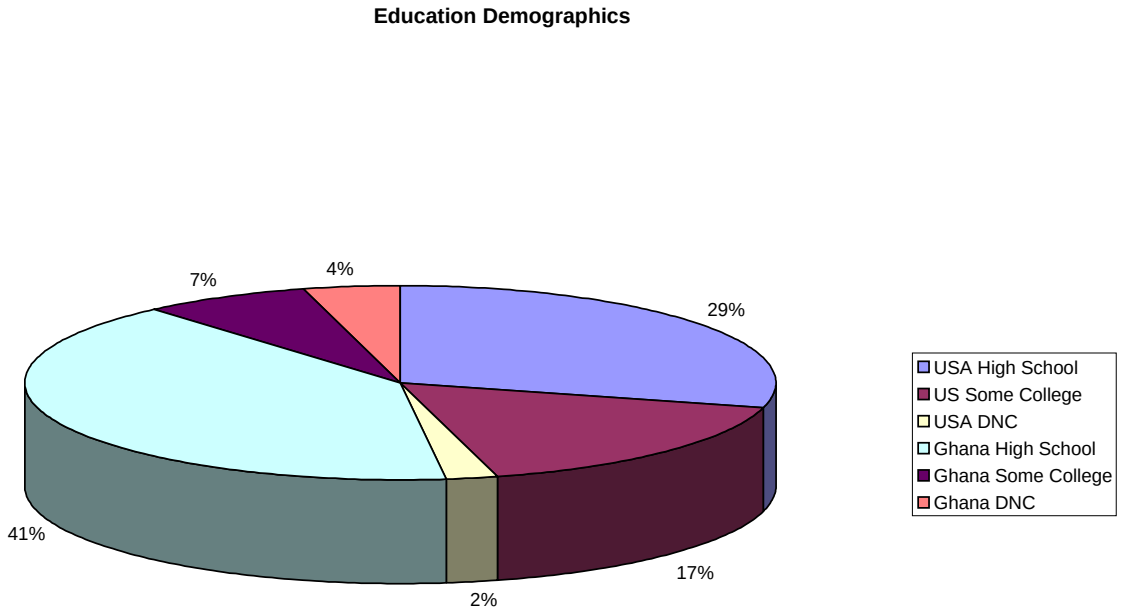

Figure 36: Education Demographics

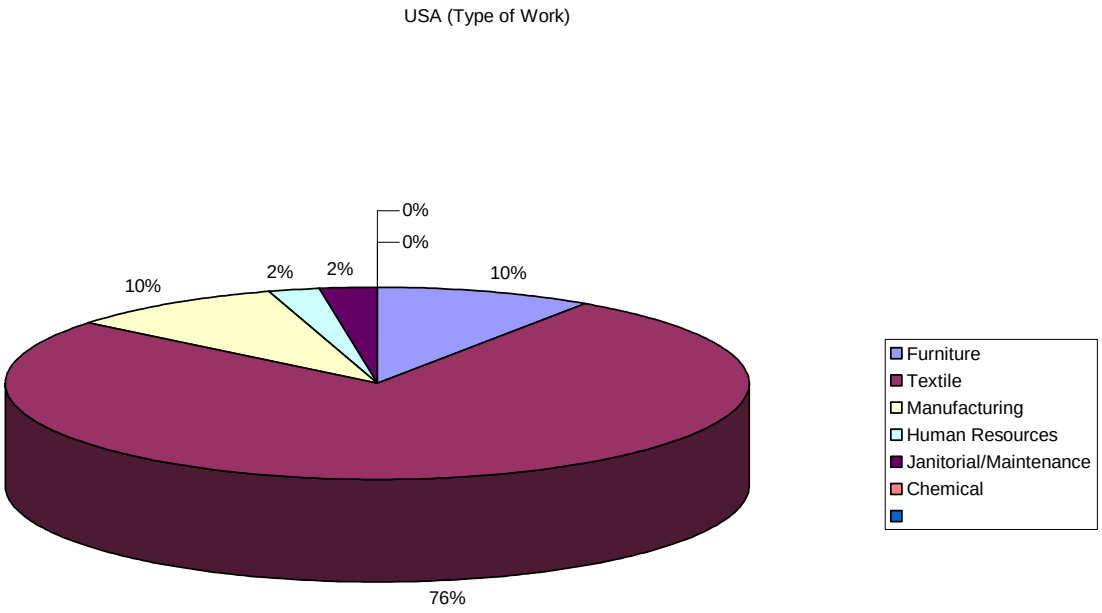

Figure 37: USA (Type of Work)

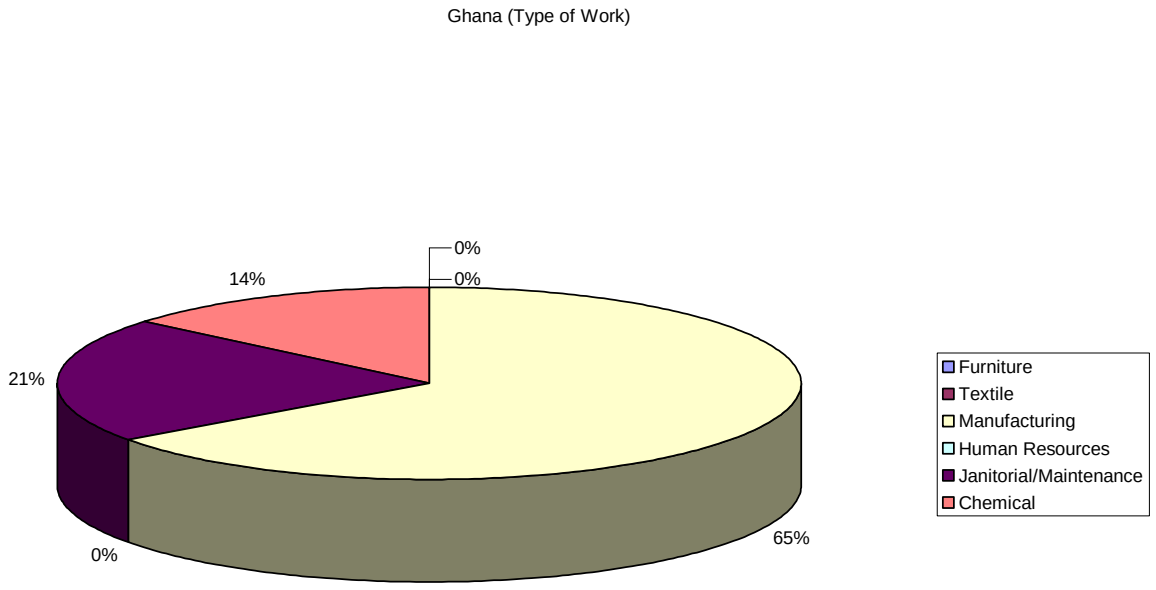

Figure 38: Ghana (Type of Work)

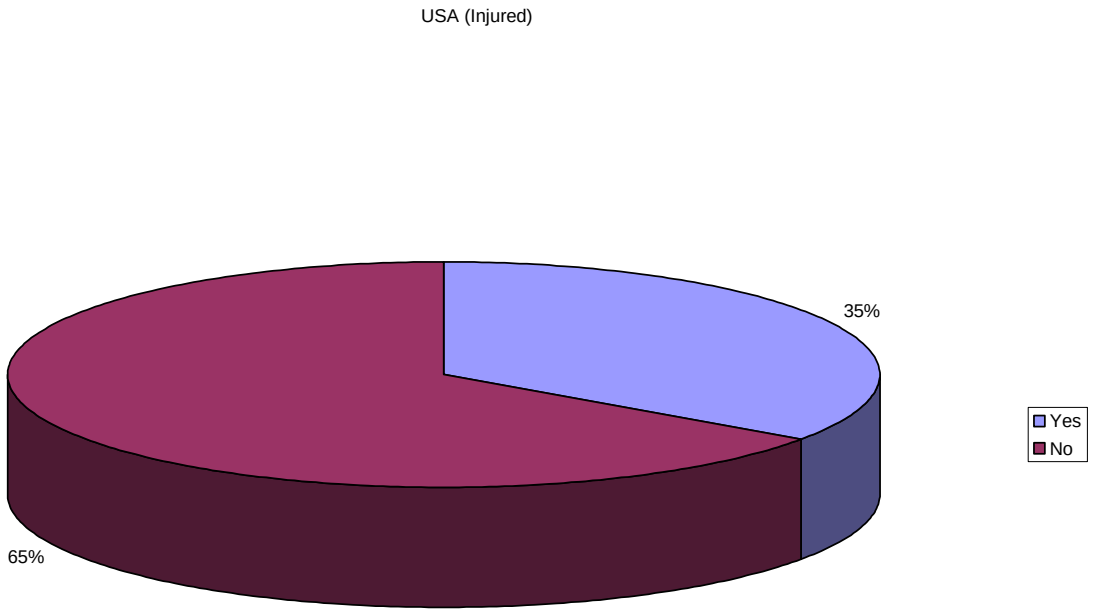

Figure 39: Number of USA Participants Injured on the Job

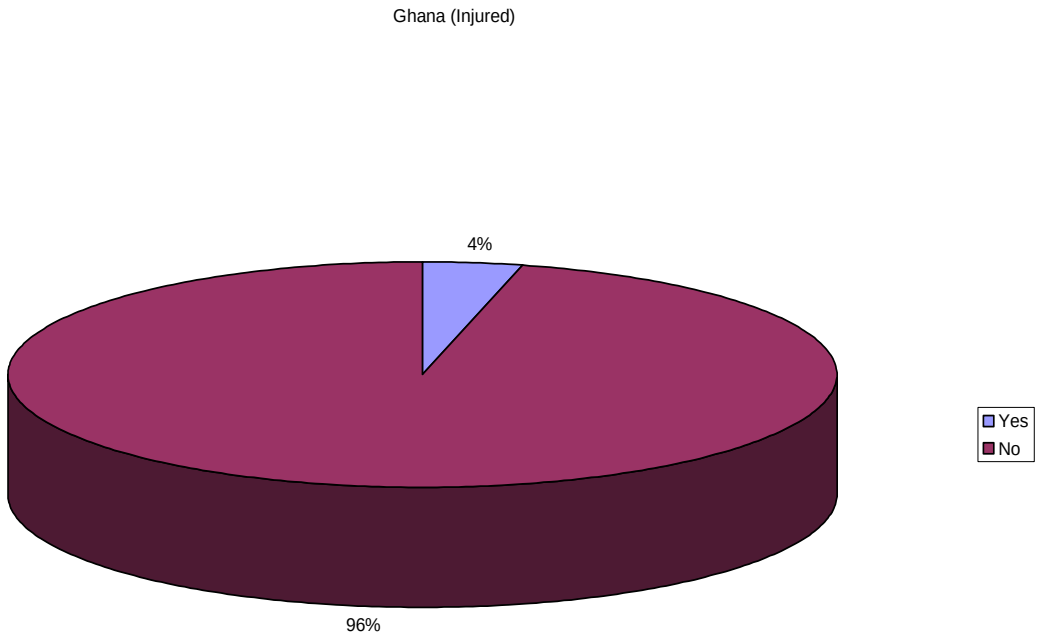

Figure 40: Number of Ghanaian Participants Injured on the Job

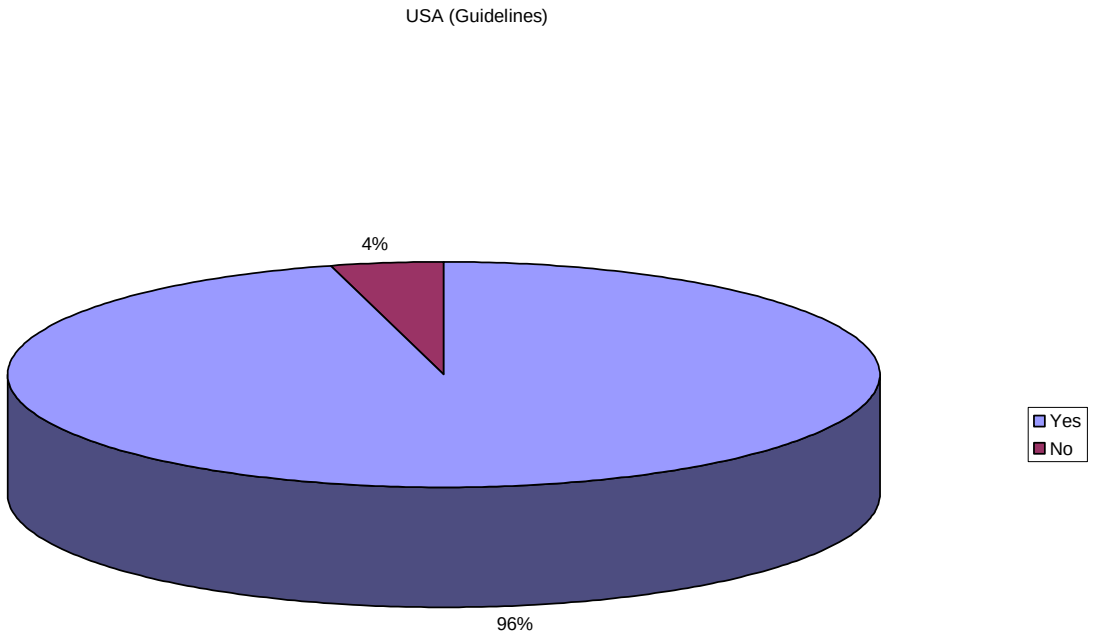

Figure 41: Number of USA Participants aware of company safety guidelines and procedures

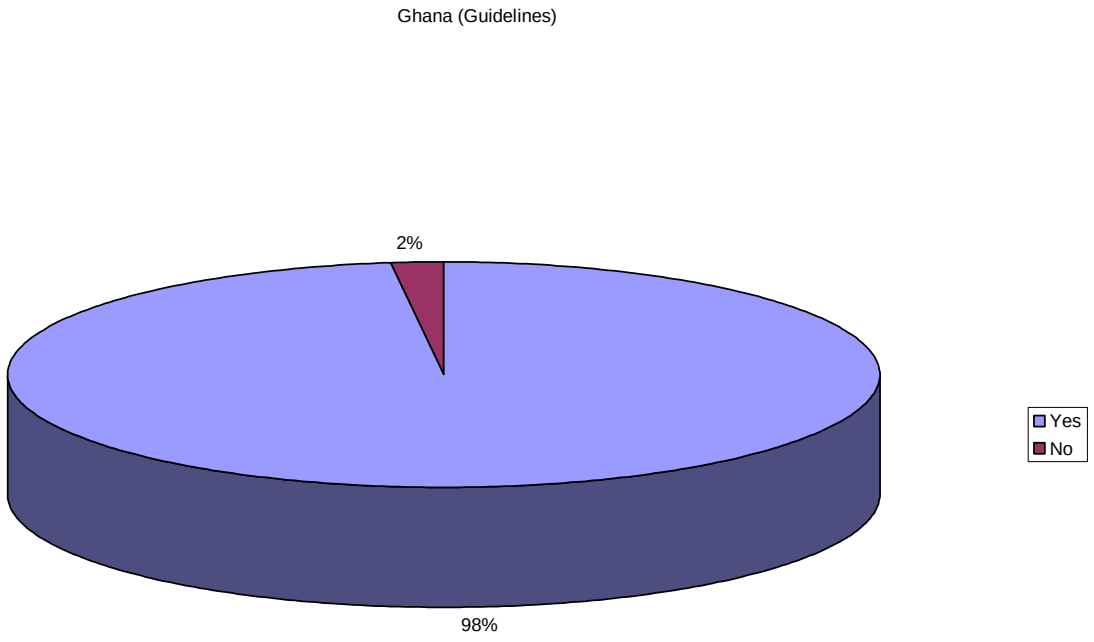

Figure 42: Number of Ghanaian Participants aware of company safety guidelines and procedures

Appendix P: Complete Questionnaire

Rate the level of risk involved with each statement by circling the number that you feel is associated with each statement.

1. Not wearing protective goggles while welding.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

2. Not wearing ear plugs in a high intensity noise environment.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

3. Not wearing steel toe safety shoes in high risk environments where objects are known to fall.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

4. Not wearing a hard hat in construction areas where posted signs state that they are required.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

5. Removing a cutting guard from a cutting machine.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

6. Not reporting a machine malfunction.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

7. Placing your hand on a hot surface.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

8. Not wearing gloves when handling hot objects.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

9. Having sex with a partner that you have known for a very brief time.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

10. Being in the outdoors, away from shelter, during an electrical storm.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

11. Using an electric power tool without protective goggles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

12. Exceeding the speed limit by 10 mph (16 km/h).

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

13. Pulling an electric plug out of the socket by the cord.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

14. When driving, passing when the solid yellow line is nearest you.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

15. Not wearing your seatbelt while you are driving a distance of over 20 miles (32 kilometers.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

16. Driving the wrong way on a one-way street.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

17. Flying a small private plane.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

18. Flying in a commercial airplane.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

19. Not wearing your seatbelt while you are a passenger riding a distance of over 20 miles (32 kilometers).

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

20. Not wearing you seatbelt while you are a passenger riding a distance less that 3 miles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

21. Jump starting a car without wearing protective goggles.

Not at all risky		Slightly risky		Risky		Very risky		Extremely risky
0	1	2	3	4	5	6	7	8

22. I am in control of what happens to me.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

23. Accidents are due to fate, nothing can be done about it

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

24. People must be the master of their own fate.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

25. Persistence and hard work usually lead to success.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

26. Other people usually control my life.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

27. I usually get what I want in life.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

28. If I do not succeed in a task, I usually give up.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

29. Leaders are successful when the work hard.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

30. The success I have is largely a matter of chance.

Strongly agree	Agree	Disagree	Strongly disagree
1	2	3	4

For the next section, please answer each question based on the symbol presented on the top of each page.

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

5. What is the LIKELIHOOD of injury implied by this symbol?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

6. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

7. How CAREFUL would you be after seeing this symbol?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

8. How UNDERSTANDABLE is this symbol?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

5. What is the LIKELIHOOD of injury implied by this symbol?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

6. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

7. How CAREFUL would you be after seeing this symbol?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

8. How UNDERSTANDABLE is this symbol?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

5. What is the LIKELIHOOD of injury implied by this symbol?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

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Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

7. How CAREFUL would you be after seeing this symbol?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

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Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

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never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

6. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

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Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

8. How UNDERSTANDABLE is this symbol?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

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never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

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Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

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Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

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Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

5. What is the LIKELIHOOD of injury implied by this symbol?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

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Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

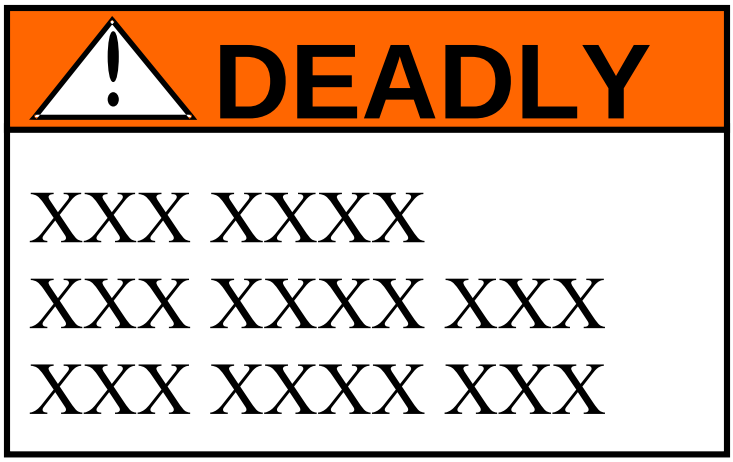
7. How CAREFUL would you be after seeing this symbol?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

8. How UNDERSTANDABLE is this symbol?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

Answer each question based on the sign presented.



1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

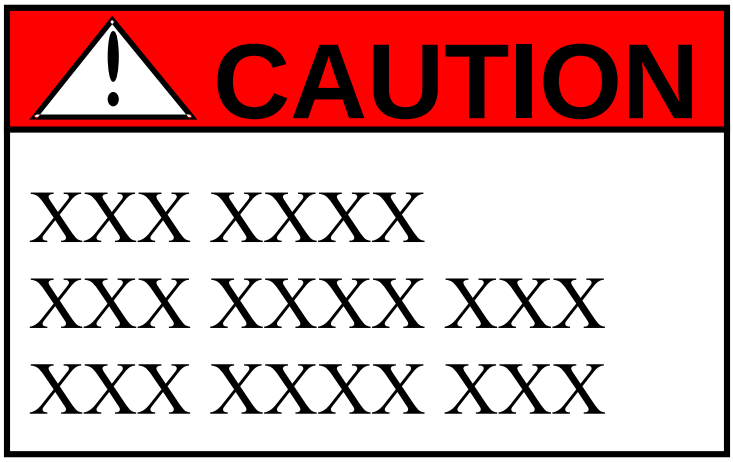
Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8



1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

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No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

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Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

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No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

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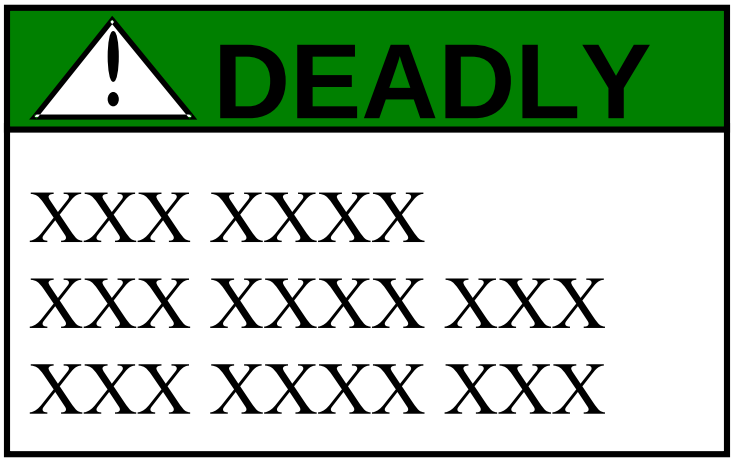
No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

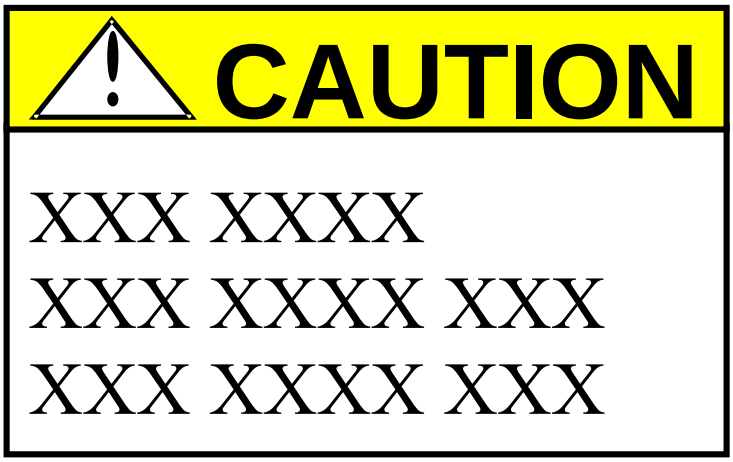


1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8



1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

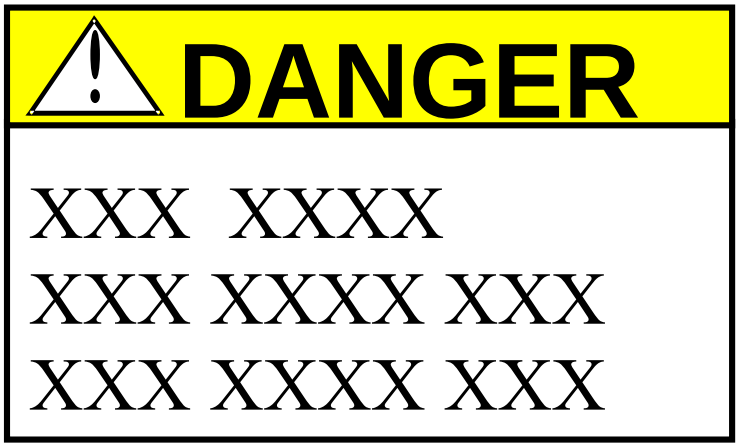
Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8



1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

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No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

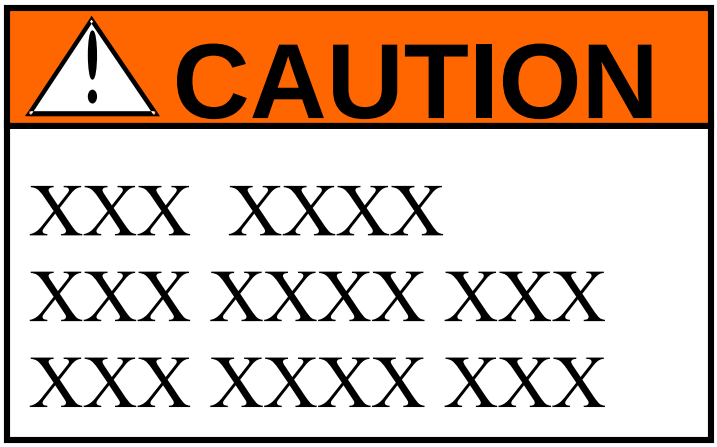
Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

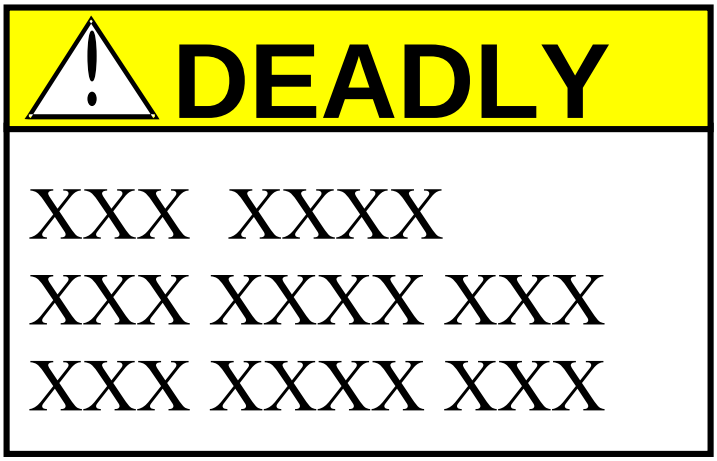


1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

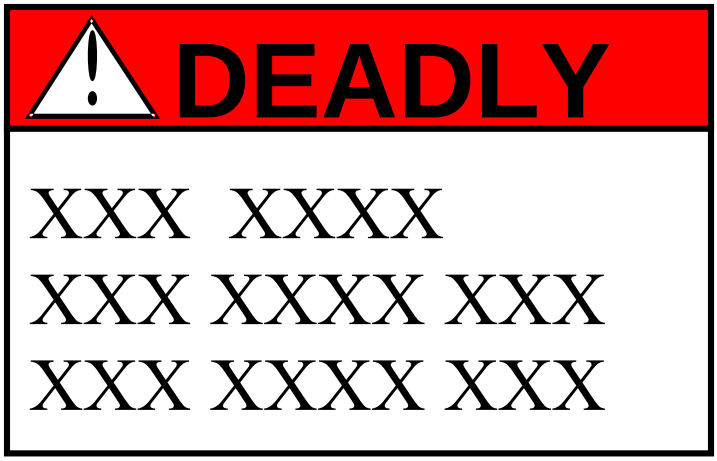


1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

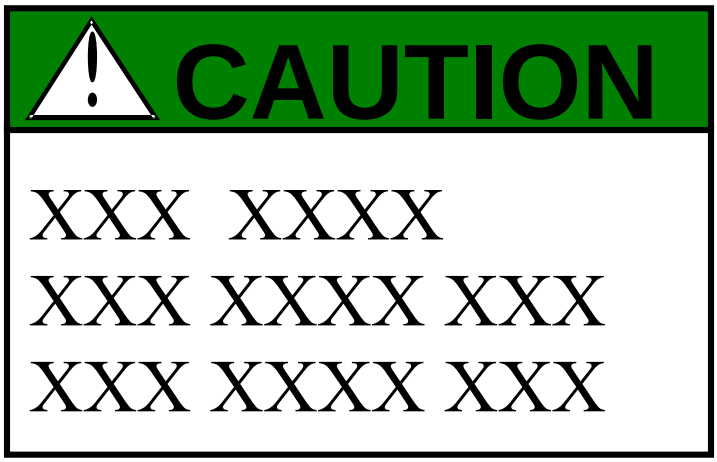


1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8



1. What is the level of hazard conveyed by this sign?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is this sign?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

You will be shown 120 different warning sign combinations. Each combination will contain two different signs labeled “A” and “B”. For each combination shown, you are to circle the letter that corresponds with the MOST PERCEIVED HAZARDOUS warning sign.

1.	A	B	31.	A	B	61.	A	B	91.	A	B
2.	A	B	32.	A	B	62.	A	B	92.	A	B
3.	A	B	33.	A	B	63.	A	B	93.	A	B
4.	A	B	34.	A	B	64.	A	B	94.	A	B
5.	A	B	35.	A	B	65.	A	B	95.	A	B
6.	A	B	36.	A	B	66.	A	B	96.	A	B
7.	A	B	37.	A	B	67.	A	B	97.	A	B
8.	A	B	38.	A	B	68.	A	B	98.	A	B
9.	A	B	39.	A	B	69.	A	B	99.	A	B
10.	A	B	40.	A	B	70.	A	B	100.	A	B
11.	A	B	41.	A	B	71.	A	B	101.	A	B
12.	A	B	42.	A	B	72.	A	B	102.	A	B
13.	A	B	43.	A	B	73.	A	B	103.	A	B
14.	A	B	44.	A	B	74.	A	B	104.	A	B
15.	A	B	45.	A	B	75.	A	B	105.	A	B
16.	A	B	46.	A	B	76.	A	B	106.	A	B
17.	A	B	47.	A	B	77.	A	B	107.	A	B
18.	A	B	48.	A	B	78.	A	B	108.	A	B
19.	A	B	49.	A	B	79.	A	B	109.	A	B
20.	A	B	50.	A	B	80.	A	B	110.	A	B
21.	A	B	51.	A	B	81.	A	B	111.	A	B
22.	A	B	52.	A	B	82.	A	B	112.	A	B
23.	A	B	53.	A	B	83.	A	B	113.	A	B
24.	A	B	54.	A	B	84.	A	B	114.	A	B
25.	A	B	55.	A	B	85.	A	B	115.	A	B
26.	A	B	56.	A	B	86.	A	B	116.	A	B
27.	A	B	57.	A	B	87.	A	B	117.	A	B
28.	A	B	58.	A	B	88.	A	B	118.	A	B
29.	A	B	59.	A	B	89.	A	B	119.	A	B
30.	A	B	60.	A	B	90.	A	B	120.	A	B

Appendix Q: Symbols

Electric Shock

Bolt

Skull and Crossbones

MR. YUK

Asterisk

Exclamation

Figure 43: Symbols used for research

Appendix R: Questions for Symbols

1. Have you seen this symbol before? Yes No

2. What do you think this symbol means? _____
_____

3. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

4. What is the SEVERITY of injury implied by this symbol?

Not severe		Slightly severe		Severe		Very severe		Extremely severe
0	1	2	3	4	5	6	7	8

5. What is the LIKELIHOOD of injury implied by this symbol?

never		unlikely		likely		Very likely		Extremely likely
0	1	2	3	4	5	6	7	8

6. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

7. How CAREFUL would you be after seeing this symbol?

Not at all careful		Slightly careful		careful		Very careful		Extremely careful
0	1	2	3	4	5	6	7	8

8. How UNDERSTANDABLE is this symbol?

Not at all understandable		Slightly understandable		understandable		Very understandable		Extremely understandable
0	1	2	3	4	5	6	7	8

Appendix S: Example Signs

(YELLOW CAUTION, RED CAUTION, GREEN CAUTION, and ORANGE CAUTION; RED WARNING, RED CAUTION, RED DEADLY, and RED DANGER)

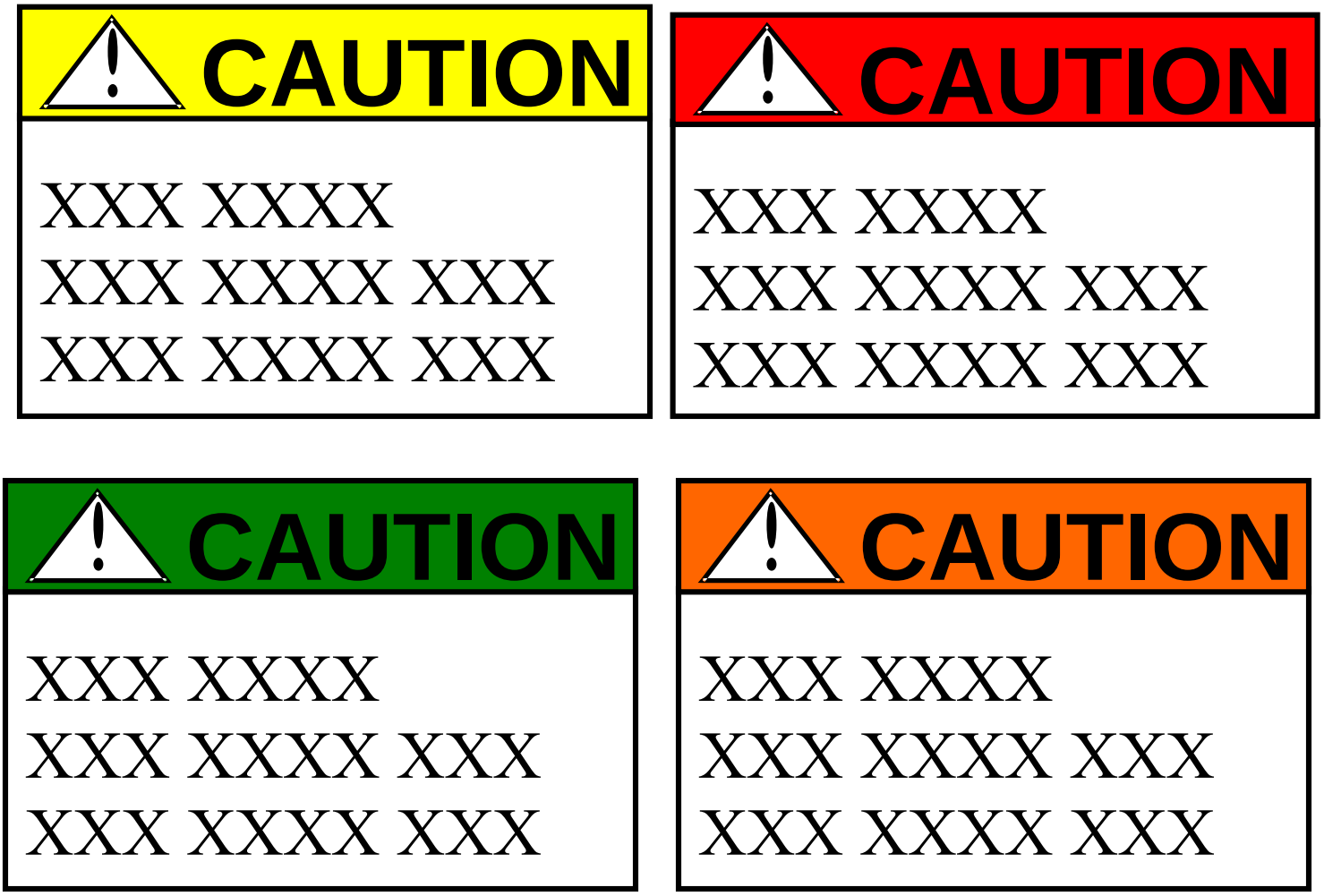


Figure 44: Caution Multiple Colors

1. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

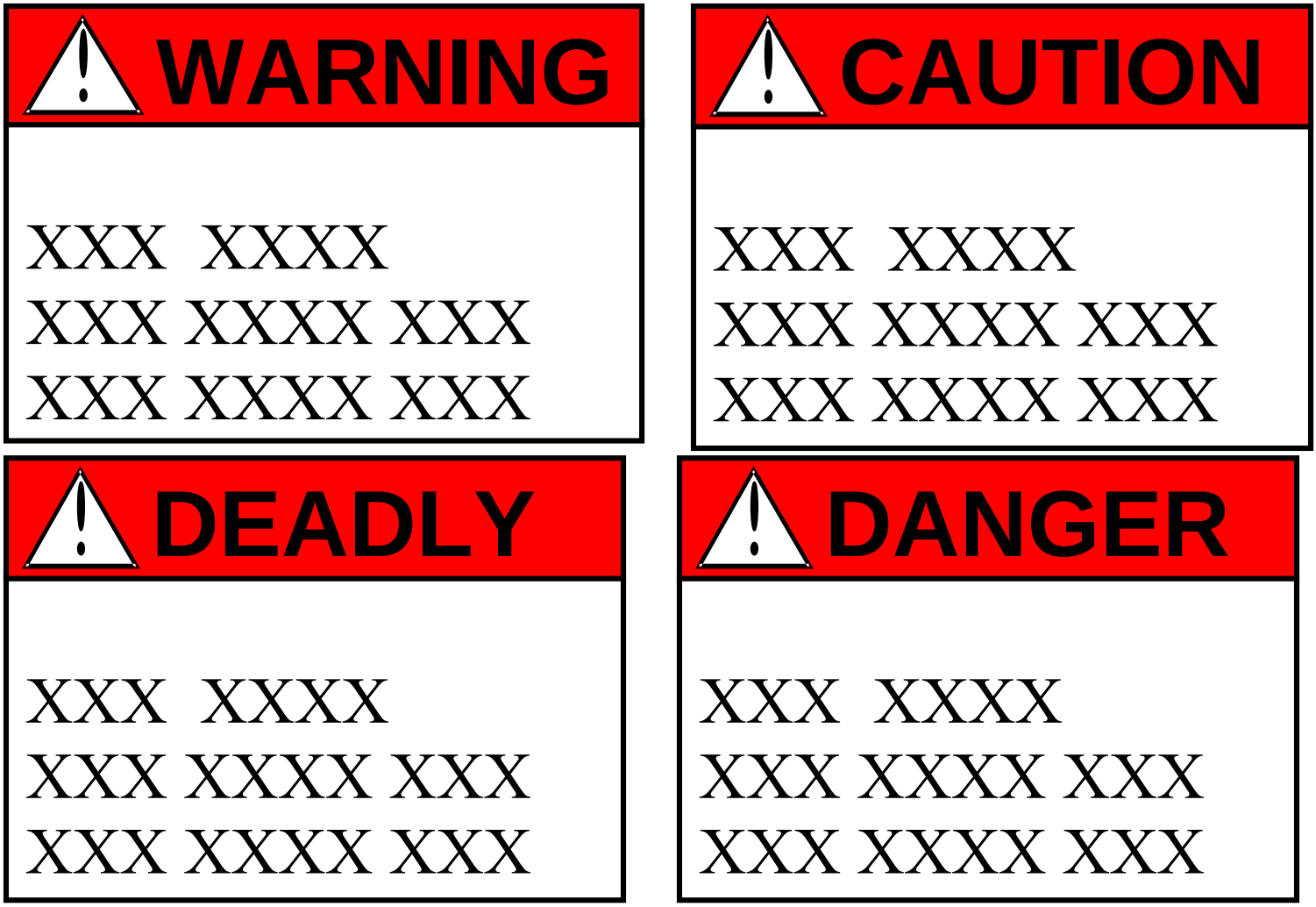


Figure 45: Red Signs

1. What is the level of hazard conveyed by this symbol?

No Hazard		Low		Moderate		High		Extreme Hazard
0	1	2	3	4	5	6	7	8

2. How ATTENTION-GETTING is the symbol?

Not at all attention-getting		Slightly attention-getting		Attention-getting		Very attention-getting		Extremely attention-getting
0	1	2	3	4	5	6	7	8

Appendix T: Informed Consent for Thesis Research

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY GRADO DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING ASSESSMENT AND COGNITIVE ERGONOMICS LABORATORY

Informed Consent for Participants of Investigative Projects

Title of Project: Cultural Differences in Risk Perception

Principal Investigators: LaTanya F. Martin, Graduate Student
Dr. Tonya L. Smith-Jackson, Assistant Professor, ISE

Faculty Advisor: Dr. Tonya L. Smith-Jackson, Assistant Professor, ISE

I. THE PURPOSE OF THIS RESEARCH

The purpose of this research is to determine if there are any distinct cultural differences in the way people perceive risk in industrial/hazardous environments.

II. PROCEDURES

First, you will be given a short questionnaire used to obtain general information about yourself. The questionnaire will consist of 10 to 12 questions.

This experiment consists of one study in which you will be given a questionnaire to complete.

The questionnaire consists of three different parts in which you will answer questions.

Part one of the questionnaire will entail you reading twenty hazards statements and rating the level of risk you feel is associated with each statement using a nine-point likert-type scale.

Part two of the questionnaire will entail you viewing six different symbols. For each symbol that you view, you will be asked to answer five questions based on that symbol using a nine-point likert-type scale.

Part three of the questionnaire will consist of you observing a number of hazard signs. You will be shown one sign at a time and will be asked to answer two questions based on that sign. Once all of the signs have been shown to you, you will be show a set of four signs in which you are to rank the sings from least perceived hazardous to most perceived hazardous.

If you have any questions related to any of the procedures or purpose of this experiment after reading this document, please feel free to ask them. If you wish to be a participant in this experiment after reading this form, sign your name at the appropriate place at the end.

III. RISKS

There are no factors related to this research experiment that should pose more than minimal risk to you.

IV. BENEFITS OF THIS RESEARCH

Your participation in this research will be used to better understand the different cultural differences that influence the perceptions of risk. Additionally, your participation will contribute to the effort to standardize safety communications such as symbols, signal words, sign text, training protocols, and manuals.

V. EXTENT OF COFIDENTIALITY/ANONYMITY

The results of this study will be kept strictly confidential. At no time will the researchers release the results of the study to anyone other than the individuals working on the project without your consent. The information you provide will have your name removed and only a number will identify you during analyses and any written reports of the research.

VI. COMPENSATION

For participation in this study, you will be compensated $7.50 an hour for hour of participation.

VII. FREEDOM TO WITHWRAW

You are free to withdraw from this study at anytime without penalty. If you choose to withdraw, you will be paid for the time that you participated in the study.

VIII. APPROVAL OF THIS RESEARCH

This research has been approved, as required by the Institutional Review Board for projects involving human participants at Virginia Polytechnic Institute and State University, and by the Grado Department of Industrial and Systems Engineering.

IX. PARTICIPANT'S RESPONSIBILITIES

I voluntarily agree to participate in this study and know of no reason in which I would not be able to participate. I have the following responsibilities:

- Answer each question as openly and as honestly as possible.
- Listen and pay attention carefully
- Express my own opinions and beliefs

_____

Signature of Participant

X. Participant's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I herby consent to participate, with the understanding that I may discontinue participation at any time, being compensated only for the portion of time that I spend in the study.

Signature: _____

Printed Name: _____

Date: _____

Should you have any questions or concerns about this research or its conduct, you may contact:

LaTanya F. Martin:
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Dr. David Moore:
Chair, IRB

Office of Research Compliance
Research & Graduate Studies
(540) 231-4991
moored@vt.edu

Appendix U: Symbol Graphs

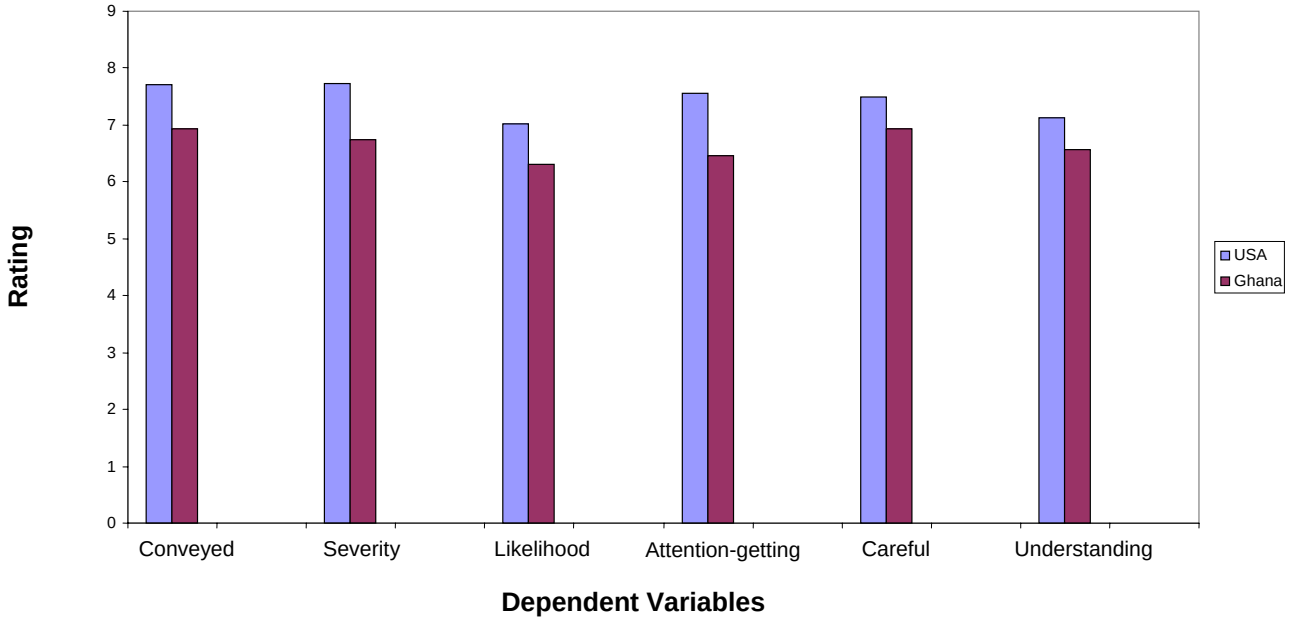

Figure 46: Skull Means

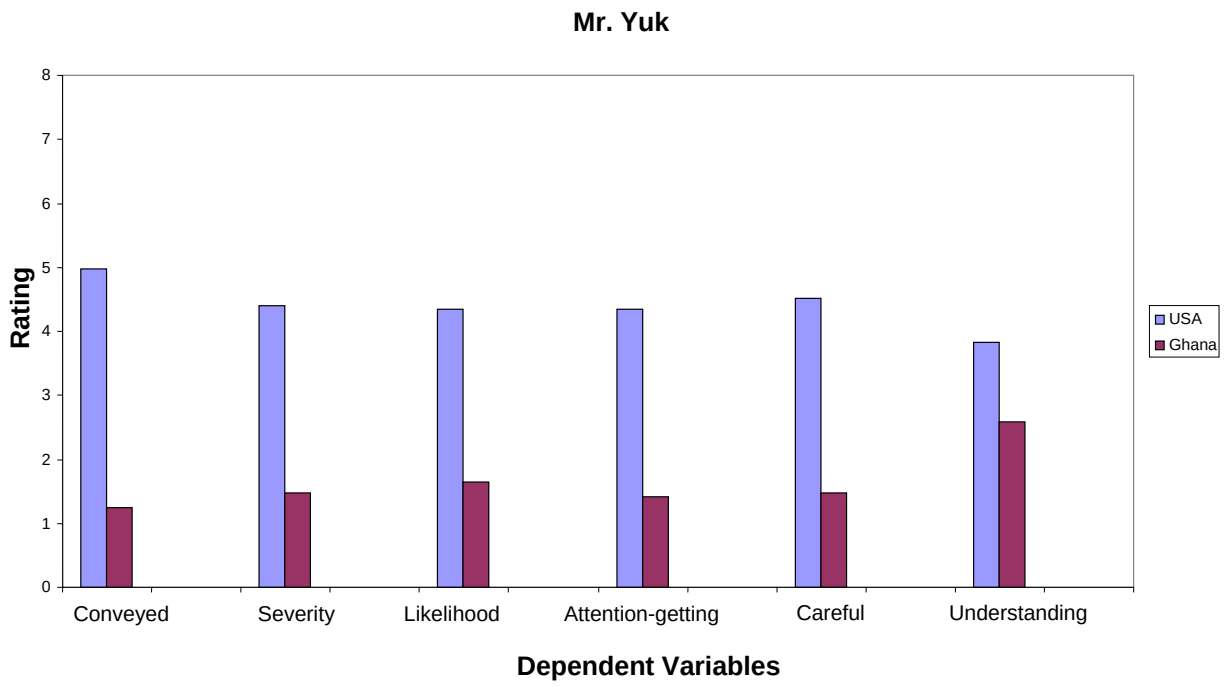

Figure 47: Mr. Yuk

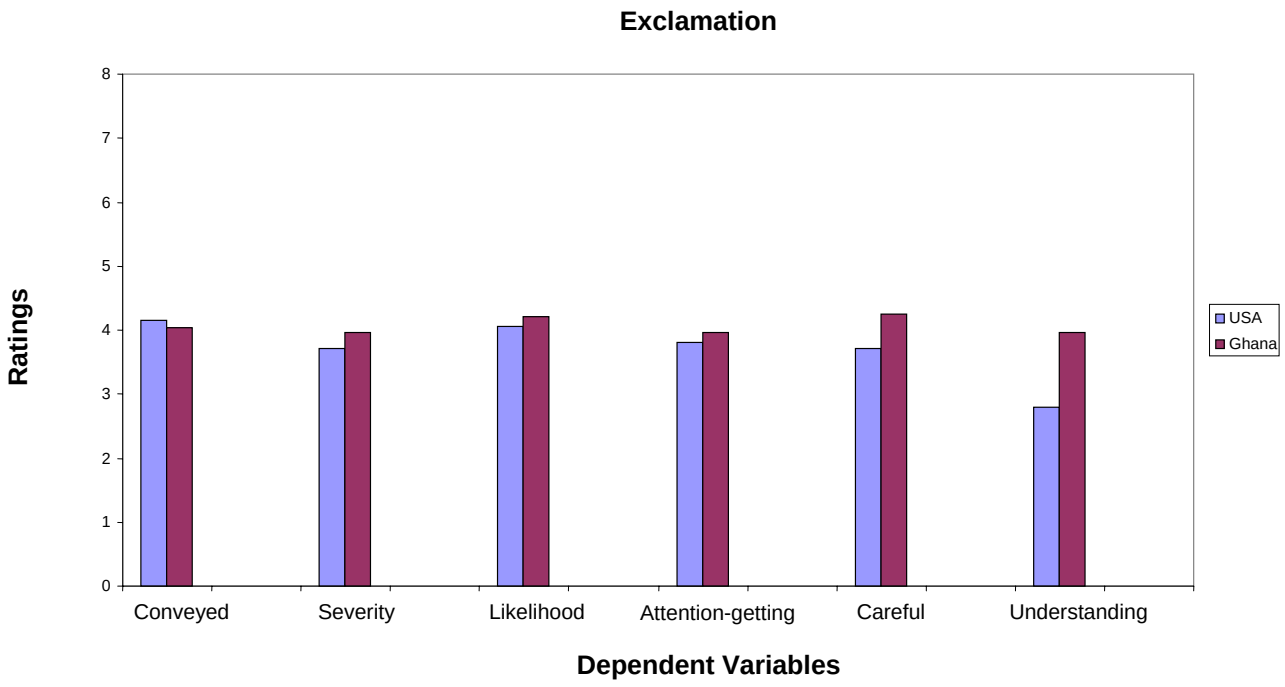

Figure 48: Exclamation

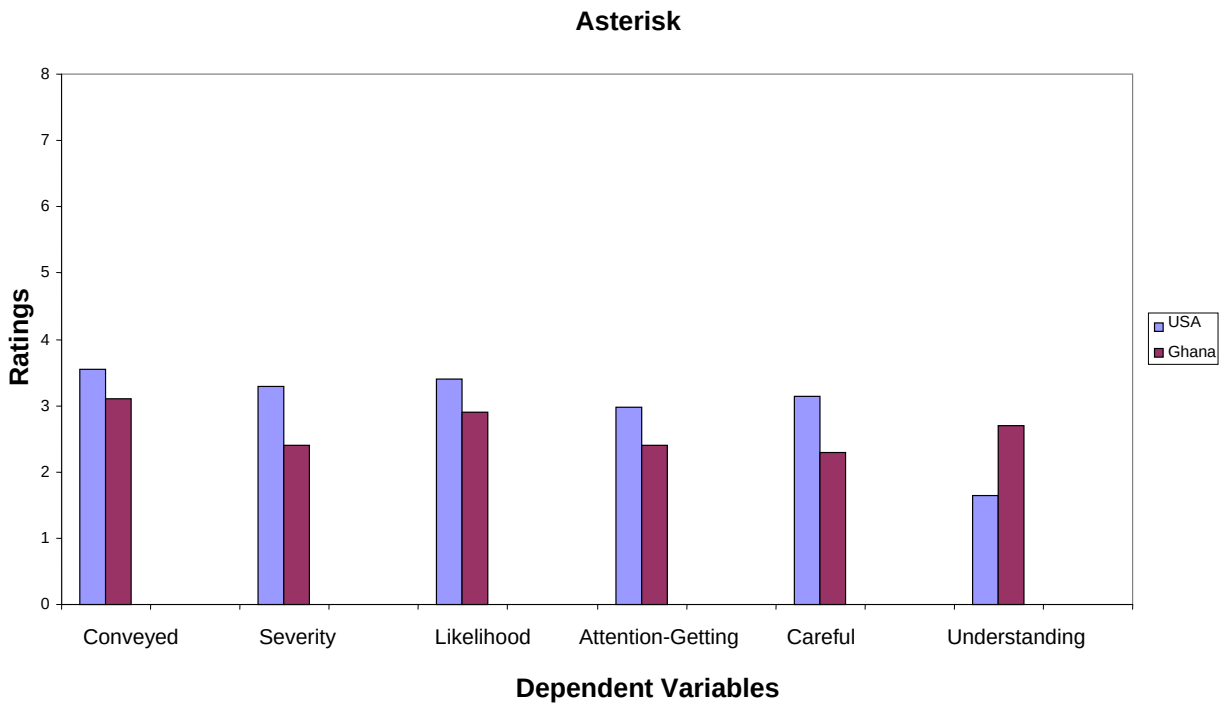

Figure 49: Asterisk

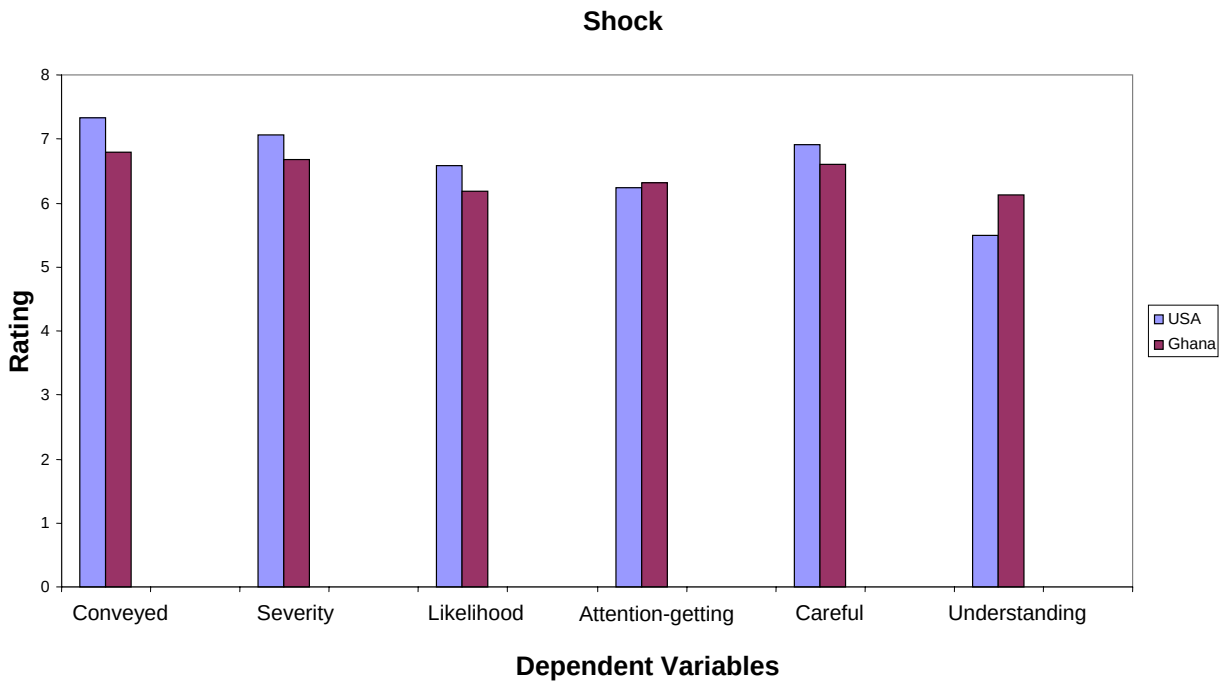

Figure 50: Shock

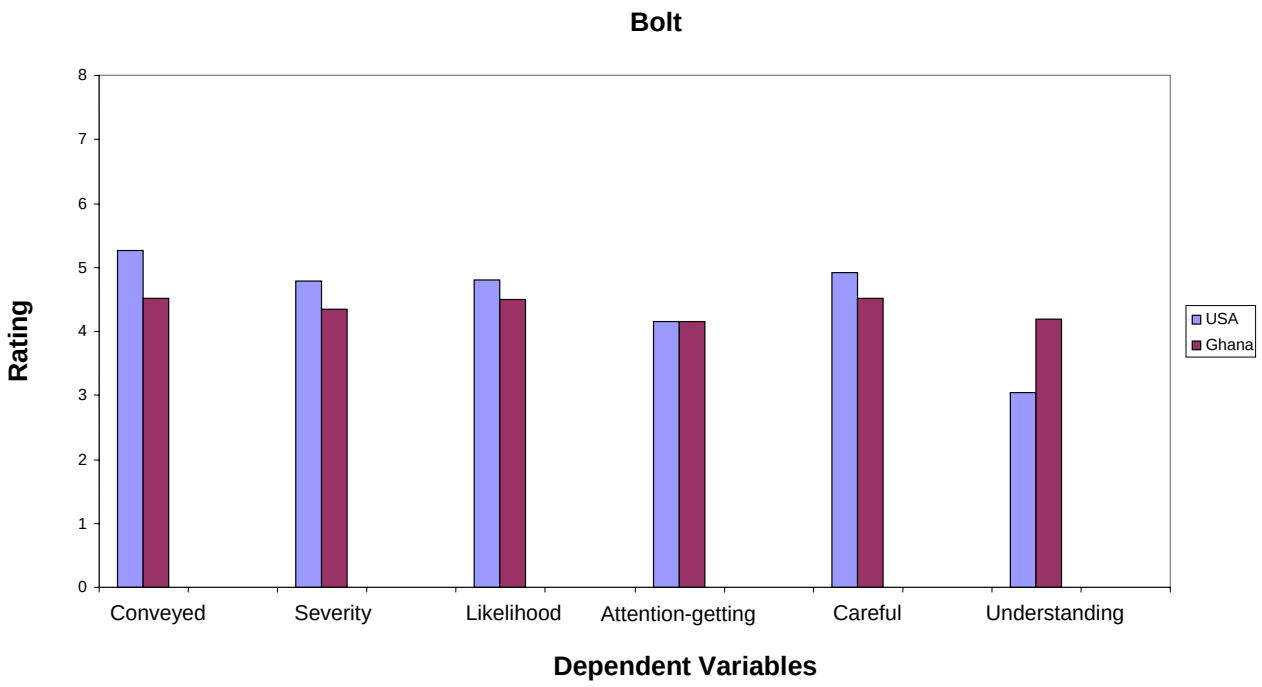

Figure 51: Bolt

Appendix V: Symbol Familiarity Charts

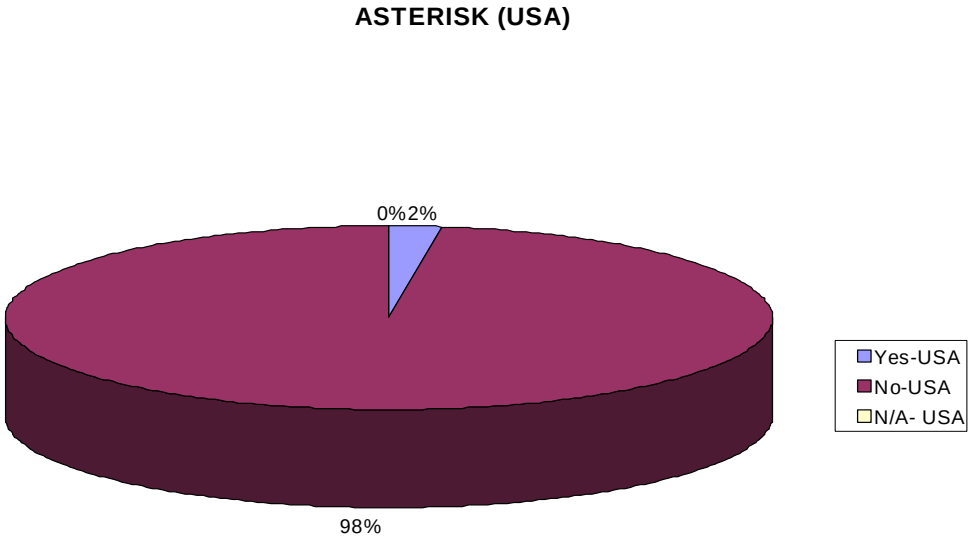

Figure 52: USA Asterisk Familiarity

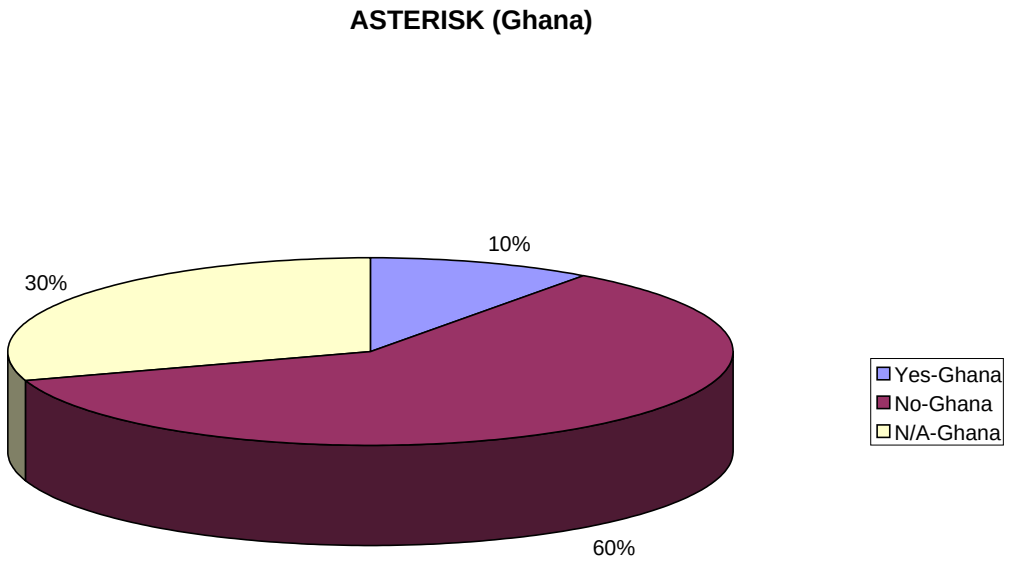

Figure 53: Ghana Asterisk Familiarity

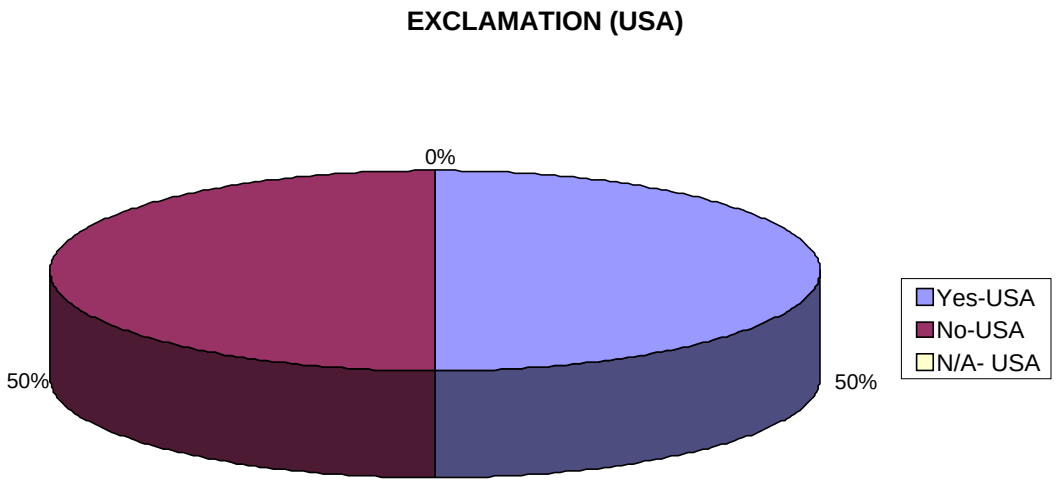

Figure 54: USA Exclamation Familiarity

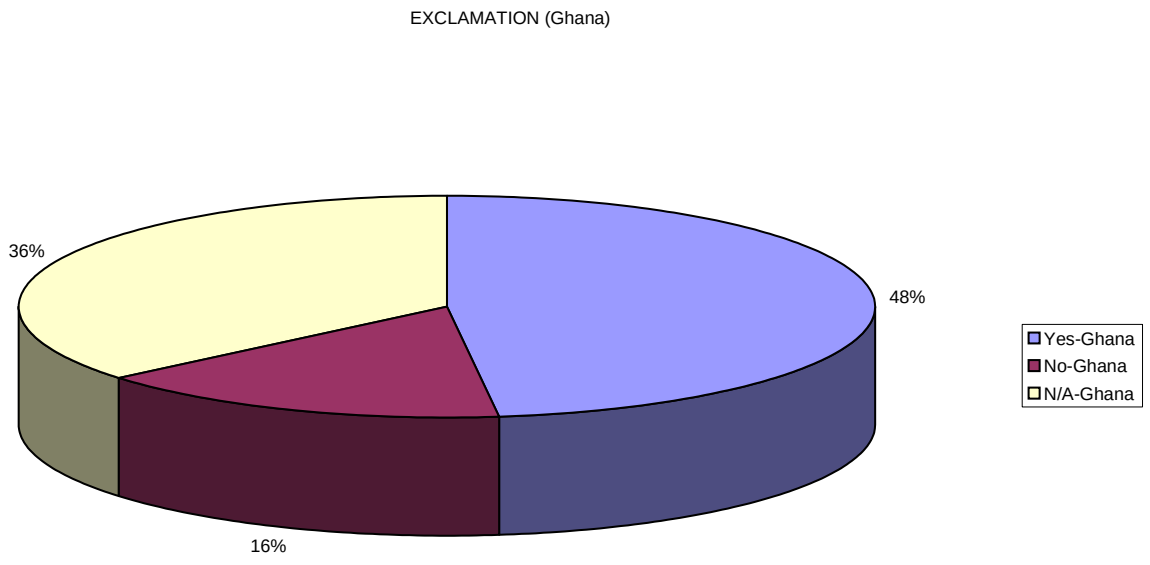

Figure 55: Ghana Exclamation Familiarity

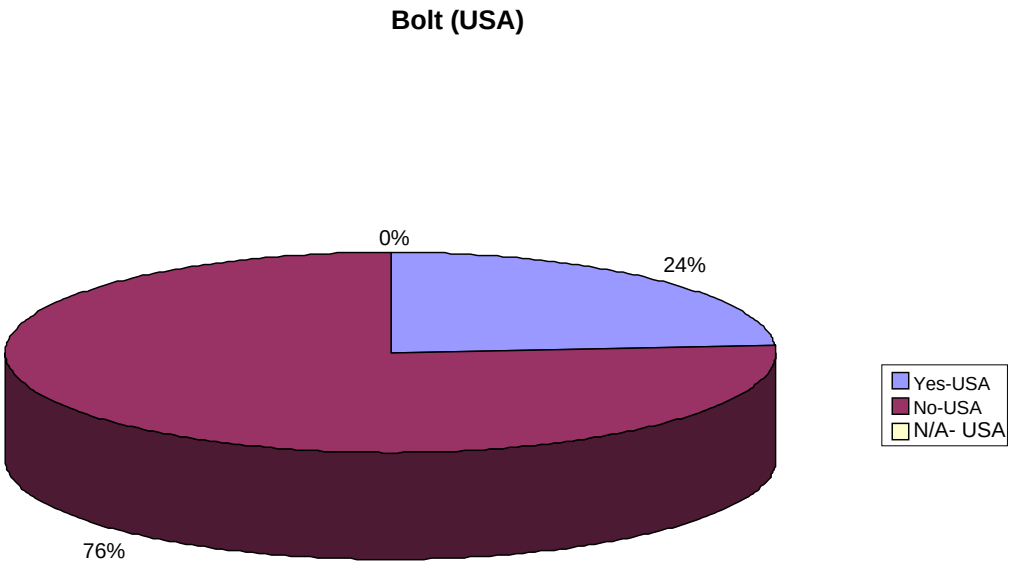

Figure 56: USA Bolt Familiarity

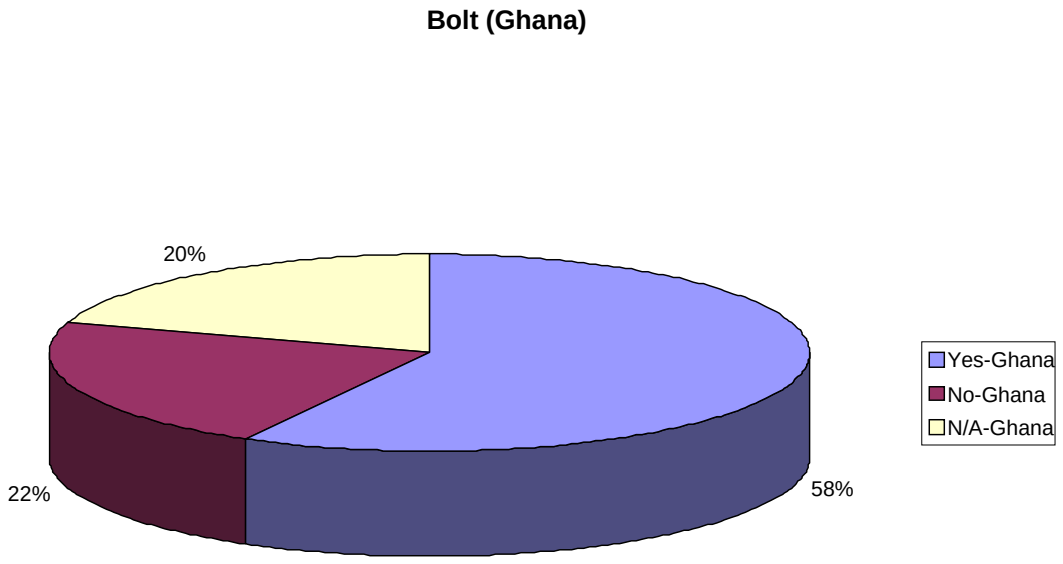

Figure 57: Ghana Bolt Familiarity

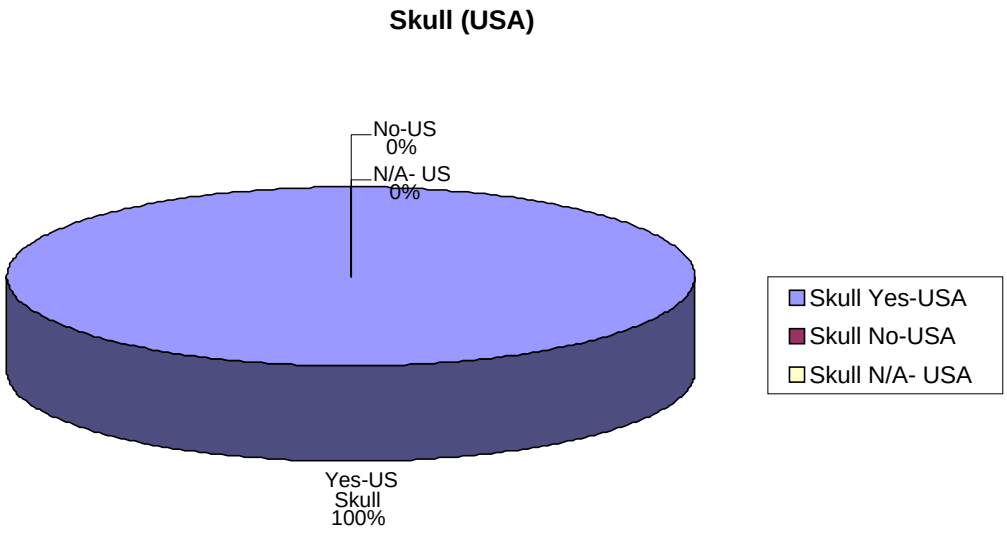

Figure 58: USA Skull Familiarity

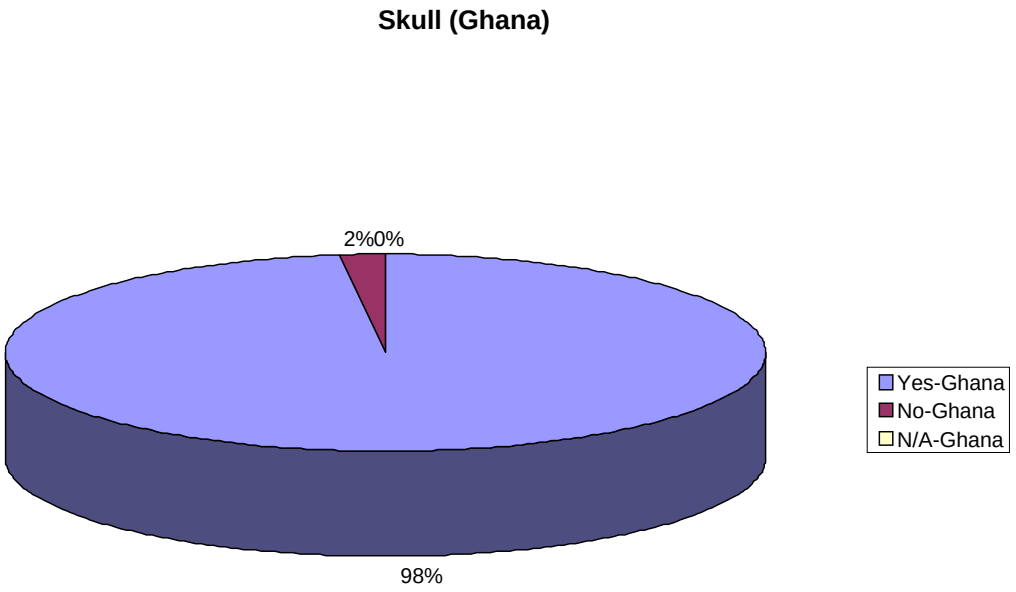

Figure 59: Ghana Skull Familiarity

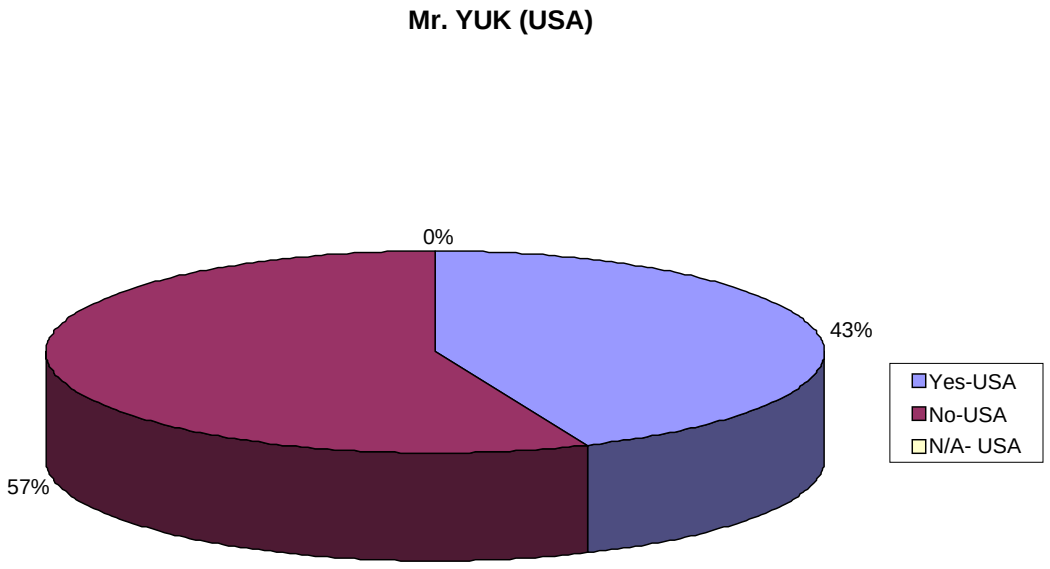

Figure 60: USA Mr. Yuk Familiarity

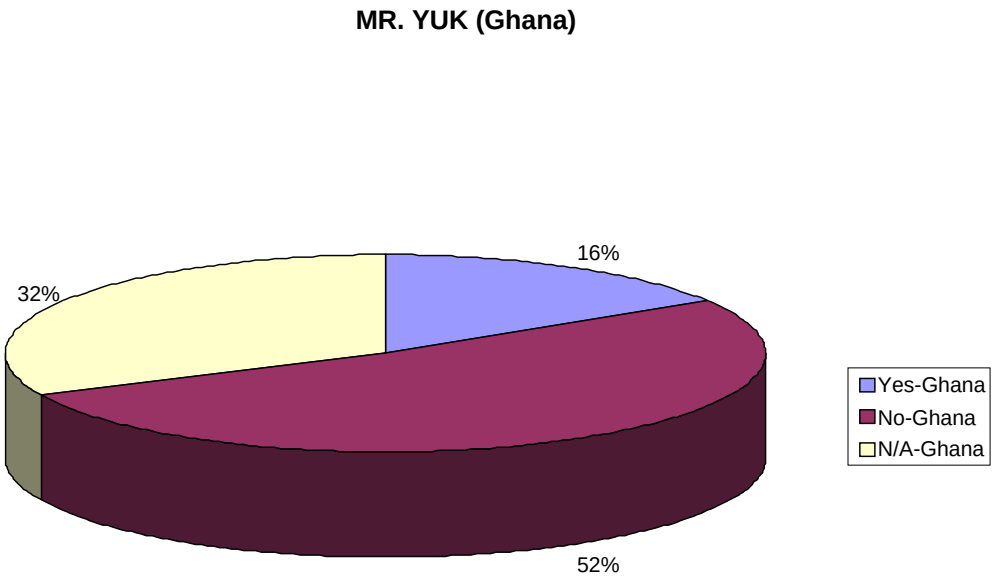

Figure 61: Ghana Mr. Yuk Familiarity

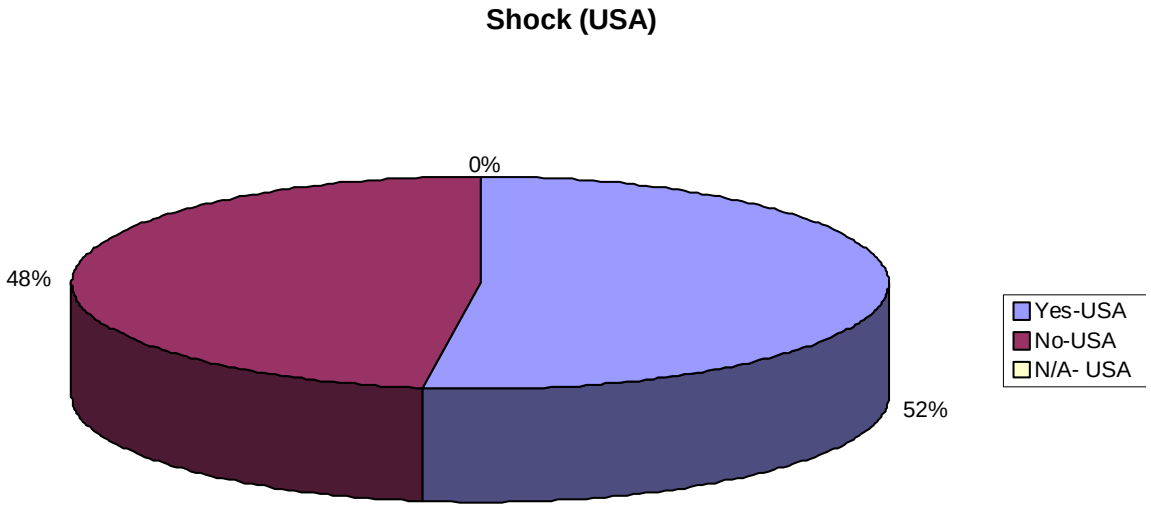

Figure 62: USA Shock Familiarity

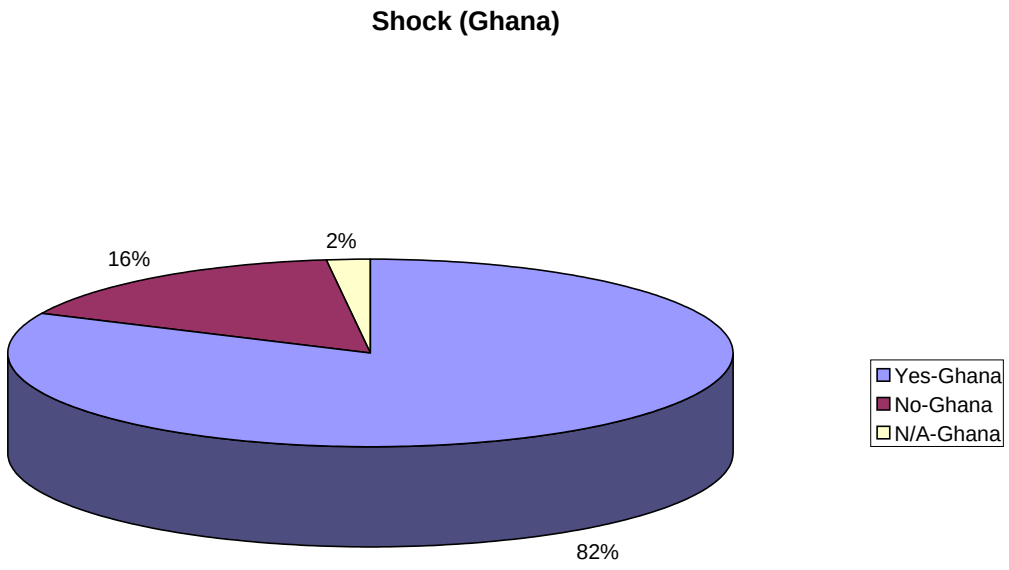

Figure 63: Ghana Shock Familiarity

Appendix W: Hazard Sign Graphs

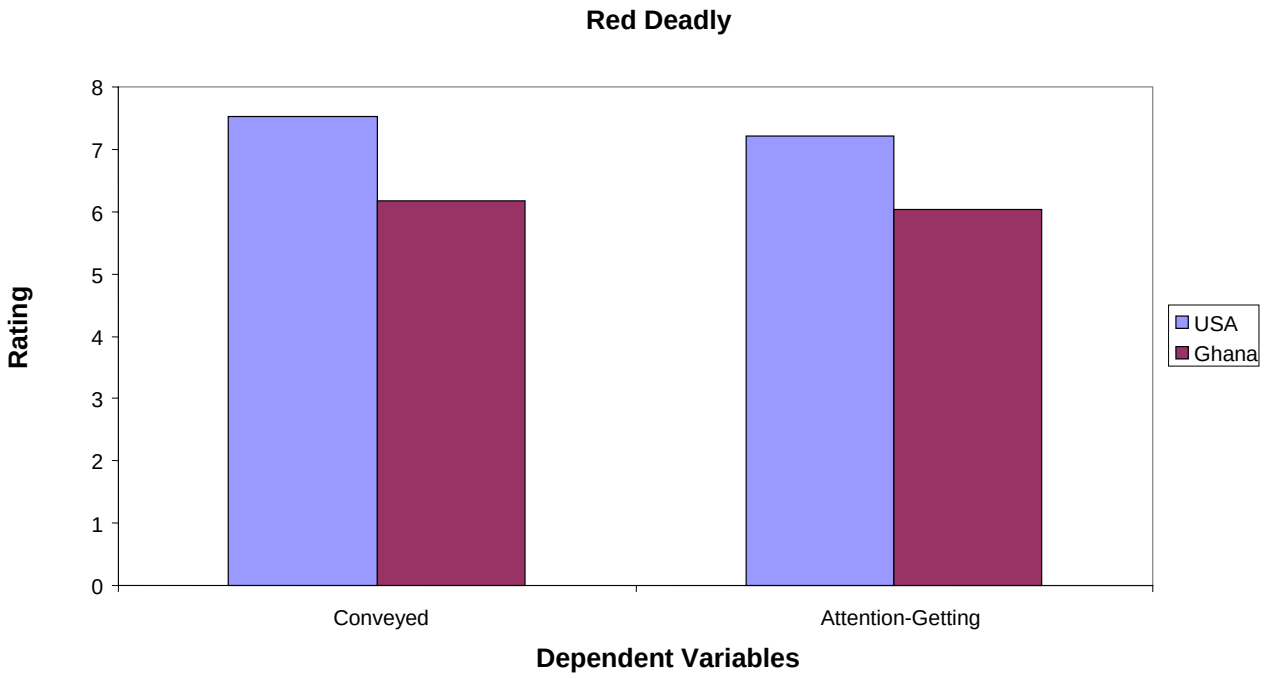

Figure 64: Red Deadly

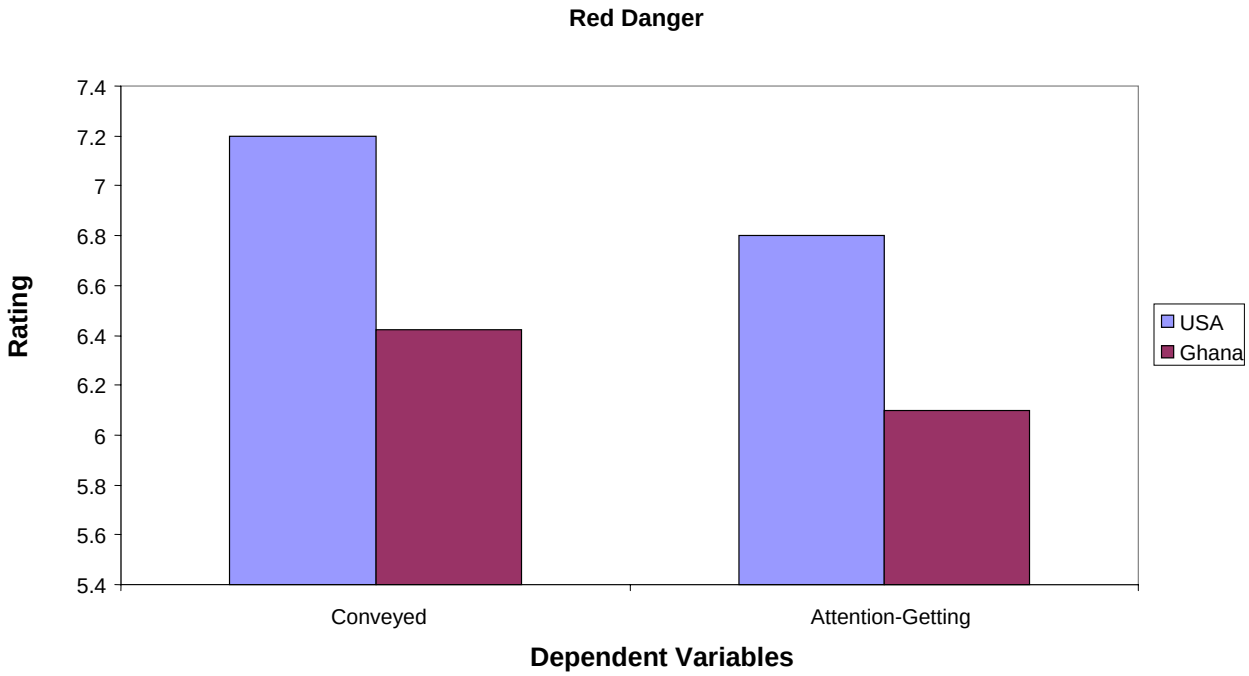

Figure 65: Red Danger

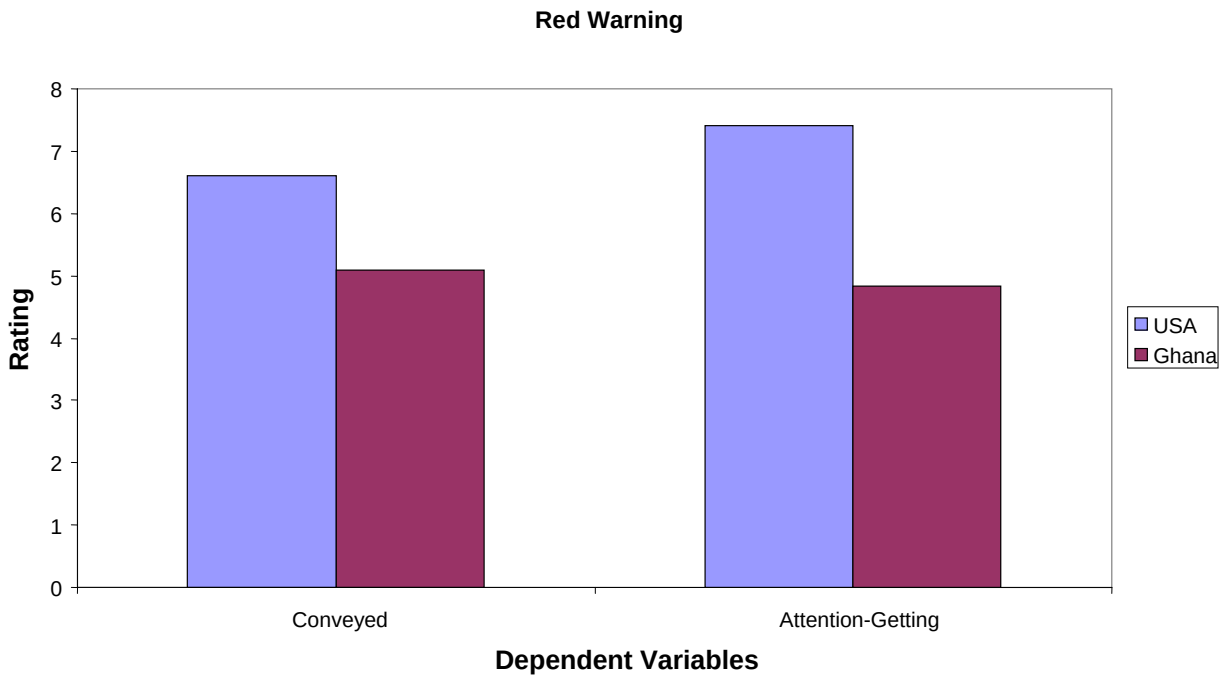

Figure 66: Red Warning

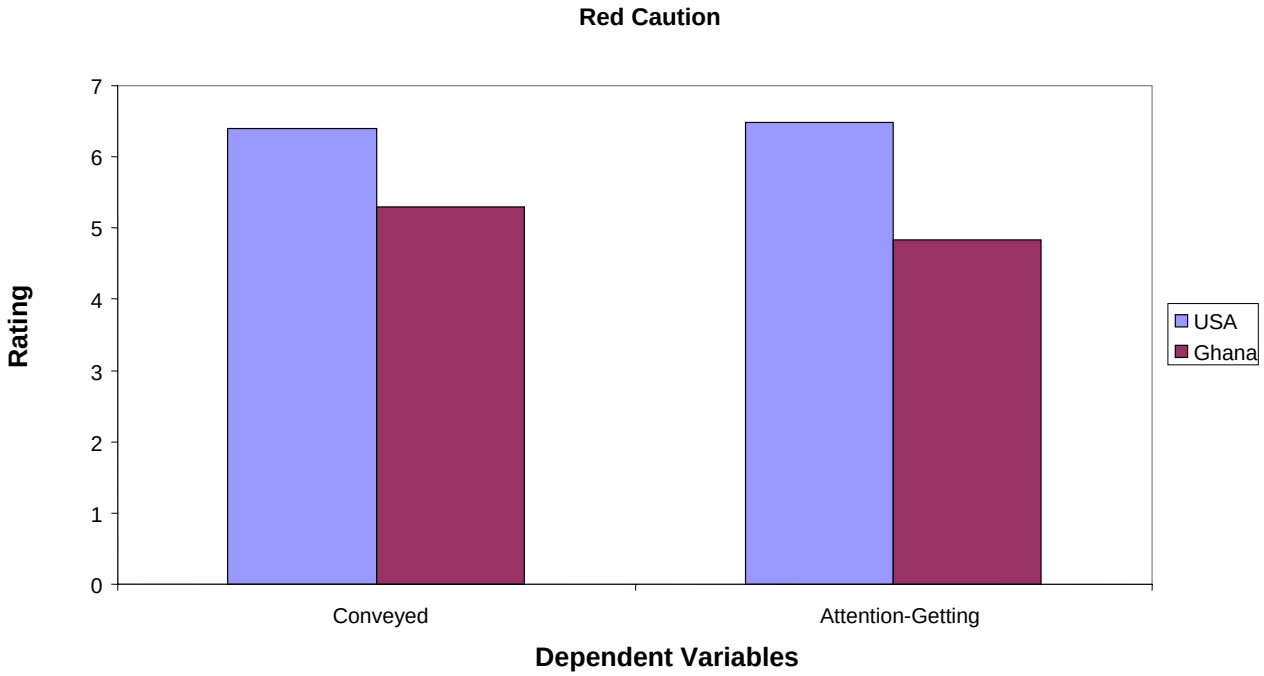

Figure 67: Red Caution

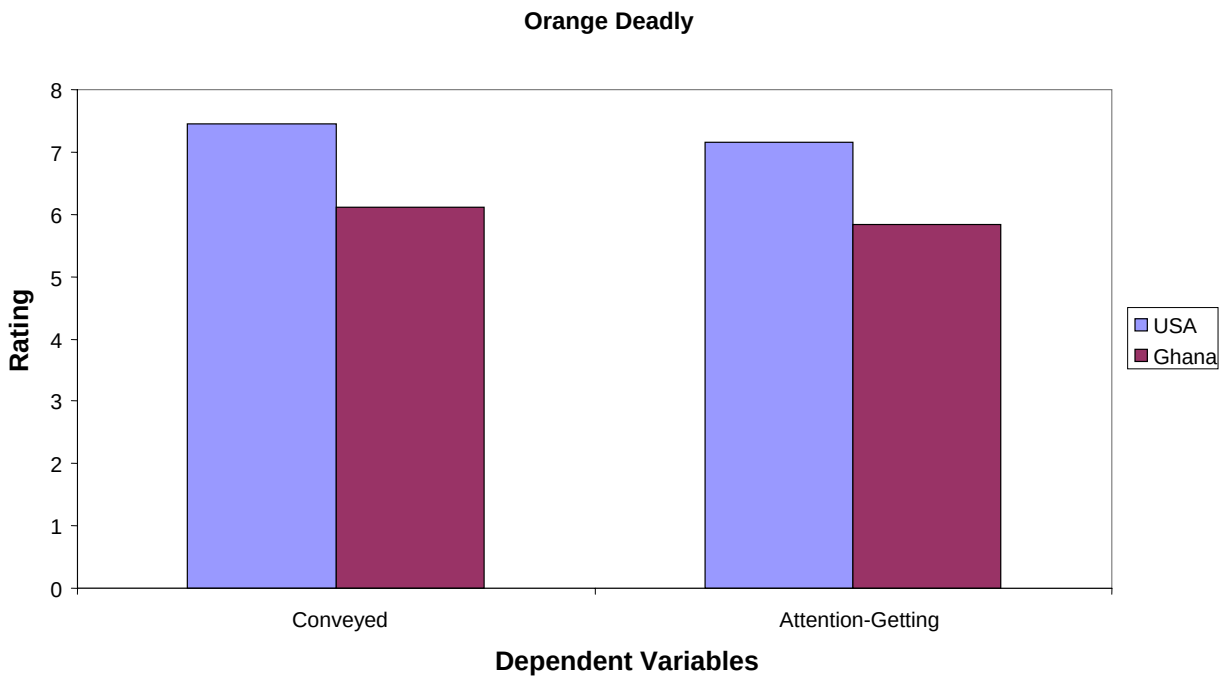

Figure 68: Orange Deadly

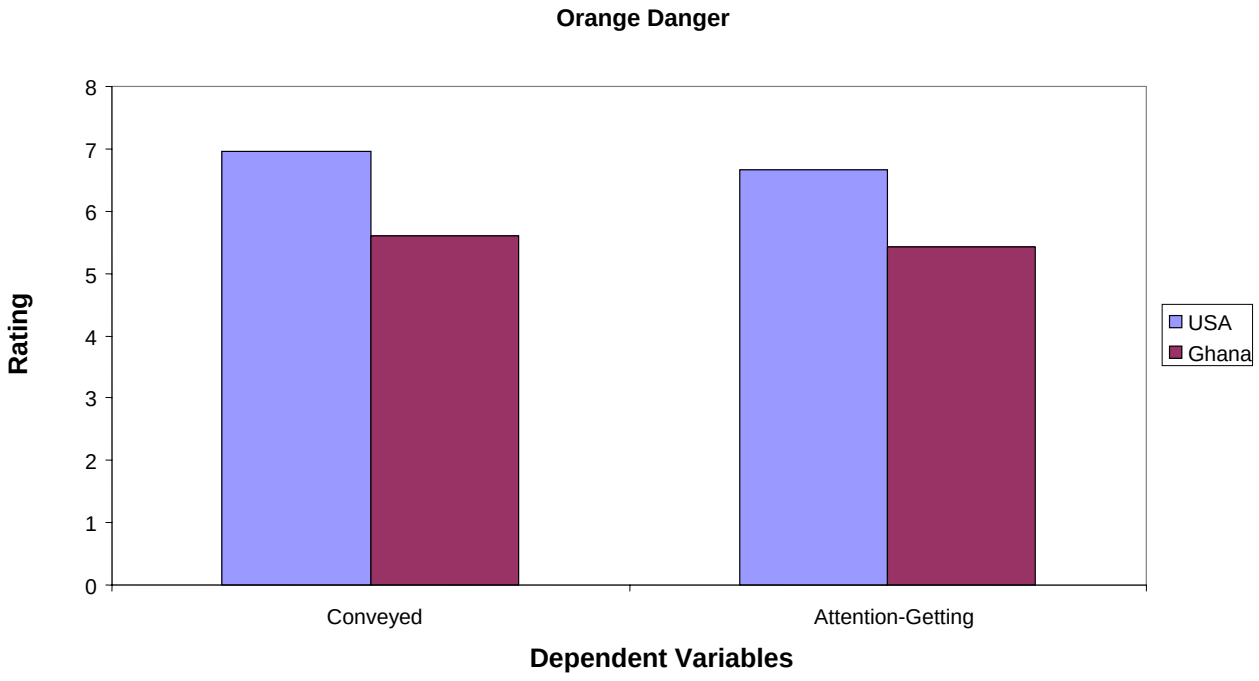

Figure 69: Orange Danger

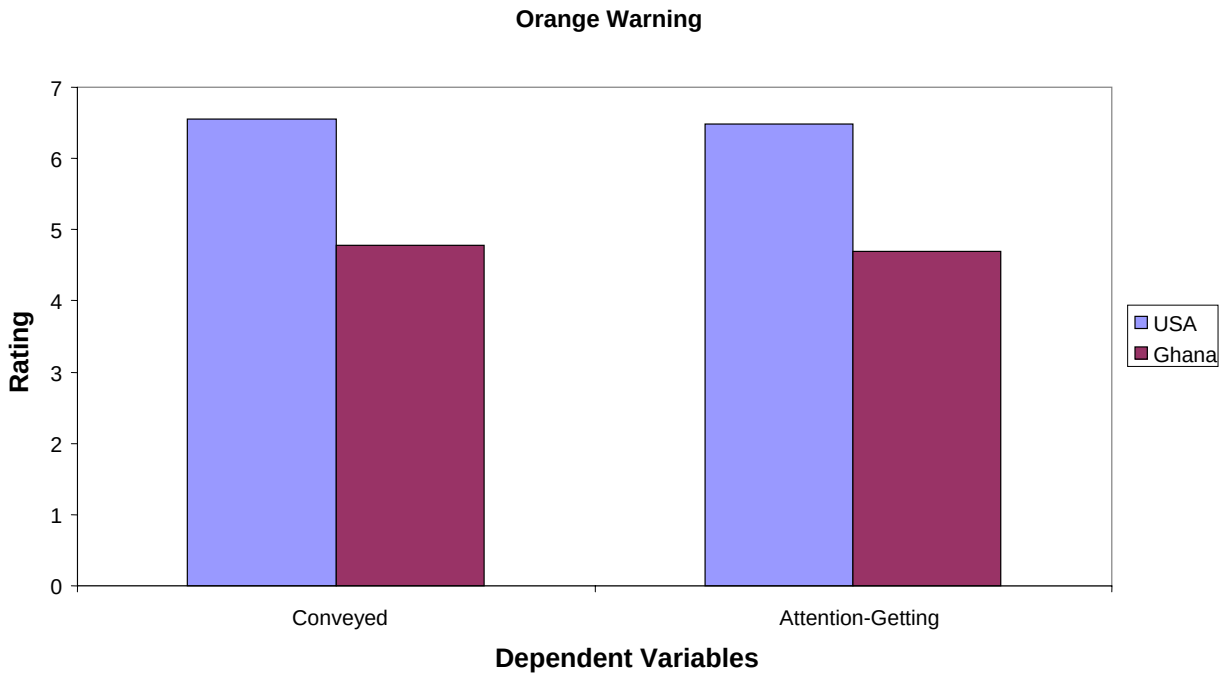

Figure 70: Orange Warning

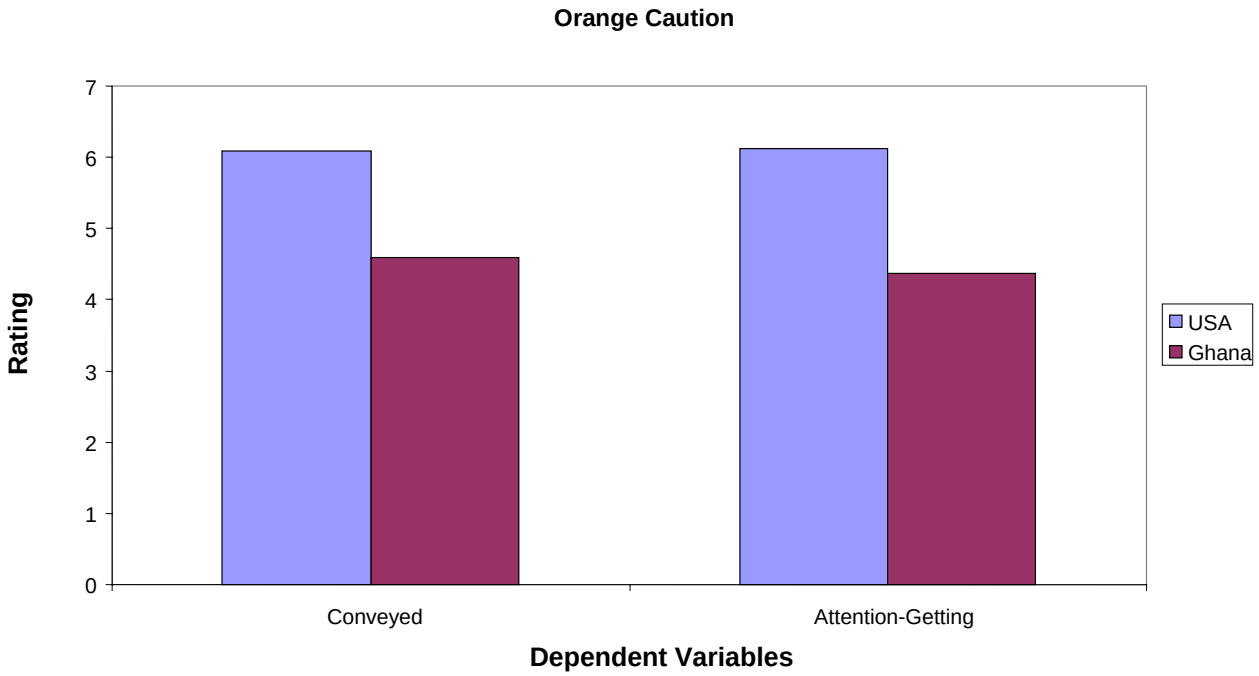

Figure 71: Orange Caution

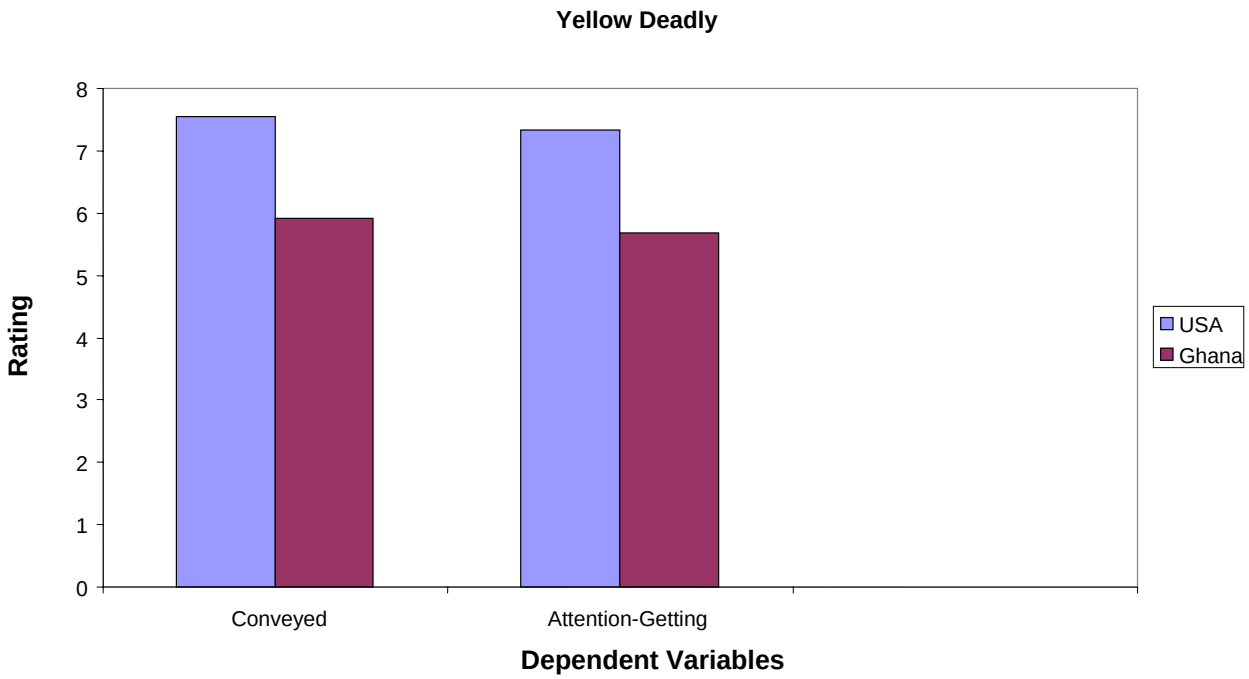

Figure 72: Yellow Deadly Means

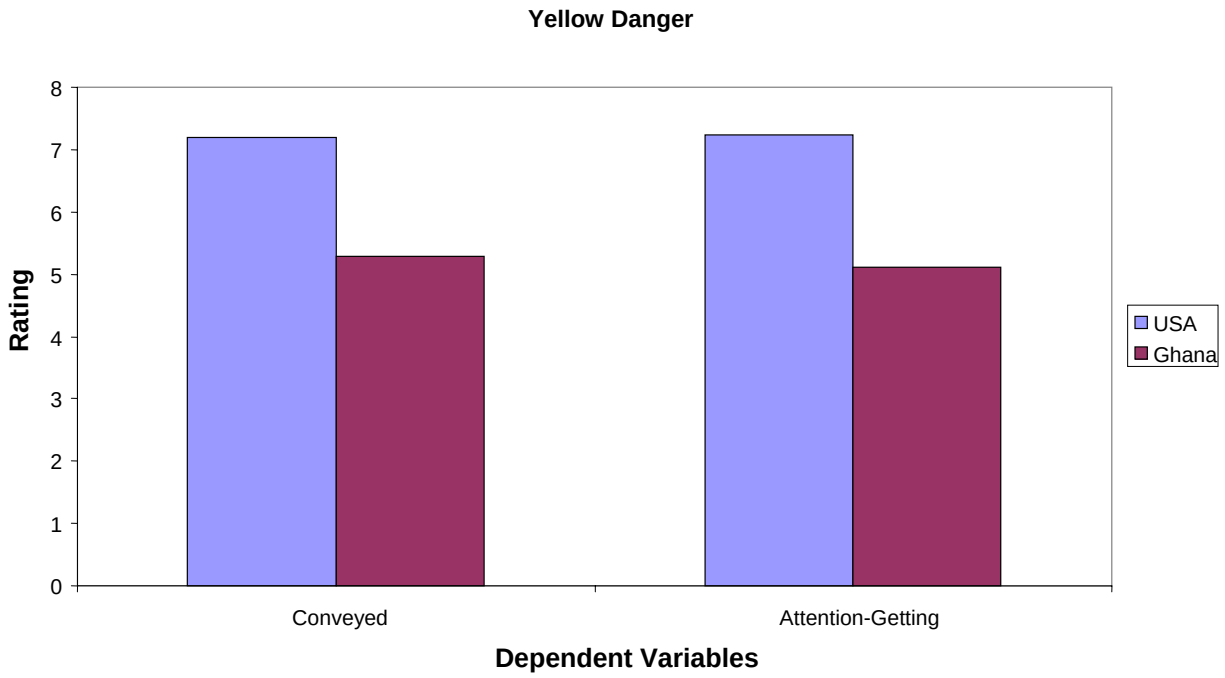

Figure 73: Yellow Danger Means

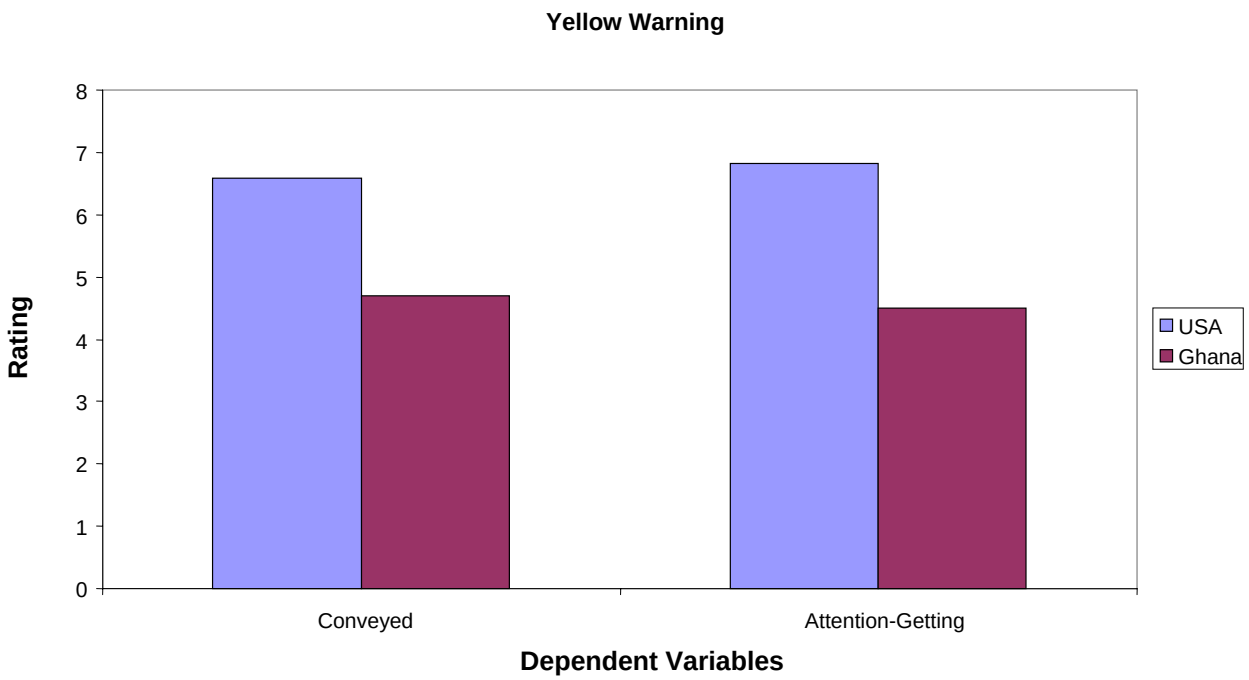

Figure 74: Yellow Warning Means

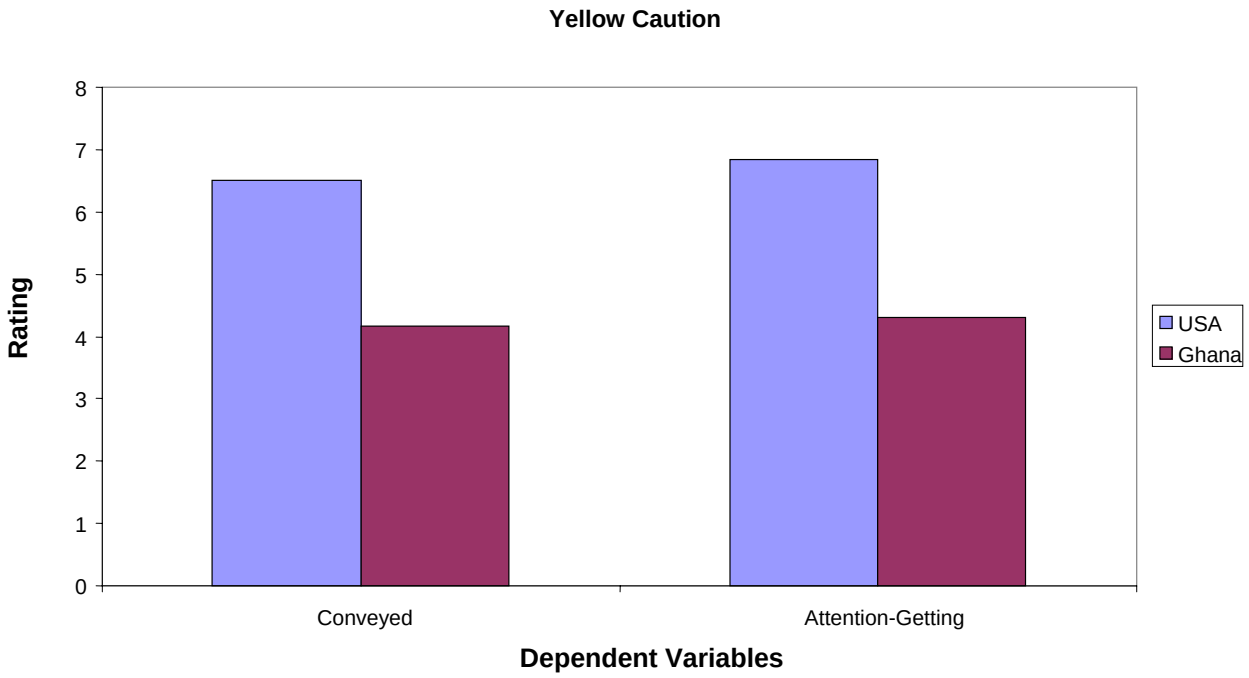

Figure 75: Yellow Caution Means

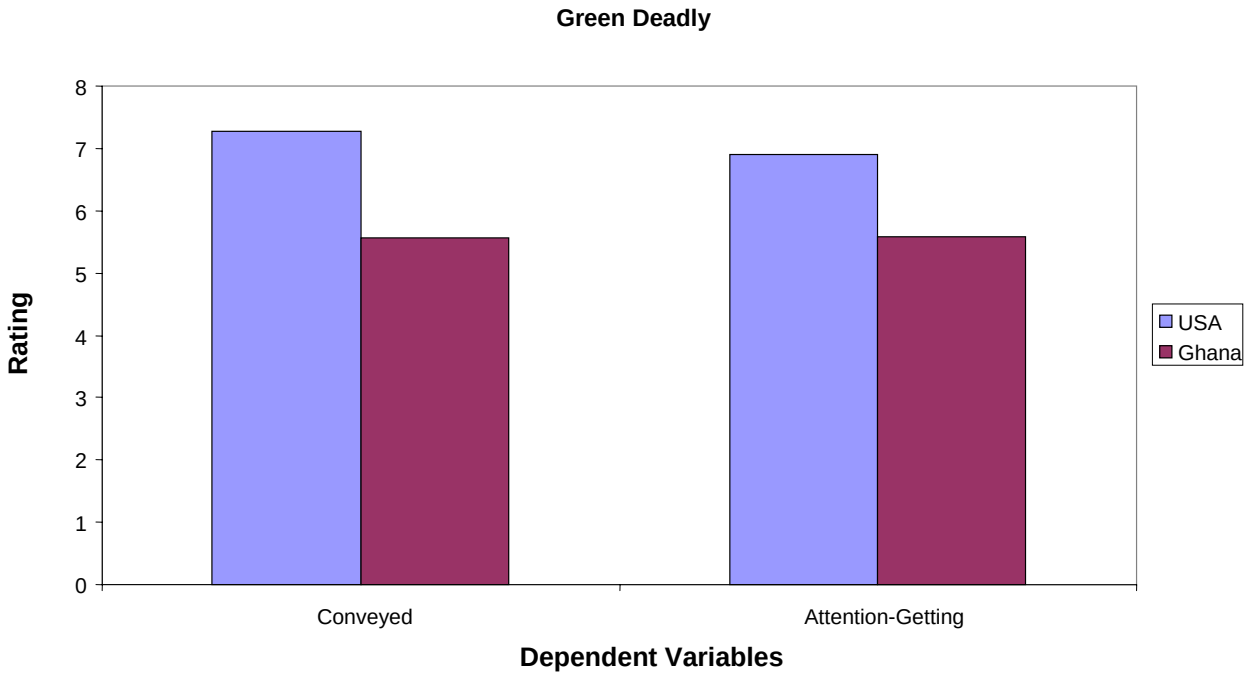

Figure 76: Green Deadly

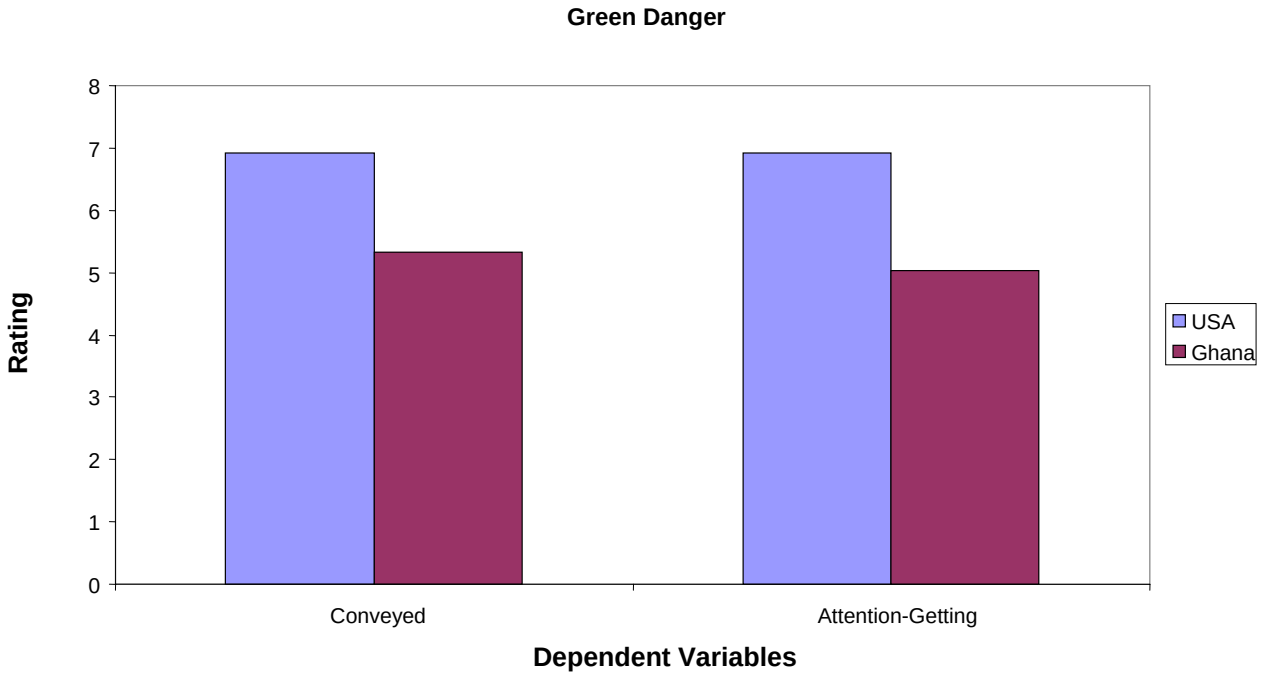

Figure 77: Green Danger Means

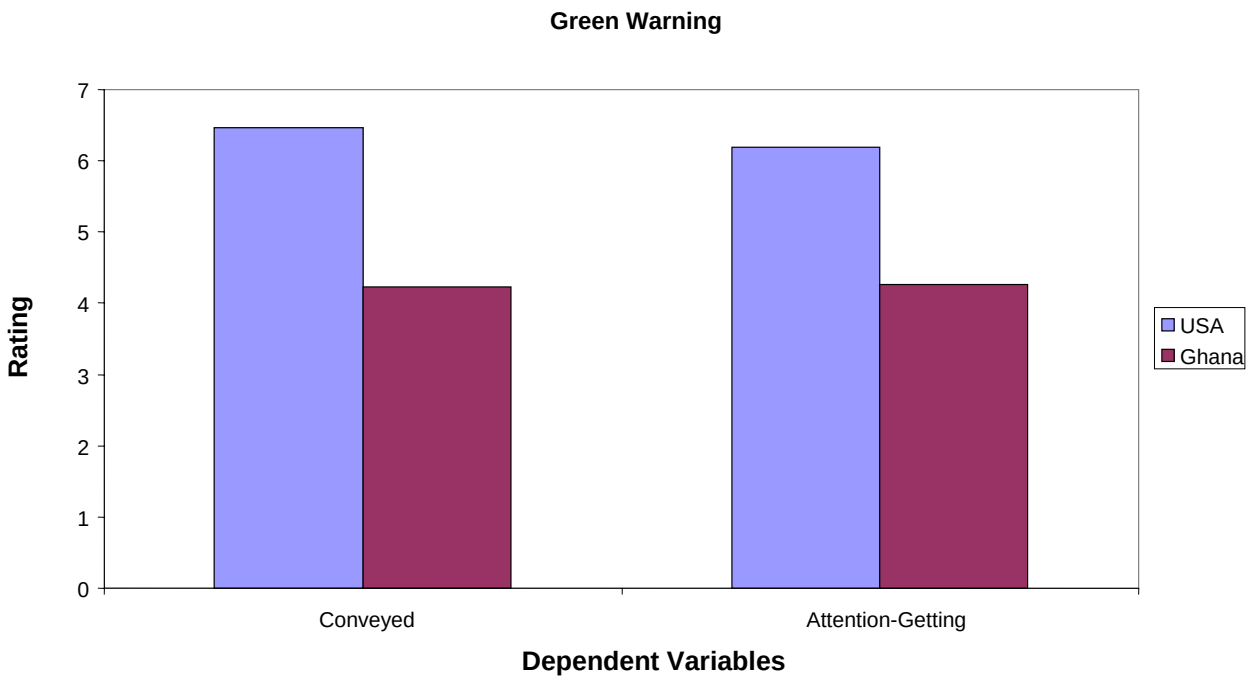

Figure 78: Green Warning Means

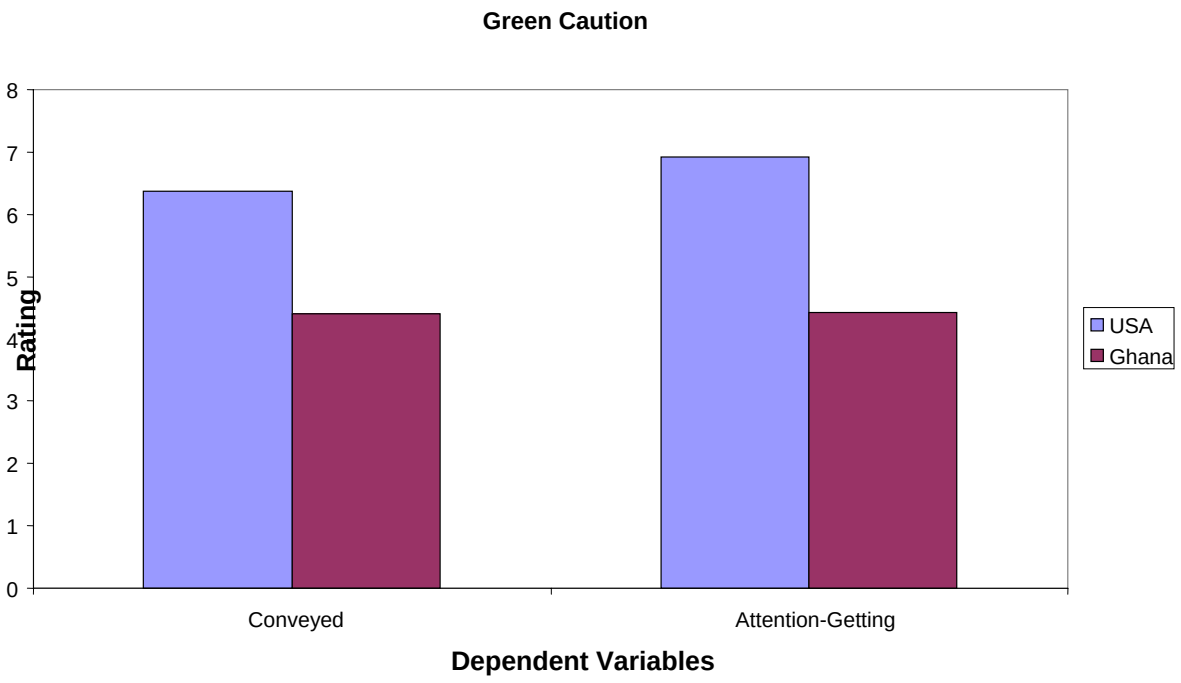

Figure 79: Green Caution Means

Appendix X: Individual Chi Square Results

Color/Signal Word Combination	χ^2	P-Value	*Explanation*
DANGER DANGER	χ (1, N = 96) = 35.23	< .001	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
CAUTION CAUTION	χ (1, N = 96) = 28.05	< .001	Proportionally more Ghanaians picked "Orange CAUTION" as compares to the proportion of USA participants who picked "Orange CAUTION"
DEADLY WARNING	χ (1, N = 96) = 5.95	< .05	Proportionally more Ghanaians picked "Red DEADLY" as compared to the proportion of USA participants who picked "Red DEADLY"
DANGER DANGER	χ (1, N = 96) = 8.77	< .01	Proportionally more Ghanaians picked "Orange Danger" as compares to the proportion of USA participants who picked "Orange DANGER"
CAUTION DEADLY	χ (1, N = 96) = 6.00	< .05	Proportionally more Ghanaians picked "Orange CAUTION" as compared to the proportion of USA participants who picked "Orange CAUTION"
DANGER CAUTION	χ (1, N = 96) = 8.11	< .01	Proportionally more Ghanaians picked "Yellow DANGER" as compares to the proportion of USA participants who picked "Yellow DANGER"
CAUTION DANGER	χ (1, N = 96) = 10.10	< .01	Proportionally more Ghanaians picked "Orange CAUTION" as compared to the proportion of USA participants who picked "Orange CAUTION"

CAUTION DEADLY	χ (1, N = 95) = 40.65	< .001	Proportionally more Ghanaians picked "Orange DEADLY" as compares to the proportion of USA participants who picked "Orange DEADLY"
WARNING DEADLY	χ (1, N = 96) = 26.01	< .001	Proportionally more Ghanaians picked "Green DEADLY" as compared to the proportion of USA participants who picked "Green DEADLY"
WARNING CAUTION	χ (1, N = 96) = 5.03	< .05	Proportionally more Ghanaians picked "Yellow WARNING" as compares to the proportion of USA participants who picked "Yellow WARNING"
DANGER WARNING	χ (1, N = 96) = 13.36	< .001	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
DEADLY CAUTION	χ (1, N = 96) = 20.04	< .001	Proportionally more Ghanaians picked "Yellow DEADLY" as compares to the proportion of USA participants who picked "Yellow DEADLY"
DANGER WARNING	χ (1, N = 96) = 17.82	< .001	Proportionally more Ghanaians picked "Yellow WARNING" as compared to the proportion of USA participants who picked "Yellow WARNING"
CAUTION WARNING	χ (1, N = 96) = 15.87	< .001	Proportionally more Ghanaians picked "Orange CAUTION" as compares to the proportion of USA participants who picked "Orange CAUTION"
CAUTION DANGER	χ (1, N = 96) = 4.09	< .05	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
CAUTION DANGER	χ (1, N = 96) = 37.33	< .001	Proportionally more Ghanaians picked "Orange DANGER" as compares to the proportion of USA participants who picked "Orange DANGER"

DEADLY CAUTION	χ (1, N = 96) = 8.31	< .01	Proportionally more Ghanaians picked "Yellow DEADLY" as compared to the proportion of USA participants who picked "Yellow DEADLY"
DANGER WARNING	χ (1, N = 96) = 8.02	< .01	Proportionally more Ghanaians picked "Orange DANGER" as compares to the proportion of USA participants who picked "Orange DANGER"
WARNING CAUTION	χ (1, N = 95) = 36.42	< .001	Proportionally more Ghanaians picked "Red WARNING" as compared to the proportion of USA participants who picked "Red WARNING"
DANGER CAUTION	χ (1, N = 96) = 5.44	<. 05	Proportionally more Ghanaians picked "Yellow DANGER" as compares to the proportion of USA participants who picked "Yellow DANGER"
DEADLY CAUTION	χ (1, N = 96) = 28.02	< . 001	Proportionally more Ghanaians picked "Red CAUTION" as compared to the proportion of USA participants who picked "Red CAUTION"
DEADLY CAUTION	χ (1, N = 94) = 22.17	< .001	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
DANGER DANGER	χ (1, N = 96) = 24.41	< .001	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
CAUTION DANGER	χ (1, N = 96) = 5.89	< .05	Proportionally more Ghanaians picked "Yellow DANGER" as compares to the proportion of USA participants who picked "Yellow DANGER"
WARNING DANGER	χ (1, N = 96) = 30.37	< . 001	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"

DEADLY DANGER	χ (1, N = 96) = 22.17	< .001	Proportionally more Ghanaians picked "Orange DANGER" as compares to the proportion of USA participants who picked "Orange DANGER"
WARNING DEADLY	χ (1, N = 96) = 4.20	< .05	Proportionally more Ghanaians picked "Orange WARNING" as compared to the proportion of USA participants who picked "Orange WARNING"
DANGER WARNING	χ (1, N = 96) = 18.34	< .001	Proportionally more Ghanaians picked "Red DANGER" as compares to the proportion of USA participants who picked "Red DANGER"
DEADLY DEADLY	χ (1, N = 95) = 5.48	< . 05	Proportionally more Ghanaians picked "Orange DEADLY" as compared to the proportion of USA participants who picked "Orange DEADLY
CAUTION DEADLY	χ (1, N = 96) = 20.39	< . 001	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
CAUTION DANGER	χ (1, N = 96) = 10.53	< . 01	Proportionally more Ghanaians picked "Orange DANGER" as compared to the proportion of USA participants who picked "Orange DANGER"
WARNING DEADLY	χ (1, N = 96) = 15.14	< .001	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
DANGER DEADLY	χ (1, N = 96) = 9.07	< . 01	Proportionally more Ghanaians picked "Orange DANGER" as compared to the proportion of USA participants who picked "Orange DANGER"
DEADLY WARNING	χ (1, N = 96) = 10.23	< . 001	Proportionally more Ghanaians picked "Red WARNING" as compares to the proportion of USA participants who picked "Red WARNING"

WARNING DANGER	χ (1, N = 96) = 4.98	< . 05	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
WARNING WARNING	χ (1, N = 96) = 31.24	< .001	Proportionally more Ghanaians picked "Yellow WARNING" as compares to the proportion of USA participants who picked "Yellow WARNING"
WARNING CAUTION	χ (1, N = 96) =10.11	< .01	Proportionally more Ghanaians picked "Green WARNING" as compared to the proportion of USA participants who picked "Green WARNING"
WARNING DANGER	χ (1, N =96) = 26.01	< .001	Proportionally more Ghanaians picked "Orange DANGER" as compares to the proportion of USA participants who picked "Orange DANGER"
DEADLY WARNING	χ (1, N = 96) = 6.96	< .05	Proportionally more Ghanaians picked "Yellow WARNING" as compared to the proportion of USA participants who picked "Yellow WARNING"
WARNING WARNING	χ (1, N = 96) = 20.65	<. 001	Proportionally more Ghanaians picked "Orange WARNING" as compares to the proportion of USA participants who picked "Orange WARNING"
DEADLY DEADLY	χ (1, N = 96) = 6.89	< .01	Proportionally more Ghanaians picked "Orange DEADLY" as compared to the proportion of USA participants who picked "Orange DEADLY"
WARNING DEADLY	χ (1, N = 96) = 35.23	< .001	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
CAUTION DEADLY	χ (1, N = 95) = 27.40	<. 001	Proportionally more Ghanaians picked "Green DEADLY" as compared to the proportion of USA participants who picked "Green DEADLY"

CAUTION WARNING	χ (1, N = 96) = 35.99	< .001	Proportionally more Ghanaians picked "Orange WARNING" as compares to the proportion of USA participants who picked "Orange WARNING"
DANGER DANGER	χ (1, N = 96) = 9.56	< .01	Proportionally more Ghanaians picked "Yellow DANGER" as compared to the proportion of USA participants who picked "Yellow DANGER"
CAUTION CAUTION	χ (1, N = 96) = 26.81	< .001	Proportionally more Ghanaians picked "Red CAUTION" as compares to the proportion of USA participants who picked "Red CAUTION"
DANGER WARNING	χ (1, N = 96) = 6.54	< .01	Proportionally more Ghanaians picked "Yellow DANGER" as compared to the proportion of USA participants who picked "Yellow DANGER"
WARNING DANGER	χ (1, N = 95) = 4.52	< .05	Proportionally more Ghanaians picked "Green DANGER" as compares to the proportion of USA participants who picked "Green DANGER"
DANGER WARNING	χ (1, N = 96) = 11.76	<. 01	Proportionally more Ghanaians picked "Orange DANGER" as compared to the proportion of USA participants who picked "Orange DANGER"
DEADLY DANGER	χ (1, N = 95) = 3.88	< .05	Proportionally more USA participants picked "Orange DEADLY" as compares to the proportion of Ghanaians who picked "Orange DEADLY"
DEADLY DEADLY	χ (1, N = 96) = 13.87	< . 001	Proportionally more Ghanaians picked "Red DEADLY" as compared to the proportion of USA participants who picked "Red DEADLY"
DANGER CAUTION	χ (1, N = 96) = 29.23	< . 001	Proportionally more Ghanaians picked "Yellow DANGER" as compares to the proportion of USA participants who picked "Yellow DANGER"

WARNING DANGER	χ (1, N = 96) = 7.21	< . 01	Proportionally more Ghanaians picked "Orange DANGER" as compared to the proportion of USA participants who picked "Orange DANGER"
WARNING CAUTION	χ (1, N = 96) = 23.27	< .001	Proportionally more Ghanaians picked "Orange WARNING" as compares to the proportion of USA participants who picked "Orange WARNING"
DEADLY DANGER	χ (1, N = 96) = 23.50	< . 001	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
WARNING DEADLY	χ (1, N = 96) = 13.83	< .001	Proportionally more Ghanaians picked "Orange DEADLY" as compares to the proportion of USA participants who picked "Orange DEADLY"
DANGER CAUTION	χ (1, N = 96) = 8.21	< . 01	Proportionally more Ghanaians picked "Red DANGER" as compared to the proportion of USA participants who picked "Red DANGER"
DEADLY DEADLY	χ (1, N = 95) = 40.84	< .001	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
DANGER WARNING	χ (1, N = 96) = 6.89	< .01	Proportionally more Ghanaians picked "Orange DANGER" as compared to the proportion of USA participants who picked "Orange DANGER"
DANGER DEADLY	χ (1, N = 96) = 11.91	< .001	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
DEADLY DEADLY	χ (1, N = 95) = 30.39	< . 001	Proportionally more Ghanaians picked "Yellow DEADLY" as compares to the proportion of USA participants who picked "Yellow DEADLY"

DANGER CAUTION	χ (1, N = 96) = 9.56	< .01	Proportionally more Ghanaians picked "Red DANGER" as compares to the proportion of USA participants who picked "Red DANGER"
CAUTION WARNING	χ (1, N = 96) = 18.34	< .001	Proportionally more Ghanaians picked "Orange WARNING" as compares to the proportion of USA participants who picked "Orange WARNING"
DEADLY DANGER	χ (1, N = 96) = 20.65	< .001	Proportionally more Ghanaians picked "Yellow DEADLY" as compares to the proportion of USA participants who picked "Yellow DEADLY"
DANGER WARNING	χ (1, N = 96) = 15.14	< .001	Proportionally more Ghanaians picked "Yellow DANGER" as compares to the proportion of USA participants who picked "YELLOW DANGER"
DEADLY CAUTION	χ (1, N = 96) = 9.45	< .01	Proportionally more Ghanaians picked "Orange DEADLY" as compared to the proportion of USA participants who picked "Orange DEADLY"
DANGER DEADLY	χ (1, N =96) = 5.85	< .05	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"
DEADLY WARNING	χ (1, N = 96) = 12.52	< .001	Proportionally more Ghanaians picked "Green WARNING" as compared to the proportion of USA participants who picked "Green WARNING"
CAUTION DEADLY	χ (1, N = 96) = 13.04	< .001	Proportionally more Ghanaians picked "Orange DEADLY" as compares to the proportion of USA participants who picked "Orange DEADLY"
DANGER WARNING	χ (1, N = 96) = 30.83	< .001	Proportionally more Ghanaians picked "Yellow DANGER" as compared to the proportion of USA participants who picked "Yellow DANGER"

CAUTION CAUTION	χ (1, N = 96) = 17.75	< .001	Proportionally more Ghanaians picked "Orange CAUTION" as compares to the proportion of USA participants who picked "Orange CAUTION"
DEADLY DANGER	χ (1, N = 96) = 9.97	< .01	Proportionally more Ghanaians picked "Red DEADLY" as compares to the proportion of USA participants who picked "Red DEADLY"

Note 1: USA =1 Ghana = 2.* $p < .05$, ** $p < .01$, *** $p < .001$.

Appendix Y: Pair-wise Results

Table 35: WARNING versus CAUTION

WARNING CAUTION
Yellow WARNING beat Red CAUTION
Orange CAUTION beat Green WARNING
Red WARNING beat Green CAUTION
Green WARNING beat Yellow CAUTION
Orange WARNING beat Green CAUTION
Orange WARNING beat Yellow CAUTION
Orange WARNING beat Orange CAUTION

Table 36: WARNING versus DEADLY

WARNING DEADLY
Green DEADLY beat Green WARNING
Orange WARNING beat Orange DEADLY
Red DEADLY beat Yellow WARNING
Red WARNING beat Green DEADLY
Yellow WARNING beat Green DEADLY
Red DEADLY beat Red WARNING
Orange DEADLY beat Green WARNING
Green WARNING beat Yellow DEADLY
Red DEADLY beat Green WARNING

Table 37: CAUTION versus DANGER

CAUTION DANGER
Red DANGER beat Yellow CAUTION
Orange DANGER beat Green CAUTION
Yellow DANGER beat Orange CAUTION
Yellow DANGER beat Yellow CAUTION
Orange DANGER beat Red CAUTION
Yellow DANGER beat Green CAUTION
Red CAUTION beat Red DANGER
Yellow DANGER beat Red CAUTION
Orange CAUTION beat Green DANGER

Table 38: CAUTION versus CAUTION

CAUTION CAUTION
Red CAUTION beat Green CAUTION
Orange CAUTION beat Green CAUTION
Orange CAUTION beat Yellow CAUTION

Table 39: DEADLY versus DEADLY

DEADLY DEADLY
Orange DEADLY beat Yellow DEADLY
Orange DEADLY beat Green DEADLY
Red DEADLY beat Yellow DEADLY
Red DEADLY beat Green DEADLY
Yellow DEADLY beat Green DEADLY

Table 40: WARNING versus WARNING

WARNING WARNING
Yellow WARNING beat Green WARNING
Orange WARNING beat Green WARNING

Table 41: DANGER versus DANGER

DANGER DANGER
Red DANGER beat Orange DANGER
Yellow DANGER beat Orange DANGER
Red DANGER beat Green DANGER
Orange DANGER beat Green DANGER

Table 42: WARNING versus DANGER

WARNING DANGER
Red DANGER beat Orange WARNING
Yellow WARNING beat Green DANGER
Orange DANGER beat Yellow WARNING
Red DANGER beat Yellow WARNING
Red DANGER beat Orange WARNING
Red DANGER beat Red WARNING
Orange DANGER beat Orange WARNING
Yellow DANGER beat Orange WARNING
Green DANGER beat Green WARNING
Orange DANGER beat Red WARNING
Orange DANGER beat Green WARNING
Orange DANGER beat Yellow WARNING
Yellow DANGER beat Green WARNING
Yellow DANGER beat Yellow WARNING

Table 43: DEADLY versus DANGER

DEADLY DANGER
Orange DANGER beat Green DEADLY
Orange DANGER beat Yellow DEADLY
Orange DEADLY beat Orange DANGER
Red DANGER beat Green DEADLY
Red DEADLY beat Green DANGER
Yellow DEADLY beat Yellow DANGER
Red DEADLY beat Orange DANGER
Red DEADLY beat Yellow DANGER

Table 44: CAUTION versus DEADLY

CAUTION DEADLY
Orange DEADLY beat Green CAUTION
Yellow DEADLY beat Green CAUTION
Yellow DEADLY beat Red CAUTION
Red CAUTION beat Red DEADLY
Red DEADLY beat Green CAUTION
Red DEADLY beat Yellow CAUTION
Green DEADLY beat Green CAUTION
Orange DEADLY beat Yellow CAUTION
Orange DEADLY beat Orange CAUTION
Orange CAUTION beat Green DEADLY

Table 45: Red versus Orange

Red Orange
Red DANGER beat Orange WARNING
Red DANGER beat Orange DANGER
Red DANGER beat Orange WARNING
Orange DANGER beat Red CAUTION
Orange DANGER beat Red WARNING
Red DANGER beat Orange CAUTION
Red DEADLY beat Orange DANGER

Table 46: Red versus Green

Red Green
Red DANGER beat Green DANGER
Red DEADLY beat Green WARNING
Red WARNING beat Green CAUTION
Red DEADLY beat Green CAUTION
Red WARNING beat Green DEADLY
Red CAUTION beat Green CAUTION
Red DANGER beat Green DEADLY
Red DEADLY beat Green DEADLY
Red DEADLY beat Green DANGER

Table 47: Orange versus Yellow

Orange Yellow
Orange CAUTION beat Yellow CAUTION
Orange DANGER beat Yellow WARNING
Yellow DANGER beat Orange CAUTION
Orange DEADLY beat Yellow DEADLY
Orange DANGER beat Yellow DEADLY
Yellow DANGER beat Orange DANGER
Yellow DANGER beat Orange WARNING
Orange WARNING beat Yellow CAUTION
Orange DANGER beat Yellow WARNING
Orange DEADLY beat Yellow CAUTION

Table 48: Orange versus Orange

Orange Orange
Orange WARNING beat Orange DEADLY
Orange DEADLY beat Orange DANGER
Orange DANGER beat Orange WARNING
Orange WARNING beat Orange WARNING
Orange DEADLY beat Orange CAUTION

Table 49: Yellow versus Yellow

Yellow Yellow
Yellow DANGER beat Yellow CAUTION
Yellow DEADLY beat Yellow DANGER
Yellow DANGER beat Yellow WARNING

Table 50: Red versus Yellow

Red Yellow
Yellow WARNING beat Red CAUTION
Red DANGER beat Yellow CAUTION
Yellow DANGER beat Red CAUTION
Yellow DEADLY beat Red CAUTION
Red DANGER beat Yellow WARNING
Red DEADLY beat Yellow CAUTION
Red DEADLY beat Yellow WARNING
Red DEADLY beat Yellow DEADLY
Red DEADLY beat Yellow DANGER

Table 51: Red versus Red

Red Red
Red CAUTION beat Red DEADLY
Red DANGER beat Red WARNING
Red DEADLY beat Red WARNING
Red CAUTION beat Red DANGER

Table 52: Orange versus Green

Orange Green
Orange DEADLY beat Green CAUTION
Orange CAUTION beat Green WARNING
Orange DANGER beat Green CAUTION
Orange DANGER beat Green DANGER
Orange CAUTION beat Green DEADLY
Orange CAUTION beat Green DANGER
Orange DANGER beat Green DEADLY
Orange WARNING beat Green WARNING
Orange DEADLY beat Green DEADLY
Orange WARNING beat greed CAUTION
Orange DANGER beat Green WARNING
Orange DEADLY beat Green WARNING
Orange CAUTION beat Green CAUTION

Table 53: Green versus Green

Green Green
Green DEADLY beat Green WARNING
Green DEADLY beat Green CAUTION
Green DANGER beat Green WARNING

Table 54: Yellow versus Green

Yellow Green
Yellow DEADLY beat Green CAUTION
Yellow WARNING beat Green DANGER
Green WARNING beat Yellow CAUTION
Yellow WARNING beat Green DEADLY
Yellow WARNING beat Green WARNING
Yellow DANGER beat Green CAUTION
Yellow DEADLY beat Green DEADLY
Yellow DANGER beat Green WARNING
Green WARNING beat Yellow DEADLY

Appendix Z: Vita

Vita

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EDUCATION

Virginia Polytechnic Institute and State University, Blacksburg, VA

M.S., Industrial and Systems Engineering, 2004
Thesis: *Cultural Differences in Risk Perception: An Examination of USA and Ghanaian Perception of Risk Communication*
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RESEARCH INTERESTS

Cultural ergonomics, safety, warnings and risk communication, transportation safety, user interface design, risk perception, and globalization.

PAPERS AND PUBLICATIONS

Martin, L. F., Smith-Jackson, T .L. and Artis, S. (2003). Cultural Differences in Risk Perception: Comparison of USA and Ghanaian Workers. *In Proceeding of the Human Factors and Ergonomics Society 47th Annual Meeting*, 1762 - 1766. (Denver, CO: USA). Santa Monica, CA: Human Factors and Ergonomics Society.

OTHERS

Martin, L. F. and Smith-Jackson (2003, March). Cultural Ergonomics: A Comparison of USA and Ghanaian Industry Workers' Perception of Hazard Connotations. *Poster presented at the annual meeting of the National Society of Black Engineers*. Anaheim, CA.

Martin, L. F., Smith-Jackson, T.L., and Artis, S. (2003). Cultural Differences in Risk Perception: Comparison of Ghanaian and American Workers. [Abstract] *Safety News: A Publication of the Human Factors and Ergonomics Society Safety Technical Group* (Fall 2003 Issue).