EFFECTS OF COLOURS, SHAPES AND ICONS ON PERFORMANCE AND FAMILIARITY

BY

INGA YOLA DAMBUZA

THESIS

Submitted in fulfilment of the requirements for the degree Master of Science

Department of Human Kinetics and Ergonomics

Rhodes University, 2011

Grahamstown, South Africa

ABSTRACT

Occupational injuries and illnesses remain to be a heavy burden on workers and employees in industrial developing and industrially developed societies, and health and safety in workplaces continues to be an important issue for ergonomists. Steps are being taken to stimulate health and safety agendas and to discover ways in which health and safety in industries can be improved. The main responsibility of employers is to provide employees with information, instructions and training that they required to carry out their work tasks in a healthy, practical and safe manner. The role of education as a countermeasure to occupational injury and illness is being re-examined by health and safety practitioners and safety training is being considered as a vital part of accident prevention strategies. Effective training programmes should guarantee that workers possess the skills they require to complete their tasks in a safe and healthy manner. Very little is known about the type and quality of training workers undergo and how that training affects the safety outcomes of companies. There has been an attempt over the past 20 years to increase the research on safety communications and a great deal of this research has been focused on safety warnings; with the greatest attention been placed on the components of safety signs, such as colours, size, shapes and icons. The effects of these components on comprehension with relation to age and education have not received the same amount of attention. The impact of familiarity on safety warnings with respect to age and education has also received very little attention; despite the knowledge that familiarity has been shown to increase the noticing of warnings and the comprehension of safety information. Despite the increase in the research on safety communication, the literature and research in South Africa is scarce. Studies present in South Africa do not encompass the comprehension of safety signs or the ability of individuals with different age and education levels to learn the information included in the signs. Due to the multi-linguistic nature of South Africa and the fact that South Africa is an Industrially Developing Country (IDC) with high levels of illiteracy, issues such as the comprehension of safety information must be addressed. Therefore, the objectives of this study were to investigate the effects of safety sign attributes on learning and familiarity, in subjects that differed in age and education levels. These effects were investigated through measuring the reaction and response times of the different subject groups, as well as the number of

components in the safety signs that were recalled correctly. The combined results of these responses were used as a measure for familiarity. A set of signs was designed for the study by the researcher using three different colours, three different shapes, three different icons and text. Certain variables were omitted from some signs to create the test pool and the eight conditions that were tested in a laboratory setting. Each condition contained different components of the designed signs and 60 subjects were used to test these conditions. The subjects were placed in groups according to their age and level of education. Subjects were required to learn a set of 64 signs, either “With Occlusion” or “Without Occlusion”, and asked to recall the meanings of the components in the signs. Reaction time, response time and error rate were measured from the responses. The results showed that the conditions resulted in different reaction times, response times and error rates for all subjects. The signs containing a combination of shapes and text resulted in the best performance. Age and education were found to have a significant effect on various performance criteria as did the method in which the signs were displayed (Occlusion and No Occlusion). The increased repetitions and sessions elicited lower reaction times, response times and error rates. The conclusions drawn from this study suggest that different attributes be considered carefully when subjects are expected to learn and recall information in safety signs. The results also highlighted the need to increase the exposure of individuals to safety signs in order to increase familiarity and ultimately improve the recall and comprehension of the attributes.

ACKNOWLEDGEMENTS

I would like to acknowledge the following people for their encouragement and unfailing support during this project:

Professor Matthias Goebel for providing his expertise, patience and his Christmas break to ensure that my thesis was completed on time.

My family for their support and encouragement.

Michael and Mirriam Mattison for providing participants and organising industry interviews.

Jodi Hodgkiss and Jessica Stack for their much needed help.

All the participants for giving up their valuable time to participate in this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

BACKGROUND TO STUDY

Health and safety in workplaces still remains an important ergonomics issue (Smallman, 2001) as occupational injuries and illnesses remain a heavy burden on human life in industrially developing and industrially developed societies (Heath, 1982). The number of incidents being reported is slowly decreasing (Smallman, 2001) and The Health and Safety Executive (1999) have reported that in the United States of America and Britain, statistical and anecdotal evidence exists suggesting that the trend towards safer workplaces has decreased or even reached a plateau. This has been found to result in severe social implication and significant economic costs (Smallman, 2001). Governments, such as the British government, are taking steps to revive health and safety agendas, to identify ways in which the health and safety performance in workplaces can be improved and to ensure that the health and safety laws continue to be compatible with the ever-changing trends in the development of industries (Smallman, 2001).

According to Sgourou *et al*. (2009), safety performance is a vital component of safety management systems as it provides information on how the safety system is performing in terms of development, implementation and results. It has been recommended that the measurement of employee attitudes towards safety is a useful tool for the assessment of safety (Schroder, 1970). The traditional approach of investigating the safety performance of a workplace is through the measurement and statistical analyses of incident-related data, such as recording the number of injuries, the frequency of accidents, the costs of accidents or the damages linked to poor safety behaviour (Sgourou *et al*., 2009). Actual work tasks, unsafe working environments as well as poor design and inappropriate equipment maintenance are other factors that have been shown to be responsible for the occurrence of these incidents (Wogalter *et al*., 1992). Schroder (1970) however argues that determining the safety attitudes of the employees is a better measure as the more mature the employees‟ safety attitudes are, the more likely they will be to look for safer

environments, thus causing a decrease in unsafe behaviour. Essentially, the commitment of management to safety has been shown to be a consistent factor in the success of safety programs (Cohen, 1977) and companies with low accident rates have been found to have more safety staff, safety committees and safety training than those with high accident rates (Smith *et al*., 1978). The time spent on tasks and the frequency of the repetition of tasks are also associated with incident liability, showing that there is a learning process that occurs as an individual gains experience with the tasks, which results in a decrease in the frequency of accidents occurring (Hale, 1984).

According to Hale (1984), many government acts stipulate that the main obligation of the employer is to provide information, instructions and training that is needed by the employee to carry out the tasks designated by their employment in a manner that is healthy, practical and safe. Safety and health practitioners and managers are carefully reviewing the role education can play as a countermeasure to occupational injury and illness (Heath, 1982). Safety training has been viewed by some authors, such as Hale (1984), as an integral part of accident prevention strategies, but whether the development of training programmes is high enough to result in the expected outcome is being questioned. Goldenhar *et al*. (2001) maintain that effective training programmes should ensure that the workers are taught the necessary skills in order to perform the required tasks and that the skills learned can be transferred over to the job in a safe and healthy manner. Training for job skills and health and safety should ideally occur before an individual begins employment and should continue through the employment period (Goldenhar *et al*., 2001). Goldenhar *et al*. (2001) do note that very little is known about the nature and quality of training available to workers and how this type of training may relate to safety outcomes.

Since the 1980s, there has been an attempt to increase research on safety communications, with a great deal of attention being placed on safety warnings (Laughery, 2006). According to Gill *et al*. (1987), the research on the design of warnings initially centred on their format and studies were focused on identifying factors that would increase the legibility, such as the colour and the letters in safety signs. The attributes of safety signs; such as the colour, size, shape and icons; have

received a fair amount of attention, however the comprehension of these components with relation to the education and age of the individuals utilizing the signs have not received the same amount of interest. The effectiveness of warnings can be improved through making the components of the message more noticeable (Wogalter *et al*., 1992).

According to Wogalter *et al*. (1985), the importance of safety warnings has increased, although warnings are typically considered as a last line of defence regarding the protection of users from potential hazards. Warnings are designed to decrease or prevent risks from occurring in workplaces (Lesch, 2008b) and are a common aspect in programs designed to reduce workplace accidents (Wogalter *et al*., 1992). The essential aim of a warning sign is to mediate safe behaviour, however safety signs will continue to be ineffective if individual do not comprehend what the appropriate safety behaviour is (Gill *et al*., 1993). Safety issues related to both products and environments have been incorporated in safety warning research, as warnings are viewed as an interface between the individuals utilizing and maintaining these products and environments (Laughery, 2006) and the problem of designing warnings that are effective should be the responsibility of human factors specialists (Dorris and Purswell, 1977).

Familiarity is another issue that has an impact on safety warning and whether warnings are noticed. Ecker *et al*. (2007) defines familiarity as the sensation of having encountered a person or specific object without consciously accessing the contextual details, such as the place or time of the meeting. The concept of familiarity has many effects on the safety culture of a workplace and can have a negative effect as well in that the more familiar the individuals become with their environment, the less likely they are to look for, read and comply with warnings (Rogers *et al*., 2000 and Wogalter *et al*., 1991). Familiarity has a positive effect as it can cause an individual to know more about an environment or product and the dangers or hazards therein as they become more familiar with that environment or product and a result, researchers have investigated the effect of improving the comprehension of safety signs through increasing familiarity (Duarte and Rebelo, 2005).

Despite the increase in the research on safety communications worldwide, the literature and research in South Africa is scarce. Studies investigating safety signs in the South African context do exist; however, these studies do not encompass the comprehension of safety signs or the ability of individuals with different education and age levels to learning information included in safety signs. This is a significant problem as the majority of the workforce in South African industries is composed of individuals with low education levels. South Africa is an Industrially Developing Country (IDC) and as such, has a high level of manual labourers that tend to have lower education levels (Scott, 1999). Additionally, South Africa has eleven recognized languages, which have been declared equal and official by the constitution (Brock-Utne and Holmarsdottir, 2004), thus creating added difficulty regarding the training of workers in South African industries. Despite the increase in the number of African language speaking individuals increasing their education levels (Heugh, 1999), English has been used as the main system of education in South Africa for many years (Brock-Utne and Holmarsdottir, 2004) and South Africa is still plagued with a major failure in the comprehension of safety signs.

The training of employees in South African industries has also been highlighted as a problem. Older individuals are expected to learn the safety information at the same rate as their younger counterparts. This presents a double burden for the older individuals with lower education levels. No South African studies have been found that investigate the impact of learning safety information on individuals with limited educational backgrounds or individuals that are older in age. The designers of safety signs need to bear in mind that individuals utilizing signs will not have the same level of reading comprehension (Rogers *et al*., 2000) and some individuals may not speak the language or have the adequate reading skills required when observing a safety sign (Rogers *et al*., 2000).

STATEMENT OF THE PROBLEM

The comprehension and conspicuousness of safety signs in industries have resulted in workplace accidents occurring. The design of safety signs and the level of comprehension of the individuals using the signs play a role in the prevalence of these accidents. Risks occur if employees are not noticing signs and if the training

programs the workers undergo do not fully encompass the overall sense of the risks that can be encountered or the safety that is required. Also, the majority of employees in South African industries do not have high levels of education and therefore encounter problems when attempting to complete these training programs.

It is necessary for individuals to be able to learning safety signs quickly, as they must become familiar with the safety information as soon as possible, so as not to endanger themselves in their work environments. The problem then exists in the design of these signs, as they should enable individuals to learn quickly and easily. For this study, the attributes of safety signs, such s the colours, shapes, icons and text, were used an indication as to which signs were easier to learn, recall and become more familiar with. Participants that recalled signs quicker and in a shorter amount of time were considered to have become more familiar with the signs. Lastly, age and the level of education were tested in order to determine what differences, if any, existed between the different participant groups.

Therefore, the objectives of this study were to investigate the effects of safety sign attributes on learning and familiarity in participants that differed in age and education levels. These effects were investigated through measuring the reaction and response times of the different participant groups, as well as the number of errors obtained. The combined results of these responses were used to measure familiarity.

RESEARCH HYPOTHESES

This study investigated how the different attributes in safety signs interacted and how this interaction impacted learning and familiarity. The attributes in the test signs were varied to create the test pool of signs and the variation of the attributes provided eight test conditions. Participants were required to learn several attributes and their assigned meanings in a designated amount of time, after which they were asked to recall what they had learned by viewing the test signs, which tested repetitions of the eight conditions. The variables that were controlled in this study included the learning time; the colours, shapes, icons and text used in the signs; and the age and level of

education of the participants. The variables measured were the reaction time, response time and error rate.

The expectations of this investigation were that differences in the responses would exist between the groups with the different education levels and the groups with the different age levels. It was also expected that the different conditions, i.e., the different attributes of the signs, would elicit different responses among participants. The eight conditions were expected to produce different results, in that the variation of the colours, shapes, icons and text would result in different responses for all participants, regardless of their age or level of education.

STATISTICAL HYPOTHESES

Hypothesis 1: The null hypothesis states that the responses of all the participants to the conditions will not be significantly different, regardless of age or level of education.

H_o: $\mu_{C1}=\mu_{C2}=\mu_{C3}=\mu_{C4}=\mu_{C5}=\mu_{C6}=\mu_{C7}=\mu_{C8}$

H_a: $\mu_{C1}\neq\mu_{C2}\neq\mu_{C3}\neq\mu_{C4}\neq\mu_{C5}\neq\mu_{C6}\neq\mu_{C7}\neq\mu_{C8}$

Where: $_{C1}$ is Condition 1 (the signs were comprised of only text)

$_{C2}$ is Condition 2 (the signs were comprised of text and an icon)

$_{C3}$ is Condition 3 (the signs were comprised of text and a colour)

$_{C4}$ is Condition 4 (the signs were comprised of text and a shape)

$_{C5}$ is Condition 5 (the signs were comprised of a shape, colour and icon)

$_{C6}$ is Condition 6 (the signs were comprised of text, a colour and an icon)

$_{C7}$ is Condition 7 (the signs were comprised of a shape, text and an icon)

$_{C8}$ is Condition 8 (the signs were comprised of a shape, a colour and text)

Hypothesis 2: The null hypothesis states that the responses obtained from the old participants will not be significantly different to those obtained from the young participants.

H_o: $\mu_{ResponsesOld} = \mu_{ResponsesYoung}$

H_a: $\mu_{ResponsesOld} \neq \mu_{ResponsesYoung}$

Where: $_{ResponsesOld}$ is the reaction, response time and accuracy of recall for old participants

$_{ResponsesYoung}$ is the reaction, response time and accuracy of recall for young participants

Hypothesis 3: The null hypothesis states that the responses obtained from the participants with high level of education will not be significantly different to those obtained from the participants with a lower level of education.

H_o: $\mu_{ResponsesHigh} = \mu_{ResponsesLow}$

H_a:$\mu_{ResponsesHigh} \neq \mu_{ResponsesLow}$

Where: $_{ResponsesHigh}$ is the reaction, response time and accuracy of recall for higher educated participants

$_{ResponsesLow}$ is the reaction, response time and accuracy of recall for lower educated participants

DELIMITATIONS

The focus of this study was on the effects of age and education level on learning safety information displayed in safety signs and how this in turn impacted familiarity. This was analyzed by measuring the reaction and response times, as well as the number of errors.

The participants for this study were recruited from Grahamstown and East London in the Eastern Cape Province of South Africa and included both young and old adults as well as individuals with low and high education levels. Participants were recruited from the manual labour workforce and from a university and corporate population, in an attempt to make the sample representative of the population of workers in industries and to compare differences. The participant sample ranged between the ages of 18 and 47 years and the sample size was n = 60. The protocol was standardized in that all the participants performed the same task and were given the

same learning time, which was measured by the principle investigator. All participants were given an equal number of signs that included the same number of varied attributes. The protocol was explained in the language that the participants preferred to ensure that every participant fully understood the test protocol.

LIMITATIONS

The main limitation of this study was that the participant population did not include females. Extreme difficulty was experienced when attempting to recruit female participants required for this study. The attempt to recruit the total number of female participants required for this study would have resulted in the testing period being lengthened beyond the available time to complete this study. Another limitation of the study was that participants were tested at various times of time, which may have had an effect on learning, memory and recall due to factors such as fatigue and concentration. Other limitations were that participants may have felt apprehensive about having to complete the task due to the presence of a video camera and having to recall information and terminology they were not familiar with. Both these factors may have impaired recall and additionally the use of English for the text may have provided an additional limitation for a participant sample that consisted of several non-native English speakers.

CHAPTER II

REVIEW OF RELATED LITERATURE

INTRODUCTION

According to the UK Health and Safety (Safety Signs and Signals) Regulation (1996), a safety sign represents "a specific object, activity or situation that provides instructions about health and safety at work via signboard, a safety colour, illuminated sign, acoustic signal, verbal communication or hand signal". This regulation provides rules about how signs should be provided and maintained in workplaces for the protection of workers, the organization of work and the instructions about the types of risks that may occur in the workplace.

In South Africa, the legislature is provided in terms of standards which are, according to the South African National Standards (SANS), generally used to "refer to a specification, code of practice or standard method). The standard for safety signs in South Africa is provided by the SANS and can be seen in Figure 1. This standard was revised in 1997 and contained one overall standard, which is now SANS 1186-1.

SANS 1186-1, Symbolic safety signs – Part 1: Standard signs and general requirements (revision)

Specifies requirements for standard ordinary (non-reflective) symbolic safety signs, including signs applied on mirror or on vinyl sheets (decals). Also specifies general requirements applicable to self-luminous (radioluminescent), internally illuminated, retro-reflective and photoluminescent symbolic safety signs (complete with their backing sheets, where applicable).

ICS 01.080.10; 13.100

Figure 1: Standards provided for safety signs in South Africa (SABS Standards Bulletin, 2007)

The literature on safety signs in South Africa is almost non-existent as very few studies investigating various aspects of safety signs exist; however, these studies have not looked at the situation in South Africa exclusively. Globally there is abundance in the literature regarding the attributes, comprehension and training involved with safety signs. As mentioned previously, there has been a significant increase in the amount of research focused on communicating safety and warning to individuals workplaces (Laughery, 1996); but most of this research has been focused specifically on the legibility of the components of safety signs. The literature in the South African context is limited and of the studies that exist, none investigate the comprehension of signs, the effects of education or age on the comprehension of signs and how to improve signs to ensure that workers have a better understanding of the safety requirements. These factors are of great important in an IDC such as South Africa, which has high levels of illiteracy in industries.

The economy of IDCs is not strong and many of the labourers are manual workers that are not conditioned for the jobs they perform, are under-nourished and reside in a deprived state of health due to the poor economy (Scott, 1999). Another factor plaguing these workers is that their education is basic and their vocational skills are lacking and due to the lack of job availability, these individuals end up performing manual work (Scott, 1999). As a result of these factors, South Africa is faced with a situation where the majority of individuals in the country do not comprehend most safety material presented to them (Heugh, 1999). A double burden is placed on workers in South African industries as they must compensate for their basic education and for not speaking English as their native language. For the past years, English has been used as the medium in which to educate scholars in South Africa (Brock-Utne and Holmarsdottir, 2004).

AIMS OF A SAFETY SIGN

According to Young and Wogalter (1999), the main objective of a safety sign is to prevent injury occurring to individuals, machines and the environment by providing information regarding the potential hazards that may occur. Safety signs are not only expected to pass on knowledge about hazards that may occur and ways in which injuries can be avoided, but should also serve as a reminder that there is a hazard

present (Lesch, 2003). Laughery (2006) maintains that a safety sign should accomplish two objectives, which are that it should attract the attention of the user and supply information that the user can understand. Safety warnings can either be a posted-sign warning like a safety sign, or a within-instruction warning such as an instruction manual for a product (Wogalter *et al*., 1985). A safety sign must attract attention in that it should be noticed and encoded. Individuals normally do not look out for warnings; therefore signs should be eye-catching (Laughery, 2006), which is generally accomplished through the use of signal words, colours and shapes (Adams *et al*., 1998). The sign also needs to provide information that the user is able to understand and required in order to make knowledgeable decisions concerning compliance (Laughery, 2006).

There is a general agreement in design standards and guidelines as well as in research literature that safety signs should include information not only about the hazard, but also instructions on how to comply with the hazard and the consequences that can arise without compliance (Laughery, 2006). Adams *et al*. (1998) concur that an effective sign must include specific instructions about the hazard, i.e. the sign should declare what should or should not be done to avoid undesirable consequences.

EFFECTIVENESS OF A SAFETY SIGN

Factors that influence the effectiveness of safety signs are being identified in behavioural compliance research (Wogalter *et al*., 1993). The effectiveness of a safety sign is dependent of the characteristics of the sign itself, the situation in which the sign can be found in and the characteristics of the person using the sign, such as familiarity and age (Lesch, 2003). Lesch (2008b) states that for a safety sign to be effective, a series of events must occur in which the person is first exposed to the sign, attention to the warning occurs followed by the active processing and the process of comprehension and agreement with the warning; and lastly, the individual must be able to select and perform a response. The effectiveness of the warning can be decreased should failures occur at any of these stages (Lesch, 2008b).

Adams *et al*. (1998) assert that a sign is more likely to be complied with if more of the attributes are present in the sign. Wogalter *et al*. (1985) found that when signs contained signal words, hazard statements, consequences and instructions; the signs were rated as more effective than when any one of these factors was absent. Wogalter *et al*. (1993) add that by making the message constituent of warnings more noticeable, warning effectiveness can be improved upon. Lesch (2008b) reports that compliance is one way of measuring the effectiveness of warnings. Leonard and Matthews (1986) argue that it seems reasonable to declare that the stronger a warning is, the more likely it will be regarded; however the literature on how general populations differentiate levels of warnings is lacking.

Duarte and Rebelo (2005) maintain that it is very important to determine the relative importance of a set of internal and external sign variables in order to understand the effectiveness of safety signs. The internal variables consist of the colours, icons, shapes and the type and message of the sign. The external variables include gender, education, age, occupation and familiarity with the internet and computers.

SAFETY SIGN ATTRIBUTES

According to Lesch (2003), safety signs generally have a message, a signal word and an icon. Attributes such as colour, font, message layout and size are design factors that affect whether individuals initially notice, encode or comprehend safety signs (Lesch, 2003). Many studies have demonstrated relationships between the different variables of safety signs and comprehension scores and many authors have studied the effects of the different safety sign components on comprehension (Duarte and Rebelo, 2005).

Hakiel and Easterby (1984) state that signs should contain four attributes, 1) an image containing graphic content and a colour, 2) a background with a shape and colour, 3) an enclosure with a shape and colour and 4) a surrounding composed of a shape and colour. There are endless ways in which safety sign attributes can be investigated, such as the impact of icons on comprehension scores (Bruyas *et al*., (1998); the effects of colour on compliance with printed warnings (Braun *et al*., 1998); hazard type and icon and text explicitness (Braun *et al*., 1999) as well as the

interaction between the components and the conspicuousness of the connoted hazard (Cheatham and Wogalter, 1999). The above safety sign issues have been studied extensively whereas the effects of the attributes on education and age have been somewhat ignored. The key problems concerned with education, age and comprehension of safety signs are two-fold. Firstly, text is used in a number of signs which becomes a setback for individuals that cannot read and secondly, some icons are difficult for even highly educated individuals to interpret. It is important to consider these issues when designing safety signs and when assessing comprehension scores as well. Attributes such as signal words, icons, colours and shapes all play a vital role in the design of safety signs and must be evaluated further with regards to education and age.

Message

Davies *et al*. (1997) assert that the type of message being depicted for the image content of a sign can either be classified as descriptive, prescriptive or proscriptive. Descriptive indicates that the hazard of the risk is identified by the image; prescriptive indicates that the image stipulates a positive course of action that the user must take and proscriptive signifies a course of action that is prohibited, as seen in Figure 2.

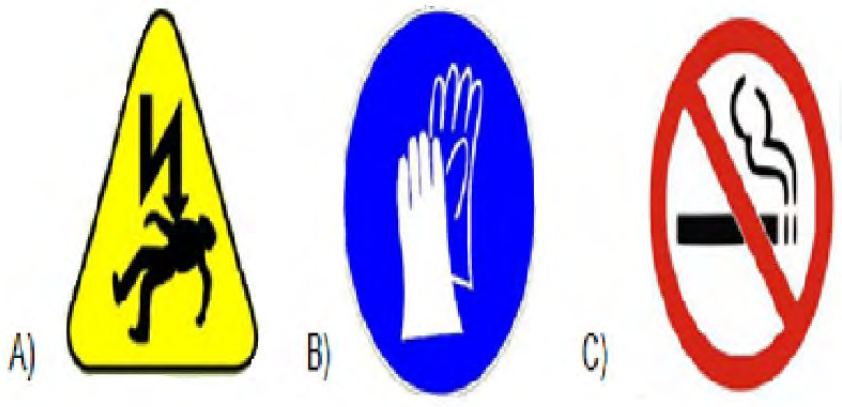


Figure 2: Message in signs conveyed as a) descriptive, b) prescriptive and c) proscriptive (Nitsch, 2005)

Signal Words

The use of signal words in safety signs have been recommended by most standards and guidelines on safety sign design, as signal words have been deemed to call attention to a sign, as well as communicate the level of seriousness of the hazard (Silver and Wogalter, 1989). Signal words in safety signs typically convey a level of hazard to the user. The American National Standards Institute (ANSI, 1991) recommends that signal words communicate two levels of hazard; however some guidelines promote more than just two levels, such as the Product Safety Sign and Label System, which recommends three hazard levels (Silver and Wogalter, 1989).

According to Chapanis (1994), *danger*, *warning* and *caution* are the signal words that are recommended the most. Young (1998) reports that with regards to signal words denoting different levels of hazard, the different standards and recommendations are somewhat identical. *Danger*, *warning* and *caution* connote the highest to lowest level of hazard, respectively, according to the three-tier approach suggested by the ANSI, the Society of Automotive Engineers (SAE), Westinghouse and the Food Machinery Corporation (FMC) (Young, 1998; Chapanis 1994 and Wogalter *et al*., 1994). The Product Safety Sign and Label System suggests that the word *danger* be reserved for risks that will cause serious personal injury of death, *warning* for risks or dangerous procedures that could cause severe personal injury or death and *caution* for risks or dangerous procedures that will cause minor personal injury or damage to property or products (Silver and Wogalter, 1989). The ANSI however suggests that hazards that pose immediate and severe risk and are capable of resulting in damage or injury that is permanent be denoted by the word *danger*, whereas signs that bring about attention to risks that may occur and could cause serious or permanent injury by denoted by the word *caution* (Silver and Wogalter, 1989). Leonard *et al*. (1986) state that no reliable differences have been reported between the risk ratings of the words above signal words. Young (1998) proposes that the conditions in which the different words are used, rather than the hazard level of the words account for the differences that exist between the standards.

According to Wogalter *et al*. (1994), the main question that arises is whether individuals distinguish the differences between the signal words. Chapanis (1994)

maintain that it is important to understand how individuals interpret signal words that are included in signs. Wogalter and Silver (1995) add that with regards to the use of signal words, comprehension should also be considered as research in this area has been vague about whether the degree of hazard in signal words is really interpreted differently by individuals. Only a few studies have investigated whether individuals really notice a difference in the strength or arousal in signal words (Silver and Wogalter, 1989). Cowan (1988) reports that it is possible that these words may no longer draw attention or indicate any level of hazard as the exposure to them is continued. According to Silver and Wogalter (1989), this continued exposure may occur as a result of overuse due to the limited number of words used in safety signs.

In order to ensure that individuals with lower level language skills comprehend the words as intended, designers of safety signs should make use of specific words that these individuals are able to interpret as injury may arise due to inappropriate care if these individuals fail to recognize the level of hazard denoted by the signal word (Silver and Wogalter, 1989). Warning design standards have also recommended that signal words be accompanied by icons as icons attract attention and convey the existence of a hazard (Wogalter *et al*., 1994). According to Young (1998), signal words can be found on most safety signs and are typically surrounded by a colour, border or shape that can be called a „signal word panel"; where both the panel and the signal words serve their own functions. It is commonly assumed that the information displayed by both the panel and the signal word is redundant in that signal words with high levels of hazard are commonly paired with panels containing colours that denote a high level of hazard (Young, 1998).

Symbols

Most standards and guidelines are increasingly recommending the use of non-verbal symbols such as icons or pictorials to communicate safety information and warnings (Wogalter and Sojourner, 1997). For the purpose of this study, the terms symbol and icon shall be interchangeably used to refer to the graphic information in safety signs.

According to Johnson-Laird (1988), a great deal of literature on signs and symbols is present. The research on the use of symbols has received little attention even though the benefits of using symbols has been said to have a positive impact on warning effectiveness (Jaynes and Boles, 1990). The ANSI standard for symbols defines them as “a configuration, consisting of an image...which conveys a message without use of words” (ANSI, 1991, p2). According to Davies *et al*. (1997), symbols are either a representative, rather precise picture of a message where the key elements are condensed into graphical terms, or symbols are abstract pictures that are made up and need to be learned.

Attracting the attention of a user to a safety sign has been demonstrated by research to be assisted by the inclusion of symbols (Lesch, 2008 and Rogers *et al*., 2000). Symbols have also been found to improve the encoding of the warning information (Rogers *et al*., 2000). Loring and Wiklund (1988) describe two characteristics that determine whether symbols are encoded, firstly that the symbol should be large enough so that the message is communicated over large viewing distances and secondly, that the message conveyed by the symbol be simple and free of any unnecessary visual clutter, but not too abstract that the user has to spend a large amount of time learning it. Symbols used in the past did not have any evident relation to real-world objects (Lesch, 2003) and tended to have a more abstract representation of the message being conveyed and hence, the meaning of these symbols needs to be learned (Rogers *et al*., 2000). The meaning of some symbols can be very clear (Lesch, 2003), but many are not and are therefore often poorly understood (Lesch, 2008a).

Symbols are capable of a) communicating instructions and ideas quickly, b) avoiding issues regarding reading skills and unfamiliarity with language, c) are easier to recall then text (Lesch, 2003) and d) can also communicate large amount of information (Lesch, 2008a). An appropriate symbol may make the meaning of a warning better understood and more obvious and immediate, whereas text requires an individual to read and process the message intended (Rogers *et al*., 2000). Research has shown that individuals are able to recognize and recall images quicker and more accurately than text (Jaynes and Boles, 1990) and signs with symbols have been found to be understood and interpreted quicker than those without symbols or those with text

(Laughery and Young, 1991 and Young, 1991). Cahill (1976) found that symbols differed amongst themselves in terms of the ease with which they are interpreted, yet when the context in which the symbols are represented or the experience of the observer with that context are introduced, these differences between symbols are not affected as these both encourage the correct identification of the meaning. According to Rogers *et al*. (2000), symbols are not likely to be encountered by users without any context and therefore, the appropriate contextual information should be supplied when the comprehension of symbols is studied (Wolff and Wogalter, 1998). Many studies use atypical testing methods and therefore, Rogers *et al*. (2000) maintain that it may be misleading to conclude the lack of understanding when the comprehension of symbols is being investigated. Different population groups also need to be considered as the ease of symbol comprehension may differ for these different groups (Rogers *et al*., 2000); however research indicates that with minimum amount of training, comprehension can be improved.

Due to symbols being viewed as a language-free and space-saving communication method for hazard information, several publications have recommended guidelines for their design. Some of the guidelines are that the design should be simple; realistic pictures should be included with limited content; background space, size and magnifications should be used and colours should be as realistic as possible if used (Mansoor and Dowse, 2004). The disadvantage in the use of symbols, according to Davies *et al*. (1997) is that many individuals will not understand abstract concepts when they are represented using symbols.

Colours

Colour has been shown to influence the behaviour of the individual using the safety sign, as existing research has suggested that colour affects the conspicuousness and memory of warnings, the compliance of behaviour and the degree of hazardousness (Braun and Silver, 1995). According to Rogers *et al*. (2000), colour also seems to affect whether the information is a warning is encoded as the encoding of colour information profoundly influences the preference of colour denoting a hazard. Empirical evidence exists that demonstrates the capacity of colour to denote a hazard, although the magnitude and direction of this effect is

indistinct (Braun and Silver, 1995). The use of unsuited colours with warnings raises an important question of whether colours interact with warnings to influence the hazards communicated and the compliance with the warnings (Braun and Silver, 1995). The highest level of hazard is typically connoted by the colour red, followed by orange and yellow (Chapanis, 1994 and Edworthy and Adams, 1996) when paired with the words danger, caution and warning (Braun and Silver, 1995). Rogers *et al*. (2000) maintain that there is some controversy about the conspicuousness with the colour red. Kline *et al*. (1993) reported that colour results in greater ratings of perceived readability and greater saliency of the warning. Braun and Silver (1995) conclude that is possible that the communication of the hazard is improved by colour.

Colour has also been associated with signal words and shapes. According to the ANSI committee, an oval filled with the colour red should be paired with the signal word *danger* and an elongated hexagon filled with the colour orange should be paired with the signal word *warning* (Young, 1998). No surround colours have been recommended for the words *caution* and *notice* (Young, 1998).

Shapes

Along with signal words, shapes are sometimes used to attract attention and to communicate hazard information (Young, 1998). Wogalter *et al*. (1995) report that shapes, other than a triangle with an exclamation point, have been found to have higher hazard association and may be more effective in communicating hazard level information. Young (1998) states that hazard information is communicated independently of the associated signal words or colour by surround shapes. Research has indicated that shapes can differ in terms of the hazard being communicated (Young, 1998). Diamond and octagon shapes, according to Collins (1983), denote more hazard than square and circular shapes do. However, the ability of surround shapes to communicate information about the level of hazard may not be significant, especially as they are currently used in the standards (Young, 1998). Dreyfuss (1972) also adds that most shapes are derived from the geometric forms first described by Faber Birren and that although Birren first discovered these

geometric shapes, other authors have made similar associations between shapes and other variables, such as colours.

Size

Attracting attention to a safety sign can also be achieved by increasing the size of the warning in the sign (Rogers *et al.*, 2000). Barlow and Wogalter (1991) state that the encoding of warning information has been shown to be influenced by the physical structure of the sign, such as the size of the warning, as they found that perceived noticeability of the warning relative to the size increased due to an increase in the size of the warning in the sign.

Display of Signs

There are a number of ways in which safety signs can be displayed in industries due to the increase in technology (Wogalter and Young, 1991). The only conditions stipulated by Ayres *et al.* (1989) for the display of warning signs is that they should be adequately conspicuous, brief, understandable and easy to read for the target market.

COMPREHENSION OF SIGNS

The designers of safety signs need to bear in mind that individuals utilizing signs will not have the same level of reading comprehension (Rogers *et al.*, 2000). Some individuals may not speak the language or have adequate reading skills when observing a safety sign (Rogers *et al.*, 2000). Laughery and Brelsford (1991) propose that the intended reading level for safety signs should be between the fourth and sixth grades, but these authors do not supply the empirical evidence regarding the appropriate reading level for warning information. Rogers *et al.* (2000) assert that little empirical evidence exists to affect person variables, but suggest that the intelligence and technical knowledge of the user should also be considered to impact the comprehension of safety signs. From some industry visits conducted by the principle investigator of this study, it was reported by managers that due to the illiteracy of many industrial employees in South Africa; the comprehension of safety signs in the country is very low. Workers are trained as to what the signs designate;

however, the number of injuries that occur as a result of not complying with the signs is very high and therefore problems with the comprehension of signs is a major problem in South Africa.

Differences between various groups of users have been found when investigating the comprehension of symbols (Duarte and Rebelo, 2005). A significant amount of the research involved in comprehension uses university undergraduate students as participants, thereby eliminating other user groups when this research should be examining all education levels and groups (Duarte and Rebelo, 2005). The comprehension scores must also be evaluated using the comprehension criteria of ANSI Z535.1-5 (1991) and ISO 3864 (1984) standards, where the ANSI stipulated that in order for the comprehension of safety signs to be seen as effective, participants must correctly recall 85% of icons in the given tests (Hancock *et al.*, 2004). Wolff and Wogalter (1998) conclude by asserting that research has shown that comprehension scores on tests are impacted by test characteristics and the material used and several studies have shown that common ANSI symbols are typically associated with accuracy rates below 85%.

MEMORY AND LEARNING

Memory and learning are very important factors to consider in this study, as they will impact all the responses measured in this study. Without learning and memory, comprehension of symbols, colours, shapes and text cannot be assessed at the various levels. As soon as an individual thinks about what is required to remember a fact, memory is revealed. According to Johnson-Laird (1988), there are five things that the memory system needs to do; 1) it must register the experience and assess whether remembering the experience has any value; 2) a representation of the experience must be laid down; 3) the memory must be maintained for a period of time; 4) the memory system must recover the memory quickly and efficiently when needed which can be conscious or spontaneous and 5) the memory that was retrieved must be retained for a short time while the individual contributes it to thought.

Learning occurs as a result of an individual being able to complete a task or do something that they could not do before (Johnson-Laird, 1988). A fairly permanent change occurs, usually as a result of experience (Johnson-Laird, 1988). Learning occurs in a variety of commands, such as trial and error, following instructions or replicating what another individual has done. Through practice, the skill can be learnt further. Many skills become automatic, in that the individual can perform them without any conscious effort at all (Johnson-Laird, 1988).

Memory

There are different parts of the memory store. The two most important components of memory are the short-term and long-term stores. These store information at different rates and for different periods of time. Due to the nature of the tasks in this study, participants will utilize both memory stores.

Short-Term Memory

Information is maintained in the short-term memory (STM) store through rehearsal otherwise it is lost quickly (Reed, 1992). Information must be actively rehearsed otherwise loss will occur in 20 – 30 seconds; therefore verbal information must be rehearsed in order for it to be kept available in STM (Reed, 1992). When attempting to learn new information, this rapid rate of forgetting can be wearisome (Reed, 1992). STM can store a limited amount of information, about seven items (Reed, 1992) and this limited capacity impacts performance on a range of tasks (Miller, 1956). When an individual performs a number of activities, Reed (1992) proposes that the ability to perform these tasks is limited by the total amount of mental exertion that is accessible for distribution to those activities. Whenever an individual attempts to learn new information, make choices or solve problems, the STM can combine information from the long term store and the environment STM is also considered as an individual"s working memory (Reed, 1992). While an individual is remembering a fact, the working memory is the memory in use as the memory receives input from sensory channels (Wickens, 1984). Working memory is comprised of several different components: a central decision-making component that controls the whole system and can process a limited amount of data, a short-term component that stores visual or spatial data and a short-term component that is a store for speech

(Johnson-Laird, 1988). Broadbent (1984) composed a theory ("Broadbent"s original model"), and one of the corollaries of this theory is that the limited ability of an individual"s memory for remembering telephone numbers and binary digits, for example, is dependent on how much material the individual can repeat during a period of two to three seconds. When no attention is paid to the working memory, information stored here will degrade and the memory will deteriorate (Wickens, 1984). The capacity is usually extended to about seven words, but Baddeley (1974) asserts that performance decreases as the number of syllables in words increases. Due to the fact that visual shapes cannot be rehearsed unless they are named, the ability to remember them is much poorer. Many researchers have conducted memory tests assessing the ability to remember visual shapes. Zhang and Simon (1985) conducted a study where they asked Chinese participants to remember sets of two different sorts of written Chinese characters. These characters were parts of a full character, but one set had names and the other did not. The participants were able to remember about six of the characters with names, but not even three of the characters without names. Distractions may arise or individuals may not take time needed to consider warnings when there is a lack in working memory capacity at any given moment (Lesch, 2003).

Long-Term Memory

The storage of information occurs in the long-term memory (LTM) store and the information stored here is stored relatively permanently (Reed, 1992). Many psychologists have implied that when problems with remembering information occurs, it is the ability to retrieve information from LTM that is lost and not the information itself, as there never comes a point where no new information can be learned due to the LTM being filled (Reed, 1992). Although LTM has unlimited capacity, entering new information into this store is not always easily achieved (Reed, 1992). New information is entered into the LTM store through learning, which is discussed later. According to Reed (1992), adding information into the long-term store and retrieving the information through the use of effective retrieval strategies determines whether learning has been successful. Direct tests of memory include recall and recognition tests, the instructions of which refer directly to material that has been presented previously in that these tests make reference to a particular

event in the person‟s past as they require the individual to recall or recognize events that took place earlier (Reed, 1992). Indirect memory tests assess whether material that has been presented previously aids individuals in performing better on tasks that do not refer to previous material (Reed, 1992).

Memory and Visual Images

Images are typically recognized easier by people than words are and this may indicate that visual imagery might provide an efficient memory code (Reed, 1992). Shepard (1967) was one of the first researchers to demonstrate that the recognition accuracy for visual materials is fairly high. The experiment consisted of participants viewing 612 pictures at their own pace. The participants then had to complete a recognition memory test on pairs of the pictures, where each pair consisted of one new picture and another they had seen previously. This test occurred two hours after they had been exposed to the pictures and the results showed that the participants‟ ability to identify which picture they had seen was almost perfect. A week later, the participants were tested again and were still able to identify in 87% of the pairs, which picture was correct. Shepard (1967) states that due to the test being easy, the performance of the participants was high as it would be possible to remember very little about a picture, but still be able to say which of two possibilities had been presented. With this in mind, the same test was repeated, but in this case words were used instead of pictures and the recognition accuracy was not as high. Participants tested immediately after being exposed to the words could indicate which of the two words had been presented to them only in 88 of the 612 pairs. After a week had passed, the performance of the participants was similar. Wickens (1984) adds that the rate of decay is faster when more items are held in the working memory.

Visual images may be used as memory codes; however, many people have trouble using the images to identify the parts of a pattern even if the pattern was just presented to them (Reed and Johnsen, 1975). Receiving visual input does not necessarily imply that visual images will be produced by the memory and also, visual images can be clearly produced from non-visual sources (Wickens, 1984). According to Reed (1992), both positive and negative outcomes are supplied by studies

illustrating the limitations of visual images. The negative aspect is that the use of visual images for improving memory performance is not a universal solution and the positive being that even if an individual is given a poor image, the image they form in their memory may still be adequate to perform the many other tasks that do not require immense detail.

Memory and Text

A great deal of the information learned is dependent on the ability to understand material that is written (Reed, 1992). Studies have shown that comprehension is impacted by a number of factors that demonstrate the ease with which integration between what an individual has read and what they are reading occurs (Reed, 1992). The first factor deals with whether a person reading material can relate any newly acquired information to ideas that are expressed in the text. According to Kieras (1978), research has shown that when sentences contain new information, recalling ideas is much harder than if the sentences referred to previous information. The second component deals with whether ideas that were expressed previously must be recovered from LTM or whether they are still active in STM as Glenberg *et al.* (1987) and Lesgold *et al.* (1979) have shown that when ideas are still active in STM, comprehension is thought to be easier. The third factor deals with whether newly acquired information can be inferred to previous information or whether the person reading the material concludes the relation. Haviland and Clark (1974) have shown that when inferences must be made, comprehension is slowed down.

According to Paivio (1997), the Dual Coding Theory proposes that information that is encoded both symbolically and verbally improves memory because memory is maintained by the other code when one code is lost or unavailable. Robinett and Hughes (1984) reported that symbols cannot realistically exist exclusively as a way of communicating information in safety signs and therefore must be paired with signal words due to the complex nature of many hazards. Davies *et al.* (1997) and Wiseman *et al.* (1985) report that researchers have recommended that memory will be improved further when text and symbols are combined, as the description provided by the text supplies supplementary information. Therefore, according to Young and Wogalter (1988), pairing symbols with text results in an association

occurring in memory and the icon could assist recall by cueing the textual message from memory when the individual is re-exposed to the sign.

Learning

Johnson-Laird (1988) asserts that when an individual learns a fact, an experience is laid down in memory that can be called to mind when required. Learning cannot occur unless some experience already exists as learning processes cannot be constructed out of thin air (Johnson-Laird, 1988). Theorists have suggested that all learning is dependent on associations, in that one experience becomes associated with another (Johnson-Laird, 1988). Associations are defined by Johnson-Laird (1988) as links in the brain that lead from one thing to another, linking one stimulus to a number of responses with different possibilities that are dependent on the strengths of the links. The ease with which all behaviours are learned is different and sometimes, learning can happen without any immediate changes in behaviour (Johnson-Laird, 1988).

Cognitive scientists have developed a number of theories as to how learning might occur. Some have created computational models of human learning, while others have sought after a universal procedure (Johnson-Laird, 1988). According to Johnson-Laird (1988), one thing that is apparent is that there is a need for more effective learning programs as learning must occur in a reasonable amount of time. Atkinson and Shiffrin (1968) created the “Atkinson-Shiffron Model” and several control processes have been proposed by this model. These processes are thought to be utilised when attempting to learn new information. Atkinson and Shiffrin (1968) define control processes as strategies that an individual requires the assistance of when gaining and retrieving knowledge. Strategies used to acquire knowledge include rehearsal, coding and imaging. Repeating information over and over, either aloud or silently, until it is learned is known as rehearsal. Placing the information in the context of additional information that is easily retrievable, such as a sentence for example, is known as coding. Remembering verbal information through the creation of visual images is known as imaging. These three control processes are the three main learning strategies. “Rote learning” is another learning strategy and this involves repeating information over and over until is it thought to be learned. This is

also known as verbal rehearsal and can be of use when abstract material must be learned as abstract information makes the use of coding or imaging very difficult. These control processes govern how memory can be used to learn information.

PERFORMANCE

Learning must occur over time and because of this, there are many factors that must be considered, such as age, education levels and testing time of day. For this study, young and old adults were recruited as participants and therefore different learning times, reaction times and response times had to be reviewed carefully so these criteria were well understood, should any differences between the age groups occur.

Learning Time

All individuals require different amounts of time to learn information. Younger and older individuals learn at different paces due to processes in the brain occurring at different rates, and therefore, age-related differences must be considered.

Age-Related Differences

Age has an impact on whether safety signs are noticed (Rogers *et al.*, 2000). According to Rogers and Fisk (1990), in order to analyse age-related differences in learning, it is important to consider that learning occurs with practice. In other words, if it is not ensured that the amount of learning across all age groups is equivalent, then the functions of reaction time will co-vary with the degree of practice. The course of development and aging is characterised by the ability of an individual to store and reproduce new information (Rogers and Fisk, 1990). This process is thought to typically follow a curvilinear trend characterised by improvements in memory from childhood to early adulthood and a steady decline from the twenties to old age during the course of development and aging (Mohn and van Hof-van Duin, 1991 and Slapater, 1950).

The Complexity Hypothesis has been proposed to explain the age-related differences in learning and performance (Rogers and Fisk, 1990). This hypothesis states that aging results in an increase in the amount of time needed to perform

mental processes, therefore, as the complexity of a task increases, so do the number of mental processes that are involved in the task (Rogers and Fisk, 1990). According to Light (1991) and Moscovitch and Winocur (1992), problems with memory can be observed frequently in participants over 50 or 60 years of age, even when no neurodegenerative illnesses are present. Newell and Rosenbloom (1981) have reported that the fact that performance improves with practice is a common characteristic of human behaviour; however Schneider and Fisk (1982) argue that the nature and degree of the improvement depend on how consistently a participant deals with the task. The bottom line, according to Fisk *et al.* (1988) is that with regards to improvement as a function of practice, young and old adults will differ, therefore, for some tasks there still remains the possibility that the function relating to the performance of young and old adults will change with practice. All the findings of the authors mentioned above show that when comparing young and old adults, the practice effects should be considered otherwise combining mixed levels of practice could be problematic (Rogers and Fisk, 1990).

There may be an improvement in the comprehension of safety information for older adults when the same information conveyed through an icon is presented in textual form (Hancock *et al.*, 2004). Craik and Salthouse (1992) contend that older individuals may experience impairments in their visual, memory and text comprehension which could result in difficulties in the comprehension of text messages. Apart from being exposed to safety signs at work, research has shown that older adults have continued exposure through the use of household products that contain symbols (Hancock *et al.*, 2001) and therefore, it is important that these individuals are able to interpret the symbols correctly (Hancock *et al.*, 2004). It is important to have an understanding of how individuals of different ages process safety information as a great deal can be learned from comprehension studies involving older individuals in terms of how age impacts specific cognitive processes (Hancock *et al.*, 2004).

Time of Day

According to Winocur and Hasher (2004), the time of day that participants are tested at will impact their cognitive functioning. This is due to a wide range of behavioural

and physiological processes that occur in different individuals at different times (Winocur and Hasher, 2004). These processes include different sleep-wake cycles, eating and drinking patterns, brain glucose uptake and neurotransmitter production (Winocur and Hasher, 2004). In a number of studies conducted by Winocur and Hasher (2004), young adults were found to perform better in the afternoon than in the morning, whereas older adults performed better in the morning than in the afternoon.

Reaction Time

According to Rogers and Fisk (1990), literature has shown that all human responses decrease with an increase in age. The response of an adult in their 20s is approximately 20 -100% faster than that of an adult in their 60s (Rogers and Fisk, 1990). According to Welford (1977), theorists have proposed that the rate at which age-related slowing occurs is constant and not dependent of the task being performed. Cerella *et al.* (1980) and Cerella (1985) however argue that the degree of difference between old adults and young adults changes as a function of the task complexity. Other factors that have been found to affect age differences in reaction time, according to Rogers and Fisk (1990), are the amount and type of practice for the task as well as how the task is structured.

According to Wickens (1984), simple reaction time in the laboratory is measured by providing a participant with a stimulus for which a response must be made as soon as the stimulus occurs. There may or may not be a warning provided to the participant as to when the stimulus will occur. The reaction time for an auditory stimulus is approximately 30 – 50 msec faster than for a visual stimulus, with the reaction for an auditory stimulus being measured at about 130 msec and 170 msec for a visual stimulus (Woodworth and Schlossberg, 1965).

Response Time

According to Ratcliff and Rouder (1998), the time taken to reach a decision boundary as well as encode and execute is known as the response time. Making choices and decisions is a part of everyday life and plays an important role in tasks used to study basic cognitive functions that include language comprehension, memory and

perception (Ratcliff and Rouder, 1998). The two important components about the decisions made by people are that firstly, they happen over a period of time as decisions are never reached immediately, and secondly, the decisions made are prone to errors (Ratcliff and Rouder, 1998). The reason as to why decisions occur over time is that information must first be accumulated and this accumulation is not constant over time, but varies instead. Response time is also impacted by age. The Complexity Hypothesis mentioned previously also states that the complexity of the task is proportional to the magnitude of the age differences (Rogers and Fisk, 1990). This causes a greater increase in the overall time required to complete the task (Birren, 1965 and Salthouse, 1982). Response time is related to accuracy, but this relationship is not fixed and varies according to whether the individual must perform the task with speed, achieve high accuracy or whether one of the two is more important than the other in the task (Ratcliff and Rouder, 1998).

Error Rate

According to Wickens (1984), the recall measure of performance has been used in a great deal of research on working memory and addresses the process of memory storage. In most recall measures of performance, participants are required to repeat or write down whatever material remains available in their memory for comparisons to be made (Wickens, 1984). According to Johnston *et al.* (1972), accuracy, latency and ease are the three components of recall that must be considered. Recall accuracy and latency are dependent variables in most memory research; recall ease has not received the same amount of attention as a parameter of recall (Johnston *et al.*, 1972). Authors such as Coughlin (1990) and Brown *et al.* (1991) claim that factors such as the time that elapses since the event occurred, as well as the significance of the event to the individual affect the precise recall memory of a participant to an individual or newly learned information. West and Crook (1990) add that age also impacts recall memory. These three components of recall are different, but need to be compared empirically (Johnston *et al.*, 1972).

The ease at which information is recalled can be defined as the degree to which the retrieval of the information occurs or utilises the processing capacity (Johnston *et al.*, 1972). Because of this, the accuracy, speed and requirements of the processing

capacity can vary according to the process of searching the memory for target information (Johnston *et al.*, 1972). Routh (1971) showed that including extra requirements in the task, such as writing down information can increase the number of errors when the participant must read the information to store it to memory, whereas presenting the information visually or vocally to the participant had virtually no effects on the recall of information.

LANGUAGE

Language has proven to be a key concern with regards to training and the comprehension of safety signs, as was noted during the industry visits conducted. Research has shown that an increasing number of minority populations have inadequate experience with English as their primary language (Mosenthal and Kirsch, 1989). However, Hancock *et al.* (2004) argue that the knowledge of the English language to correctly interpret symbols is not a major problem for non-native English speakers. The biggest problem concerning language and safety messages, according to Wogalter and Silver (1995), is the use of signal words. Non-native English speakers may not be able to discriminate between the signal words in the same manner that native English speakers would. The problem that arises from this is that it would not be feasible to provide warnings in every language and nationality (Wogalter and Silver, 1995). It is also important to consider that with respect to comprehension of signal words; non-native English speakers, children and the elderly are less likely to understand terms than more highly skilled English speakers can (Wogalter and Silver, 1995).

EDUCATION

Education has also been said to be very important when considering the comprehension of safety signs. A wide range of literacy and education levels is present in the South African workforce. According to Mosenthal and Kirsch (1989), it has been demonstrated through large scale surveys that as many as 58 million adults in the United States of America experience difficulty in performing successfully in literacy tasks associated with various social context. Provenzo (1986) maintains that illiteracy is becoming a problem due to the rising literacy demands as society shifts from a manufacturing to an information-based economy. Elementary,

secondary and post-secondary schools have not acknowledged the changes in literacy definitions, particularly as they occur in industry (Provenzo, 1986). Mikulecky (1982) recognized that the literacy skills taught in school are far different from the literacy skills required to function in society and the gap between the two continues to widen. According to Kosmidis *et al.* (2006), when comparing the performance of literate and illiterate individuals on a cognitive task, the main question that arises is the potential effect of education. Apart from being taught to read and write, school also trains other skills; such as vocabulary, working memory and associative learning and these skills improve the more an individual improves their education (Kosmidis *et al.*, 2006). The problem that illiterate individuals seem to face when completing cognitive tasks is processing information based on its phonological characteristics due to not having the knowledge of the symbolic representation typically attained in education systems (Castro-Caldas *et al.*, 1998). Hancock *et al.* (2004) argue that although illiterate individuals may encounter some difficulty in understanding the different types of safety messages if detailed text is used, their comprehension for iconic information may be higher.

FAMILIARITY

Ecker *et al.* (2007) define familiarity as a sensation of having come across a person or specific object without consciously accessing the contextual details, such as the place or time of the meeting. Other authors, such as Langley *et al.* (2008) and Turner (2008) define familiarity as a sense that something was present recently without the retrieval of specific components and the detailed knowledge of something or someone, respectively. With regards to safety warnings, familiarity is the sensation of having previous experiences with a warning (Rogers *et al.*, 2000), where the knowledge of the environment becomes more detailed, accurate and integrated as familiarity increases (Iachini *et al.*, 2009). Research has shown that familiarity is an automatic process (Ecker *et al.*, 2007) and has positive implications for safety signs in that it has been shown to increase with an increase in the comprehension of signs (Davies *et al.*, 1997). There is no direct measure of familiarity, as it is a sensation or feeling that improves as the comprehension and compliance with warnings increases (Rogers *et al.*, 2000).

Rogers *et al.* (2000) declare that familiarity has an effect on whether a warning is noticed by an individual in a number of ways as it result in a decrease in the likelihood of noticing a warning; but on the other hand, familiarity can also result in an increase in the likelihood of noticing warnings as people will be more frequently exposed to the situation (Rogers *et al*., 2000). With respect to safety signs, high comprehension scores have been reported for signs that participants were familiar with and according to Duarte and Rebelo (2005), this could indicate that comprehension scores can be improved with training, but the same is also true for the opposite. Duarte and Rebelo (2005) conclude by reporting that other signs that had low familiarity among participants also obtained high comprehension scores and from this, it was concluded that a sign that is well designed is more likely to succeed than one that is popular but not well designed.

CULTURE

Colour has had different meanings to different cultures since the beginning of time (Dreyfuss, 1972). Examples are royal purple robes from ancient Greece and red being used for the red carpet rolled out for diplomatic events (Dreyfuss, 1972). Dreyfuss (1972) asserts that the robe and the carpet in the above mentioned examples each indicate their own message by virtue of their colours and without the colours, the messages are no longer there. Some other examples include the cultural significances of some of the colours used in this study. In Egyptian culture, purple symbolises virtue and faith while symbolising grace and nobility in the Japanese culture (Dreyfuss, 1972). Brown connotes the Earth and dignity in the Japanese culture as well (Dreyfuss, 1972).

CONCLUSIONS

There are many variables that need to be considered when investigating the design of safety signs. Variables such as colours, shapes, text and symbols have been tested by various authors in different ways. Symbols have been investigated extensively through comprehension tests and many factors impact the comprehension of safety signs, such as memory, learning and familiarity. Regardless of the vast amount of literature on safety signs, research assessing the impact of age and the level of education on the learning of safety signs is limited. There is also a

lack in the amount of research conducted in Industrially Developing Countries, such as South Africa, where illiteracy and many languages prove to be major concerns. Not addressing these issues may only result in the continued increase of injuries that occur in workplaces as a result of not complying with safety signs due to a lack of comprehension.

CHAPTER III

METHODOLOGY

INTRODUCTION

The aim of this study was to investigate the effects of the different attributes in safety signs and to determine how these attributes affected learning and familiarity. This study shall assess the ability of participants to learn and recall the different attributes of safety signs, where characteristics such as colours, shapes, text and symbols were varied. The main concept of this study was to assess whether the attributes of the signs (colours, shapes, icons or text) affected how participants learned and recalled the information, how repeated learning would affect the responses measured and what attributes in the signs were easier to learn, with age and education as considerations.

EXPERIMENTAL DESIGN

Before considering the experimental design of this study, a few visits to industries in the Eastern Cape Province of South Africa were conducted in an attempt to understand how companies in South Africa decided which signs would be placed in their workplaces and how these companies trained their employees to comply with the signs. In a few of the industries it was discovered that the Health and Safety Officers selected the contents of the signs and in some cases, designed the signs themselves. The signs would then be sent to external companies for manufacturing and the Health and Safety Officers would place the signs in the workplaces. It was also discovered that no standard procedures and guidelines were used to design the safety signs and the companies designed the signs according to what they deemed to be appropriate and necessary for inclusion in the signs.

Message

Signs

Safety signs that are utilized in industries today were thought to be more complicated to use to train the participants appropriately; therefore the signs used in this study

were designed by the principle investigator and were designed to contain different scenarios and message. The pool of signs used for testing could not include any of the signs that presently exist in industries or any symbols, colours or shapes that are included in signs that have already been commercially designed. The use of existing safety signs could also have lead to participants making associations as they might have already been exposed to the signs and this could lead to a learning transfer. This would result in these participants having an unfair advantage over participants that had not been previously exposed to any safety signs, thus making the results inaccurate.

Due to the reasons mentioned above, the signs for this study did not include common dangers that are already encompassed in existing signs, so that no confusion or learning transfer could occur. The signs were designed in a way that a fictitious, but reasonable and realistic danger or behaviour was conveyed. The signs were safety specific and incorporated dangers from a range of different industries, such as the textile, catering, farming and automobile industries, to name a few. The colours, shapes and symbols were selected by the principle investigator and each was assigned a specific meaning (Appendix B2). Participants were expected to learn these attributes and their meanings and were later tested on them through exposure to the pool of signs. The signs included a combination of colours, shapes, symbols and text as Lesch (2003) states that safety signs used in industries contain a combination of these attributes.

An issue that arose was how to incorporate all the attributes into the test signs. At first, it was thought that symbols should be tested versus text as this would result in two testing conditions. However, due to the above statement from Lesch (2003), it did not seem that this would provide a true representation of safety signs, as often symbols and text are used in combination. Therefore, in this study, colours, shapes, icons and text were tested as equally valid attributes. It was also decided that the incorporation of colours and shapes would result in a larger pool of test signs. This would also result in a larger number of combinations that could be made with the different attributes.

Testing

A minor objective of this study was to try and ensure that the participants would get as familiar with the signs as soon as possible. It was decided that each participant would undergo a training session where they would have to learn a certain number of signs and after the learning session the participant would be asked to recall the signs they had previously learned (Reed, 1992).

Associations

Due to this study requiring individuals to learn new information, it was expected that associations would occur during the learning process, therefore before the signs could be designed and the protocol considered, it was important to establish what associations, if any, individuals made with certain colours, shapes and symbols. A sheet containing about 10 – 15 shapes, colours and symbols was set to be distributed to students to establish if they associated the attributes on the sheet with any objects of experiences. From this, it would be possible to determine which attributes could and could not be used in the study. From the literature, it then became clear that people generally made associations on a regular basis and therefore it would not be possible to exclude of these associations in the study. The resolution was that simple forms and colours that are not included in existing safety signs and symbols that individuals could not normally recall or would not be able to make direct associations with would be used to design the signs for the study.

Language

Another discovery from the industry visits was that industries did not account for every language spoken by their employees when training the individuals. The training was completed in English and the workers had to adjust to the language being used. Therefore, it was thought that the language in this study would be controlled as introducing different languages would result in the results being impractical as very few any signs in South African industries are printed in any of the eleven official languages, yet, workers must be able to read the signs provided in their working environments. If the participants were tested in their native languages, it would result in the need for the principle investigator and other researchers to be able to speak the same language as the participants, which would not be possible.

Finally, it was determined that in order to make the results more reliable, the participants would be given the instructions in their native language. The reasoning behind this was to ensure that participants were as comfortable with the testing procedure as possible and that they fully understood what was expected of them. The learning of the signs and the testing were conducted in English as this was thought to be more practical, as the study was focusing on the ability to recall what had been taught, not interpret the information. It was also thought that the difficulty to store and recall information would be the same in English as it would be in their native language. Also, Hancock *et al.* (2004) have maintained that the ability to correctly interpret symbols is not a problem for non-native English speakers as their comprehension for symbolic information may be higher than when detailed text was used for different types of safety messages. This protocol seemed to be the best manner in which to mirror the training situations conducted in the industries visited.

Participants

It was decided that a minimum requirement for the study would be that all participants had to be literate. Johnson-Laird (1988) stated that nothing new can be learned unless the individual already possesses some abilities as learning processes cannot be constructed out of nothing. Therefore, this requirement was set as illiterate participants would not be able to study text-based information due to the inclusion of text in the signs and many industries require that their employees be literate. Initially, only Grade 1 employees from a university population would be recruited for the study. Grade 1 workers at the university were classified as individuals that do not have tertiary education, but have however completed their secondary schooling. The use of the Grade 1 employees arose from the industry visits as the employees in the industries matched the Grade 1 employees from Rhodes University in culture and in educational background.

Older participants with a higher education level were later included in the test sample so that the researcher could compare the ability to recall and store information between individuals with higher and lower education levels. Another reason for this inclusion was that obtaining results from the Grade 1 employees would demonstrate where their level of comprehension was, but without having a test group for

comparison, the deficit in the comprehension scores would not have any practical meaning. For a developing country such as South Africa, this proves to be very important as Kosmidis *et al.* (2006) argued that the importance of comparing the performance of literate and illiterate individuals on a cognitive task was to question what the potential effect of education was. Another reason as to why individuals with a higher level of education were included in the test sample was that the aim of the study was not to investigate literacy, but rather the comprehension of individuals with different education backgrounds. Students from Rhodes University and younger workers were later included in the test sample to test the effects of age on the comprehension of the signs. This resulted in the test sample consisting of young and old participants, making the participant sample more representative of the worker populations in industries. Duarte and Rebelo (2005) stated that the majority of the research investigating comprehension makes use of undergraduate students as participants thereby eliminating other user groups, when research in this field should examine all education levels and groups, which was what this study accomplished.

The participants were placed in groups that correlated to the conditions being tested. Four factors needed to be considered when placing participants into groups and these factors were race, gender, age and education. Due to the increase of female workers in industry and the lack of data on female responses during ergonomic tasks, it was initially thought that 50% of the sample would male and 50% female, so that no gender issues arose and the groups would also be more representative of the working population. Each group would also be assigned one male and female with a high level of education and one male and female with a low education level, resulting in four different participant groups. This resulted in about 16 – 20 participants per group, because of the four participant groups. Female participants were later excluded from the sample group as the number of female participants recruited did not match the number of male participants due to problems encountered recruiting females residing and working in the Grahamstown area. Age was also deemed to play an important role in recall as older individuals working in industries must also be able to understand the safety information provided to them. The age and education differences produced four different groups.

It was decided that the level of education and age range of the participants should be incorporated into the same group. The participant groups were then divided as follows:

Table I: Testing groups for study.

GROUP 1	**GROUP 2**
Old and High education level	Young and High education level
GROUP 3	**GROUP 4**
Old and Low education level	Young and Low education level

The groups seen in Table I were the final testing groups to be used for the study, where Group 1 would consist of participants in the older age range and with a high level of education and Group 2 would consist of participants in the younger age range and high level of education. Participants with a low level of education and in the older age range would be in Group 3 and participants with a low level of education and in the younger age group would be in Group 4.

Young participants were limited to the range of 18 – 30 years and old participants were limited to the range of 40 – 65 years of age. The reason behind selecting the range of 18 – 30 years was to include the overall age range of workers in industries, but this age range also allowed for some distinction between the older and younger participant groups. The range of 40 – 65 years of age was chosen as Moscovitch and Winocur (1992) and Light (1991) declared that this age range was seen as the range where impairments in memory and recall functions would occur even without the presence of neurodegenerative illnesses.

Culture

Although the significance of colour in different cultures was mentioned in Chapter II, it was decided that culture would not be considered explicitly due to the great number of different cultures in the South African population. As mentioned previously by Dreyfuss (1972), every colour signifies something different in each culture and

therefore any colours used would result in some association to cultural significance. Symbols were also thought to have the same impact on culture. Culture can never be excluded in anyway. Therefore the signs were designed in a manner that allowed the signs not have any cultural links, by not using any unusual colours, shapes or icons.

Mental Workload

Mental workload was not measured in this study as the aim was to assess if individuals could learn and recall the information presented to them. Cognitive processes such as eye blinking and other physiological processes such as heart rate and heart rate variability (HRV) were also not measured. HRV could have been an interesting addition to the study, as it could have given an indication as to which signs were more difficult to learn and recall, by assessing the increments in heart rate and comparing them to a baseline reference. There were many conditions to consider in the experimental procedure; therefore it was important to ensure that the more important conditions were given the adequate and necessary attention to ensure that the results of this study were reliable and accurate.

Safety Sign Attributes

The test signs included a combination of colours, shapes, symbols and text and these attributes were thought to best represent different messages in the test signs. The main problem that arose was how these attributes could be represented in the signs to measure performance and how many colours, shapes and icons to include in the test signs. It was decided that three colours, three shapes and three icons were going to be used to design the test signs. The reason for choosing three of each attribute to test was that opting to design signs using two colours, shapes and icons would result in the test being too trivial. The use of four or five colours, shapes and icons would have resulted in the test pool being too large and the test being too complicated, therefore three colours, shapes and icons were tested.

Table II: Variation of three attributes.

CONDITION	SHAPE		COLOUR		ICON	
	Yes	No	Yes	No	Yes	No
1		X		X		X
2	X			X		X
3		X	X			X
4		X	X		X	
5	X		X		X	
6	X		X			X
7	X			X	X	
8		X		X	X	

*Key: Yes = attribute was included in the test sign

: No = attribute was not included in the test sign but was displayed in text form

Table II shows how the different attributes were varied in the test signs. This resulted in eight different testing conditions, where the signs in Condition 1 would not have a colour, shape or icon. The signs in Condition 2 would have a shape, but no colour or icon. Condition 3 would result in signs that had no shape or icon, but did have a colour and Condition 4 would result in signs with a colour and icon, but no shape. Conditions 5 would consist of signs with a colour, shape and icon, whereas Condition 6 would consist of signs with a colour and shape, but no icon. The signs in Condition 7 would have a shape and an icon, but no colour and the signs in Condition 8 would have an icon but no colour and shape. Whenever the attributes were not included in the signs, text would be used in place of the missing attributes.

Table III shows how the shapes, colours, icons and text were varied in each condition. The shape, colour and icon in each sign designated a certain safety message in the sign. The shape represented the instruction, the colour represented the level of the hazard and icon denoted the type of hazard. Each sign had one of the three attributes present, therefore every sign informed the participant what the hazard was (icon), how dangerous the hazard was (colour) and gave them an instruction to follow to avoid the hazard (shape).

Table III: Variation of shape, colour, icon and text in each conditions.

CONDITION	INSTRUCTION	LEVEL OF HAZARD	TYPE OF HAZARD	ABBREVIATION
1	Text	Text	Text	TTT
2	Shape	Text	Text	STT
3	Text	Colour	Text	TCT
4	Text	Colour	Icon	TCI
5	Shape	Colour	Icon	SCI
6	Shape	Colour	Text	SCT
7	Shape	Text	Icon	STI
8	Text	Text	Icon	TTI

The permutation of the three different components of the three attributes with each other resulted in 27 different messages being conveyed. Combining the 27 messages with the 8 conditions resulted in a pool of 216 signs. It did not seem to make sense to use only certain signs for certain groups, therefore it was decided that each group would be tested using all eight of the different testing conditions. This would ensure that proper comparisons could be made in that all participants would be exposed to the same combinations of test signs and the effects of age and education on learning, comprehension and familiarity could be assessed.

Display of Signs

The signs were designed and then printed out on paper so that the different groupings could be decided upon. Once the groupings were figured out, it was clear that the signs could be shown on Microsoft PowerPoint® as a slideshow, rather than shown to participants on paper. This enabled the principle investigator to control when the signs were displayed according to the pace at which the participants recalled the necessary information.

The time in which the signs were displayed was the next critical component that needed to be considered. The display time of the signs would be the amount of time that the participants were exposed to the signs. This would be an indicator of perception and so it was decided that half the participants would be exposed to the signs for an unlimited amount of time and the other half would be exposed to the signs for a few seconds. This was done because it was noted during the industry

visits that in some industries, safety information is displayed in electronic visual displays and is only available to the workers for brief periods of time. Also, safety signs are often only viewed for a short while as workers in industries do not read the signs for extended periods of time. Another reason as to why this was done was that during the pre-pilot testing, it was also discovered that the text in the signs was easier to read and recall and as a result, had an advantage over the shapes, colours and symbols. Therefore, the signs that would be flashed for a short period of time would be displayed using Occlusion Technology (OT) as this was deemed to be the only way in which perception time can be controlled. Occlusion was configured by using the "Custom Animations" feature in Microsoft PowerPoint® 2007. This was achieved by using the "Add Effect" tab, followed by the "Appear" tab, then by setting the timing to a delay of 0.5 seconds. Using this method of display may have added another level of difficulty, but this was overcome by showing the sign over and over until the participant had recalled all the information in the sign that they were expected to recall. This resulted in two different groups for the test signs, where half the participants would be tested using signs "With Occlusion" and the other half using signs "Without Occlusion". This was thought to be the best manner in which to test these particular signs and the only conditions stipulated by Ayres *et al.* (1989) for the display of warnings signs is that they should be adequately conspicuous, brief, understandable and easy to read for the target market. The participants in each group were permutated as to whether they were tested using the signs "With Occlusion" or the signs "Without Occlusion". These permutations can be seen in Appendix A5. Both sets of signs had the same number of signs and contained the same number of long and short text signs. 24 out of the 64 signs used in each set contained long text and 40 contained short text. 64 signs were tested as this number is a multiple of eight as there were eight different conditions. Each condition was repeated eight times to make the total of 64 signs and the conditions were permutated for each of the eight repetitions so that no systematic pre-conditioning effect from the conditions or protocols could occur (Appendix A4). 64 signs also allowed for the responses to be measured in eight blocks of eight to show if any learning trends occurred.

INDEPENDENT VARIABLES

The independent variables in this study were the attributes of the signs, the learning time and the level of education of participants. Each attribute represented a different part of the sign and these were varied to create different messages and types of signs.

Symbols

The symbols used, which can be seen in Figure 3, were chosen by the principle investigator as they were thought not to bear any resemblance to or representative of any symbols used in existing signs so that no associations could be made to existing symbols.

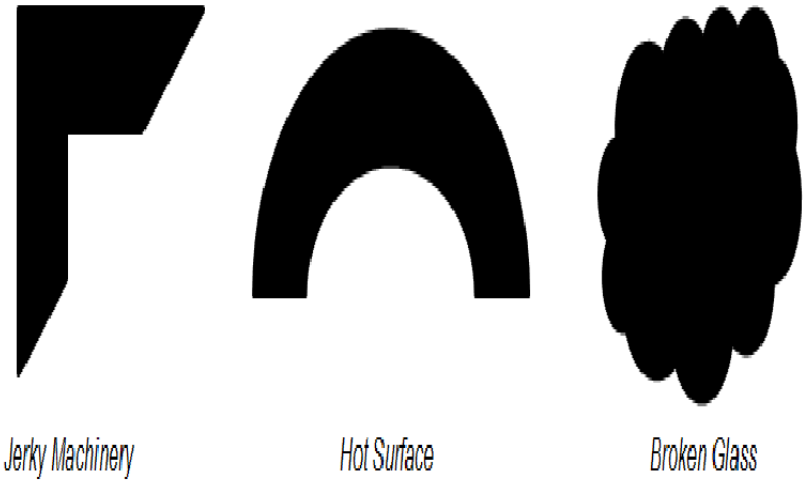


Figure 3: Symbols used to convey the type of hazard in the test signs

From Figure 3 it can be seen that the three types of hazards included in the signs were “Jerky Machinery”, “Hot Surface” and “Broken Glass”. Davies *et al.* (1997) stated that guidelines for the design had been suggested by a few publications, which recommend that symbols should be simple, realistic pictures that should be included with limited content, background space and that size and magnifications should be used appropriately (Mansoor and Dowse, 2004). The symbols in Figure 3 met these guidelines in that they were simple and realistic pictures. The content that they were included with was limited and the background space, size and

magnifications were used aptly. The problem that may have been created with the use of these symbols was that the concepts that they represented may have been fairly abstract, which could result in individuals not understanding the information they represented. It is worthwhile to note that these aforementioned design guidelines are examples of how to design symbols in order to study learning and not guidelines for the actual design of symbols.

Colours

The colours were used to designate the level of hazard in the sign. The researcher chose three colours to denote three levels of hazard, which can be seen in Table IV.

Table IV: The levels of hazard represented by the colours.

COLOUR		LEVEL OF HAZARD
Purple		Danger
Pink		Warning
Brown		Caution

The major challenge encountered in the selection of the colours was to avoid using any colours used in existing signs, which eliminated almost all of the commonly known colours. Colours such as red, blue, green, black, white, orange and yellow can be found in several signs. The second problem was the association that colours have with culture, as discussed earlier and stated by Dreyfuss (1972). Therefore, the colours chosen for this study were purple, pink and brown, which were not found to have strong cultural links. As seen in Table IV, purple stood for *danger*, pink denoted *warning* and brown represented *caution*. The colours were linked to the signal words seen in Table IV through random selection and there were no scientific or cultural reasons as to why the colours were paired with the signal words. The signal words chosen to accompany the colours were selected as the pool of signal words is limited and mainly incorporates danger, warning, caution and notice. *Notice* was not seen to be a strong signal word and therefore was not included.

Shapes

Signs do not typically include an instruction, but for this study it was thought that the instruction should be included to provide an overall context of safety as the dangers

conveyed were somewhat abstract. Wogalter *et al.* (1985) also stated that when signs contained hazard statements, consequences and instructions, the signs were considered more effective than when any of these factors were absent.

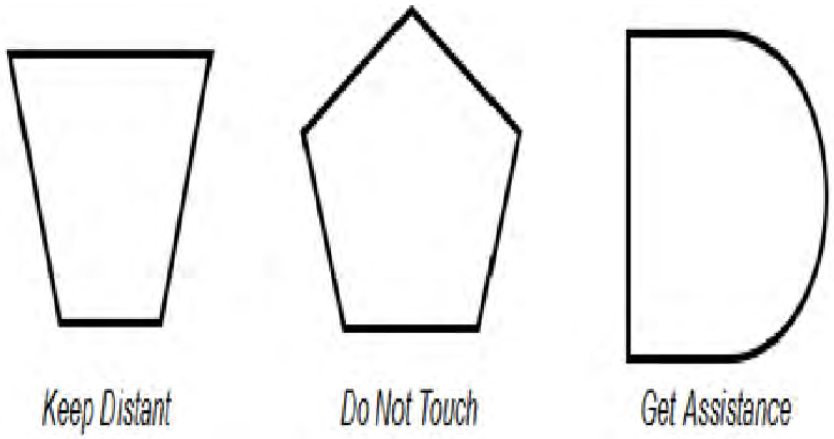


Figure 4: Shapes representing the instructions in the safety signs

The shapes in Figure 4 may resemble ones that are currently used in some existing safety signs. This was due to the fact that geometric shapes are limited in numbers and therefore it was impossible to avoid the resemblance, as Dreyfuss (1972) stated that most shapes were derived from the geometric forms first described by Faber Birren. These shapes were also selected as diamond and octagon shapes have been shown to denote more hazard than square and circular shapes did, as stated by Collins (1983).

Text

Text was used as a replacement when one of the other attributes was omitted; therefore the text represented the type of hazard, the level of hazard and the instruction when the respective attributes (symbol, colour and shape, respectively) were not present in the sign. From the pre-pilot tests, it was discovered that the shorter the message was, the easier it would be to see and recall, therefore the length of the text was varied. If the text were made shorter, it would have an advantage over the symbols, but if it were made longer then the symbols would have an advantage over the text. Therefore, some signs contained text with one to three

words in the sentence and other signs contained text with up to 10 words in the sentence. This would allow the investigator to investigate if the longer or shorter text contributed to differences in the responses and to encompass the inclusion of occlusion.

The font and size of the text were controlled and not investigated as different signs contain different fonts. The size of the text would primarily be dependent on the visibility of the sign.

Learning Time

Due to the impairments in vision, memory and comprehension with age described by Craik and Salthouse (1992), it was expected that there would be differences in learning time between older and younger participants. During the pre-pilot testing, old and young participants were tested and participants were given as much time as they needed to learn the signs. The learning time was recorded and from the results it was discovered that the participants, both young and old, took approximately the same amount of time to learn the given number of signs. From this, a decision was made that learning time would be controlled so that all participants would have the same amount of time to learn the same set of signs. Controlling the learning time also allowed for the researcher to study if a learning curve would occur during the testing period and this was achieved through the analysis of the different responses. The learning time recorded during the pre-pilot tests was two minutes; therefore this was set as the learning time for the experimentation.

Education

It was decided that the lowest education level that would be accepted for the study would be a Grade 10 qualification from a secondary education institution. Grade 10 was set as the minimum education requirement as this is the age that scholars can leave school and enter the workforce. Pre-screening was conducted to ensure that the participants in the lowed education group did not have a higher qualification such as a university or technikon diploma, but other certificates, from computer or artisan courses, for example, were allowed.

During the pre-pilot testing it was also tested whether individuals with lower education levels could learn and recall the proposed shapes, colours and icons to be used for testing. This was done to ensure that the testing protocol was suitable for all participants regardless of their education level. It was important to certify that individuals with lower education levels could complete the testing and learn all the necessary information and to ensure that the task was not too complex. It was also important to make certain that the test signs were not too simple for the individuals with a higher level of education. All participants used for the pre-pilot testing were able to complete the testing accordingly, therefore it was decided that all participants would be tested in the same manner.

DEPENDENT VARIABLES

The dependent variables in this study were the reaction time, response time and the accuracy of recall. These variables were assessed to test the hypotheses and eventually to give an indication of familiarity. Reaction time would give an indication of how long the participants took to see the sign and recall the information they had learned and the response time would indicate how long they took to recall all the variables in the sign. The error rates would signify which attributes were recalled correctly. Together these responses would highlight the level of familiarity and how well the participants knew the information in the signs.

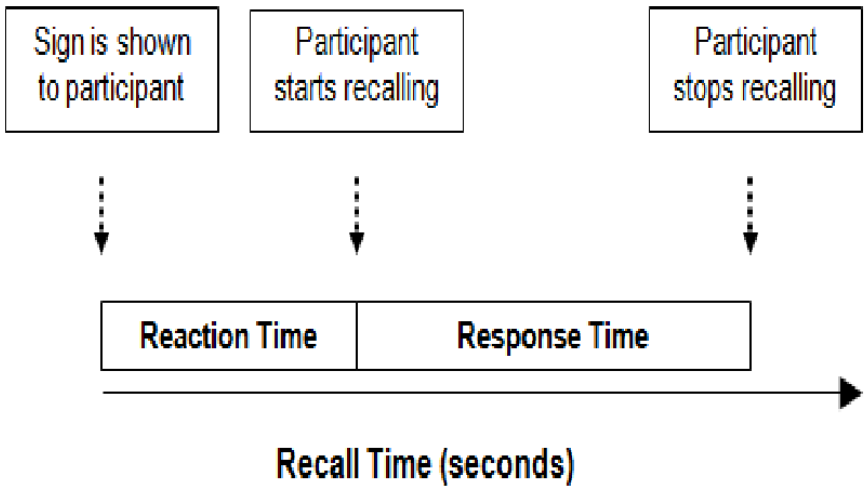


Figure 5: Measurement of reaction time and response time

Reaction Time

Reaction time was measured as it would imply which signs were easier to recall at first glance. Reaction time was measured as the time taken from when the sign appeared on the computer to the time the participant started recalling what was in the sign and was measured in seconds. The testing session was measured using a video camera and the reaction time was measured using the video recording and a stopwatch. The investigator started the stopwatch when the sign appeared on the computer screen and stopped the stopwatch when the participant started recalling the first variable, as seen in Figure 5.

Response Time

During pilot testing, it was noted that some participants started recalling information very quickly, but took a long time to finish recalling all the required information, so this lead to the inclusion of response time as a variable. Response time was measured as the time taken from when the participants started recalling the information, until the time that they had recalled all three of the attributes present in the sign correctly. Like reaction time, response time was measured in seconds using the video recording and a stopwatch, where the researcher started the stopwatch as soon as the participant started recalling the first attribute and stopped the stopwatch when all the attributes were recalled correctly, as seen in Figure 5.

Error Rate

Error rate may be linked to familiarity as obtaining fewer errors may suggest being more familiar with those signs. The error rate was measured as the number of signs and the number of attributes that were recalled correctly. For each sign, it was recorded on the data sheet (in Appendix B3) which attributes in the signs were recalled correctly and incorrectly.

Familiarity

One of the objectives was to test what it took to become familiar with a sign and to recognise the attributes of the sign reliably. There is no direct measure of familiarity, as it is defined as a feeling or sensation of being familiar with information or an

environment. In this study, familiarity was dependent on the signs, the individual and learning and was measured as a collective of reaction time, response time and error rates, in that the responses of the participants would be analyzed according to how fast the participants reacted to the signs, how long they took to recall the information and the number of attributes they recalled correctly. Quicker reaction and response times, as well as a higher number of attributes recalled correctly would be considered to demonstrate that the participants were more familiar with the information than those that obtained slower reaction and response times and a lower number of attributes recalled correctly.

PILOT STUDIES

Pre-pilot tests were conducted to assess whether the proposed experimentation was feasible. Two participants were selected to complete the protocol and each participant learned a different set of conditions. The participants each had two trials and were given an unlimited amount of learning time. Explanations for the meanings of the different attributes were printed out on a piece of paper and given to the participants. After the participants felt they were comfortable with the signs, they handed the paper with the explanations back to the researcher and were presented with 10 signs. Participants were seated in front of the computer so that they could not make use of their peripheral vision as this could have interfered with the results. Participants were asked to recall the signs and were told that they could ask to see the page with the explanations at any time during testing. Participants were asked to recall the variables orally. This was done because Routh (1971) demonstrated that including extra requirements in the task, such as writing down information, could have a negative impact on the accuracy of recall when the participant had to read the information to store it to memory. Feedback was provided when any of the attributes were recalled incorrectly and the number of signs and attributes recalled correctly were recorded. From these results, the learning time and the number of signs in the test pool were calculated.

Pilot studies were conducted to test the variables and to establish what improvements needed to be made to the protocol. Four participants were used, where two participants had a low education level and the other two participants had

a higher level of education. Of the four participants, two were male and two were female. Each participant was tested using a pool of 20 signs tested “With Occlusion” and 20 signs “Without Occlusion”. Permutations were made regarding whether the participants were tested using the signs “With Occlusion” or “Without Occlusion” first. Participants were given the page with the explanations, but this time participants were also provided with a set of 10 signs so that they could see what type of signs they would be asked. After the learning time was over, the page was taken back and the signs were shown to each participant one at a time. Participants were required to recall all three attributes as soon as they could remember what each one designated. The explanation page was available to the participants at any point during the testing and was handed to them when they asked for it. The necessary measures (reaction time and error rate) were measured after the testing session.

A second set of pilot studies was completed, however this time; the pool of signs was increased to 64 signs as this was a multiple of the eight conditions being tested. The same four participants from the first pilot test were used. The test protocol was exactly the same, except that participants were tested using 64 signs “With Occlusion” and 64 signs “Without Occlusion”, with permutations being made to determine which set was tested first. After the testing session, the accuracy of recall, reaction and response times were measured.

ETHICAL CONSIDERATIONS

Before data collection commenced, ethical approval for the study was obtained from the Human Kinetics and Ergonomics ethical committee. Before the data collection, a letter was given to participants (Appendix A2) with an explanation of the project and a brief explanation of the protocol, so that they understood how to execute the tasks. No habituation period was necessary for this study as participants did not have to utilize equipment and the testing procedure was fairly straightforward. Participants were asked to thoroughly read through a consent form (Appendix A3) and sign the form once they clearly understood the nature of the tasks to be performed during the experimentation. This form explained that the participants would be recorded using a video camera, but their faces would not be recorded for privacy and ethical reasons. The video would only contain their voices and the computer screen. The form also

explained that their names would not be mentioned on the video and all information and data pertaining to the participants would be recorded on the data sheets in numerical form to ensure that the data was kept anonymous. The form also stated that participants were allowed to withdraw from the study at any point without giving any reason for their withdrawal.

PARTICIPANT CHARACTERISTICS

Sixty participants ranging from 18 – 65 years were recruited from the Grahamstown and East London populations. These participants were placed in four different groups, which can be seen in Table V. All the participants were healthy and had no prior experience with the task. Demographic information such as age, level of education and occupation was obtained.

Table V: Participant and group characteristics.

	GROUP 1	**GROUP 2**	**GROUP 3**	**GROUP 4**
Education Level	High	High	Low	Low
Age (yrs ± SD)	47.4 ± 6.8	20.6 ± 1.5	42.1 ± 1.6	26.1 ± 3.8
n*	15	15	15	15

* Where n = number of participants in the group

Group 1, as seen in Table V, consisted of participants that had a mean age of 47.4 years with a standard deviation of 6.8. Group 2 consisted of participants with a mean age of 20.6 years and a standard deviation of 1.5. Groups 3 and 4 consisted of participants with mean ages and standard deviations of 42.1 years ± 1.6 and 26.1 years ± 3.8, respectively. All participants were male and each group had 15 participants, except for Group 1, which had only five participants.

Demographic information that included age, highest level of education and occupation of the participants was collected. The highest level of education also included any courses that the participants had completed. This was done to ensure

that the participants fell within the desired age and education ranges so that the necessary requirements of the study were met.

EXPERIMENTAL PROCEDURE

The experimental procedure was explained to the participants and any questions they had were answered. Once the participants had signed the necessary documentation and were familiar with the testing procedure, the video camera was switched on and the participants were given the page with the explanations and two minutes learning time. At the end of the two minutes, the page was taken away from the participants and the slides containing the 64 signs were shown on Microsoft PowerPoint®, one at a time. The participants had to recall the meanings of the shape, colour and symbol in the sign and the experimenter provided feedback when these attributes were recalled incorrectly. Once all the attributes were recalled correctly, the experimenter moved on to the following sign. If the participant could not remember a particular attribute in the sign, they could request to look at the page with the explanations provided they had recalled everything else they could remember in the sign. The error rate was therefore measured during the testing session. The investigator noted down whenever the participants looked at the page with the explanations. Each session was designed to take approximately 30 minutes, which was true for the participants with the higher level of education, but the participants with the lower education levels took approximately an hour for each session, on average. A week later, the participants returned for a second session, where they did not learn the signs before testing began. The rest of the testing procedure was exactly the same as for the first week of testing.

STATISTICAL PROCEDURES

The results obtained from all the participants were collated appropriately using Microsoft Excel®. These data were then correlated using „Statistica 8", where reaction time, response time and error rate were analyzed independently. Each session was assessed independently at first and then compared together to see if any differences between the responses obtained during the sessions existed. Two-way ANOVAs were conducted, with covariates of age, education and occlusion to analyze if any significant differences existed in the data obtained for the reaction

time, response time and error rate. T-tests were conducted to compare the conditions for reaction time and response time.

CHAPTER IV

RESULTS

INTRODUCTION

This study investigated the effects of attributes present in safety signs on learning and familiarity in male participants with different ages and education levels through varying the attributes in safety signs. Reaction time, response time and error rates were the variables investigated. This research was not interested in the absolute values obtained for performance, but rather the differences and similarities that existed between the different age and education groups. Therefore, trends present in the tables and figures and the patterns experienced by the different age groups and education groups will be discussed rather than the absolute values of reaction time, response time and error rates.

GENERAL EFFECTS

Table VI: Statistical reaction time results.

	SS	Degr. of - Freedom	MS	F	p
Intercept	59999.54	1,59	59999.54	114.7128	0.000000
COND	467.07	7,413	66.72	3.2194	0.002466
REPS	2522.67	7,413	360.38	9.4909	0.000000
SESS	321.89	1,59	321.89	30.5651	0.000001
COND*REPS	1499.58	49,2891	30.60	4.1390	0.000000
COND*SESS	378.34	7,413	54.05	6.9173	0.000000
REPS*SESS	35.85	7,413	5.12	0.6192	0.740181
COND*REPS*SESS	1577.37	49,2891	32.19	4.2884	0.000000

The conditions, repetitions and sessions had significant effects on the reaction time obtained as indicated by the variables displayed in red in Table VI.

Table VII: Statistical response time results.

	SS	Degr. of - Freedom	MS	F	p
Intercept	757137.9	1,59	757137.9	130.9844	0.000000
COND	19771.9	7,413	2824.6	12.6141	0.000000
REPS	90508.2	7,413	12929.7	35.0528	0.000000
SESS	7994.8	1,59	7994.8	68.1386	0.000000
COND*REPS	12871.2	49,2891	262.7	2.2524	0.000002
COND*SESS	5988.2	7,413	855.5	7.0040	0.000000
REPS*SESS	5580.9	7,413	797.3	5.1060	0.000014
COND*REPS*SESS	18703.6	49,2891	381.7	3.6816	0.000000

As with reaction time; statistical significance was found for the effects of the conditions, repetitions and sessions on response time, as seen in Table VII.

Table VIII: Statistical error rate results.

	SS	Degr. of - Freedom	MS	F	p
Intercept	58421.50	1, 59	58421.50	11663.32	0.000000
COND	23.03	7, 413	3.29	12.46	0.000000
REPS	20.26	7, 413	2.89	8.64	0.000000
SESS	2.00	1, 59	2.00	8.79	0.004361
COND*REPS	22.22	49, 2891	0.45	2.57	0.000000
COND*SESS	2.84	7, 413	0.41	2.16	0.036727
REPS*SESS	1.90	7, 413	0.27	1.38	0.213741
COND*REPS*SESS	16.14	49, 2981	0.33	1.82	0.000453

Statistical significances were found for the effects of the conditions, repetitions and sessions on the number of errors obtained (Table VIII).

CONDITIONS

The effects of the conditions on reaction time is displayed in Figure 6, where reaction time was found to decrease in the following order: TTT, SCI, TCT, TCI, SCT, STI, TTI and STT. The highest reaction time obtained overall was for the signs containing only text (TTT) and the lowest for the signs containing shape and text (STT).

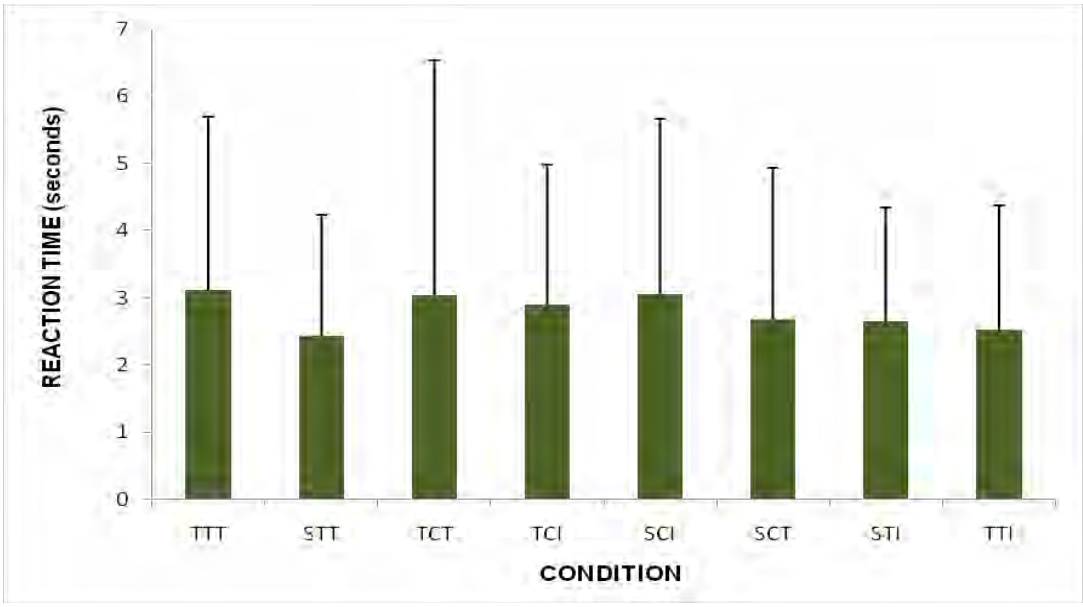


Figure 6: Effects of the conditions on reaction time.

It was expected that the lowest reaction times would be elicited by the signs only comprised of text and the highest from the signs with all three attribtues (SCI); however this as not the case (Figure 6).

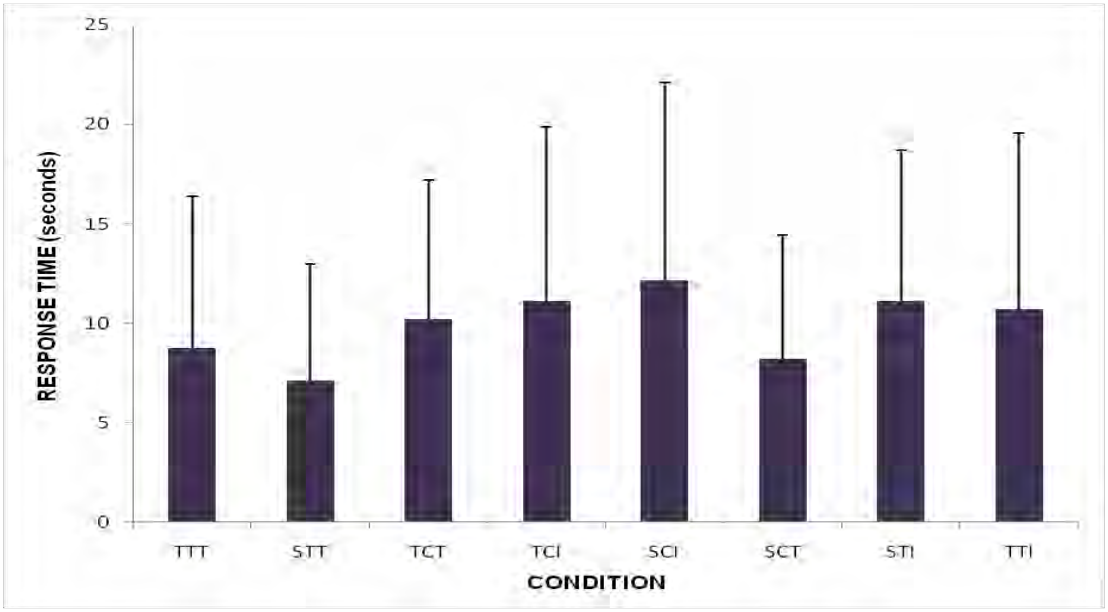


Figure 7: Effects of the conditions on response time.

Figure 7 demonstrates the effects of the conditions on response time. The highest response times were obtained for the signs where no text was present (SCI) and the lowest response times for the signs comprised of shape and text (STT). It was expected that the signs with all three attributes and no text (SCI) would take the longest to recall; however it was expected that the signs with only text (TTT) would be the easiest and therefore take the least amount of time to recall but this was not the case for this study. The response time decreased in the following order: SCI, TCI, STI, TTI, TCT, TTT, SCT and STT. This shows that the signs containing icons (SCI, TCI, STI and TTI) took the longest to recall.

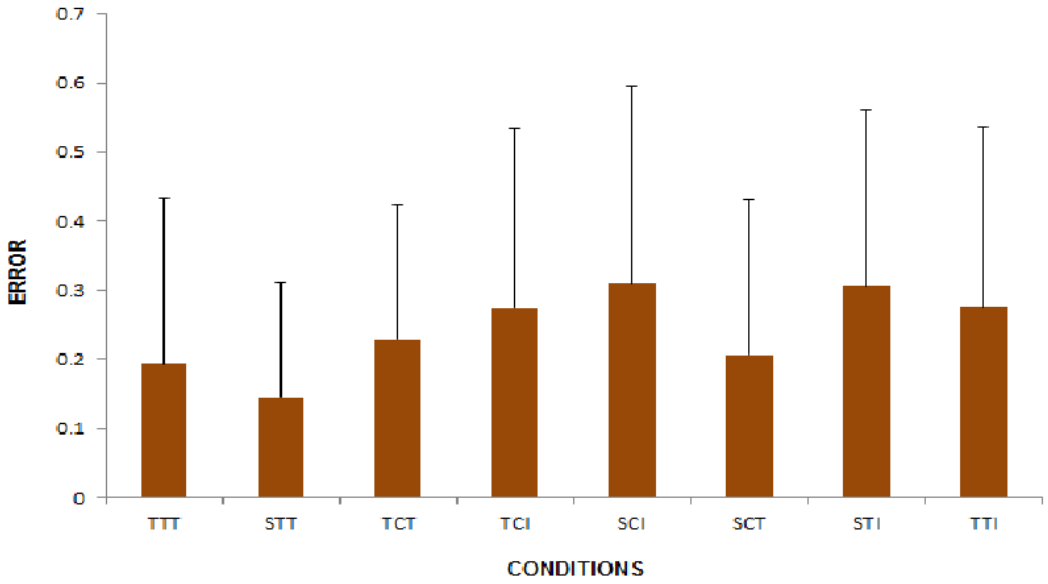


Figure 8: Effects of the conditions on the error rate.

The effects of the conditions on the number of errors obtained can be seen in Figure 8. The most errrors obtained were for the condition with all three attributes (SCI) and the least number of errors for the condition with shape and text (STT). The number of errors increased from STT, TTT, SCT, TCT, TTI, STI and SCI.

Age

Table IX: Statistical results for age effects on the conditions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
Intercept	59999.54	1	59999.54	112.9717	0.000000
COND*Age	330.75	7,406	47.25	2.3312	0.024245
RESPONSE TIME					
Intercept	759750.1	1	759750.1	130.5638	0.000000
COND*Age	6082.4	7,406	868.9	4.0832	0.000240
ERROR RATE					
None					

The conditions had a significant effect on reaction time and response time (Table IX). No statistical signifances were found for the error rate with respect to age.

As seen in Figure 9, the older participants obtained higher reaction times for five of the eight conditions; however it was anticipated that the younger participants would obtained lower reaction times for all conditions. The three conditions that the older participants obtained lower reaction times for were the conditions with SCI, SCT and TTI.

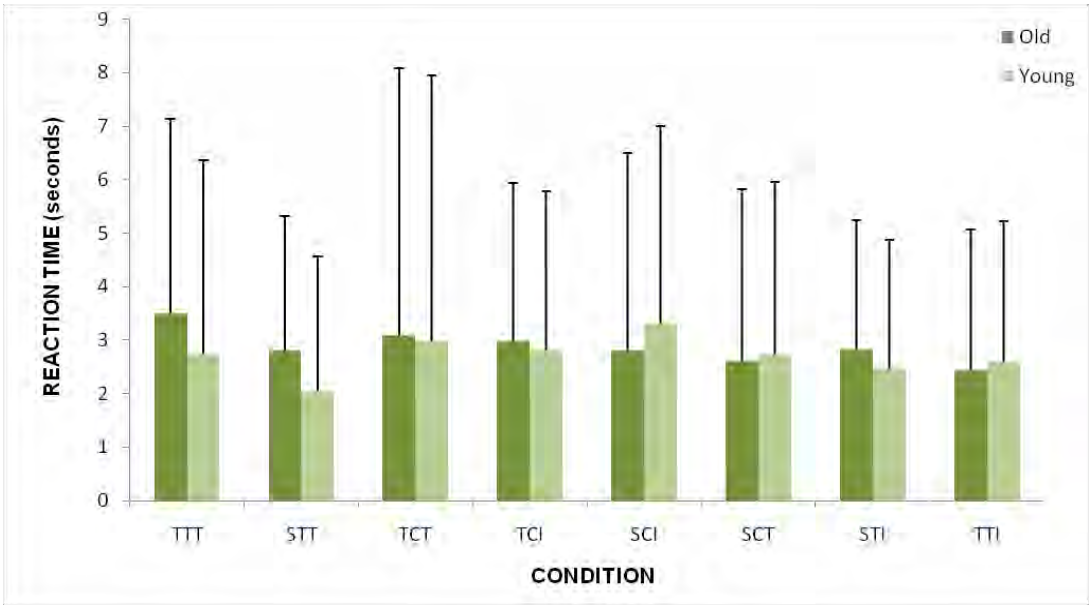


Figure 9: Age effects of the conditions on reaction time.

Both age groups however experienced similar increases and decreases throughout the eight conditions, except for the interval between SCT and STI and the interval between STI and TTI. For the older participants, reaction time decreased from TTT, TCT, TCI, STI, STT, SCI, SCT and TTI. Reaction time decreased from SCI, TCT, TCI, TTT, SCT, TTI, STI and STT for the younger participants (Figure 9).

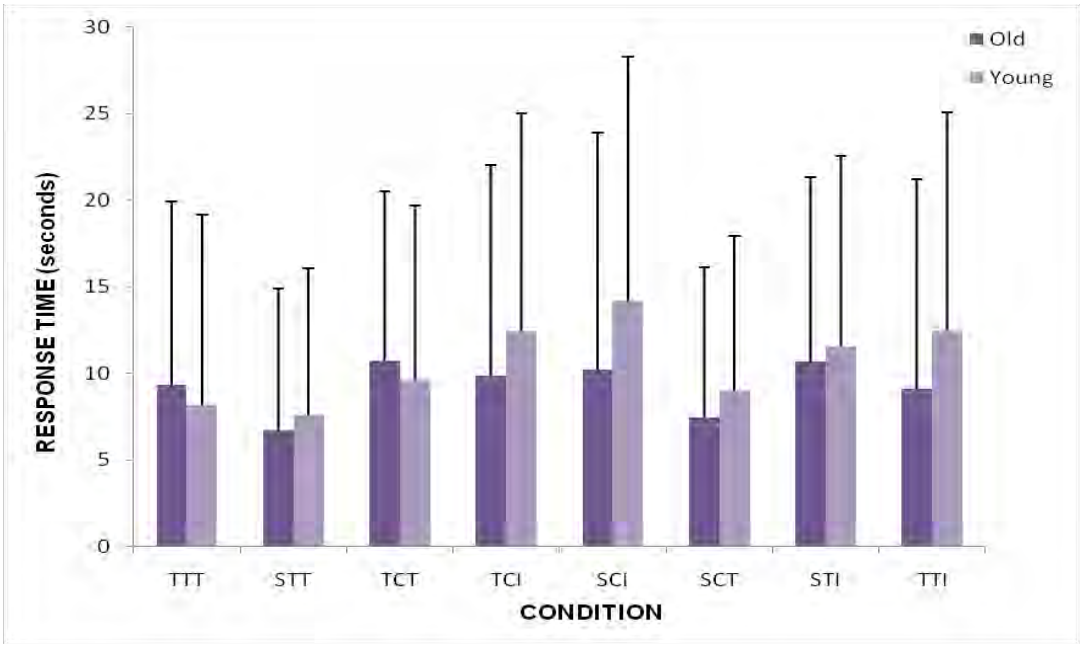


Figure 10: Age effects of the conditions on response time.

The expectation was that the younger participants would obtain lower response times than the older participants; however this was not true for this study. As seen in Figure 10, the older participants obtained higher response times than their younger counterparts for only two out of the eight conditions (TTT and TCT). Response time decreased from TCT, STI, SCI, TCI, TT, TTI, SCT and STT for the older particpants and from TTI, TCI, STI, TCT, SCT, TTT and STT for the younger participants. Although the two age groups did not experience the same increases and decreases throughout the eight conditions, both groups did obtain the lowest response times for the conditions with STT.

Education

Table X: Statistical results for the effects of education and the conditions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
None					
RESPONSE TIME					
Intercept	757137.9	1	757137.9	177.9050	0.000000
COND*Education	3638.9	7,406	519.8	2.3757	0.021719
ERROR RATE					
None					

Table X shows that for education; the repetitions and sessions had a significant effect on reaction time and response time. The conditions were found to have a significant effect on response time and the combined effects of the conditions, repetitions and sessions had a significant effect on reaction time and response time. No statistical signifances were found for the error rate with respect to age.

The response time decreased in the following order for the participant group with a higher level of education: SCI, STI, TTI, TCT, TCI, TT, SCT, and STT (Figure 11).

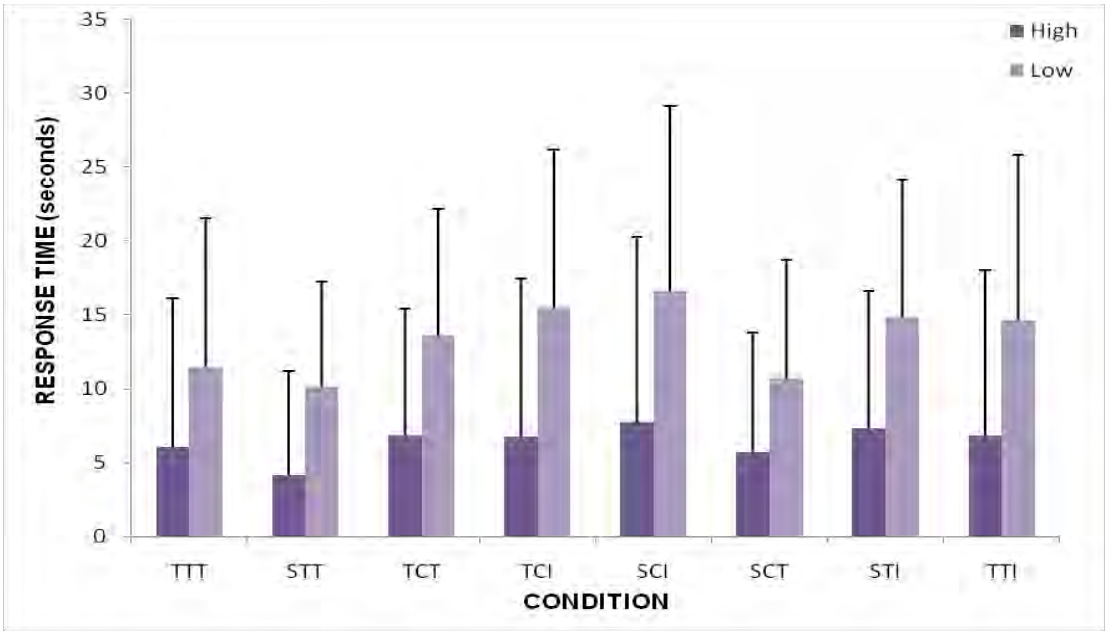


Figure 11: Education effects of the conditions on response time.

Figure 11 also shows that for the participant group with the lower education level, the response time decreased in the following order: SCI, TCI, STI, TTI, TCT, TTT, SCT and STT. Both participant groups experienced similar increases and decreases over the eight conditions and both obtained the lowest response times for the condition with shape and text (STT). For all conditions, the participants with a lower education level obtained statistically significantly higher response times than those with the higher education level.

Occlusion

Table XI: Statistical results for the effects of occlusion and the conditions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
Intercept	59073.24	1	59073.24	122.0820	0.000000
COND*Occl/No Occl	659.34	7,406	94.19	4.8405	0.000030
RESPONSE TIME					
None					
ERROR RATE					
Intercept	58384.55	1	58384.55	11576.46	0.000000
COND*Occl/No Occl	4.50	7, 406	0.64	2.50	0.016042

The effects of the conditions and occlusion were only found to be significant for reaction time and the error rate, as displayed in Table XI.

Figure 12 shows that the group exposed to signs with occlusion obtained higher reaction times than the group exposed to signs without occlusion. Reaction time decreased from TCT, TTT, TCI, SCT, SCI, STI, STT and TTI for the Occlusion group and from SCI, TTI, TCI, TTT, STI, STT, SCT and TCT for the No Occlusion group. The effects of the conditions on Occlusion and No Occlusion were not the same throughout the conditions.

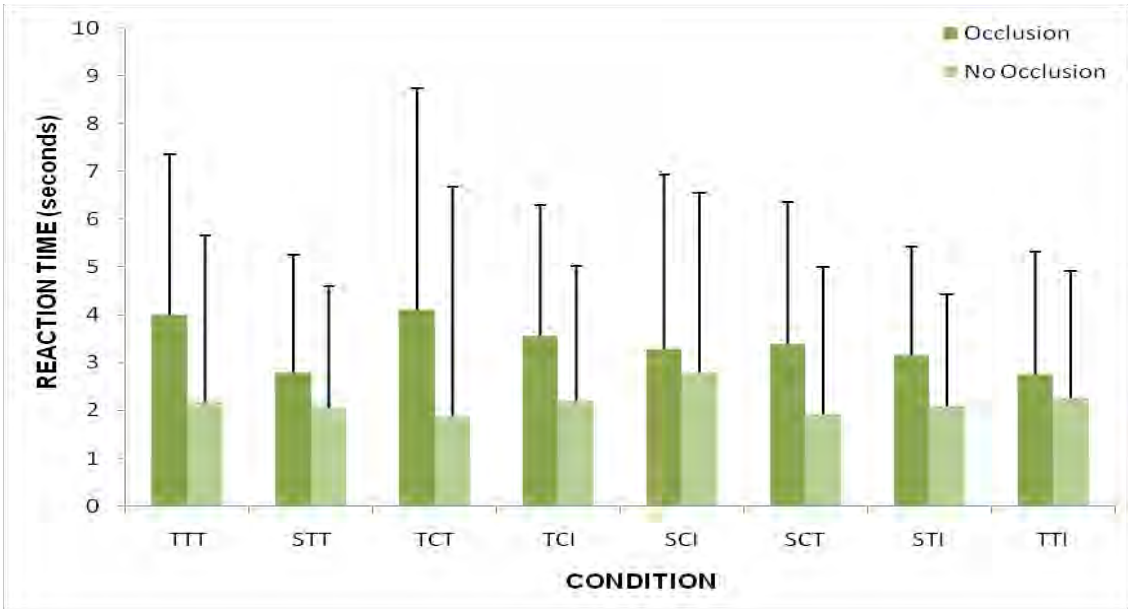


Figure 12: Occlusion effects of the conditions on reaction time.

The error rates obtained by the Occlusion group were higher than those obtained by the No Occlusion group for five out of the eight conditions (Figure 13).

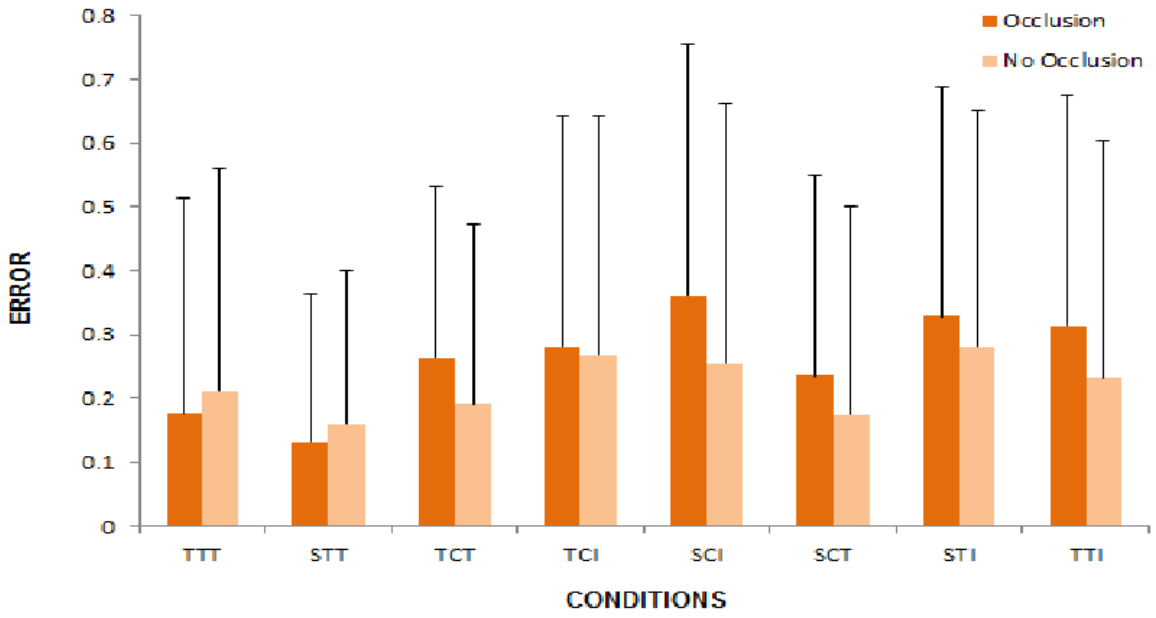


Figure 13: Occlusion effects of the conditions on the error rate.

The conditions did not have the same effect on the number of errors incurred for both as the two groups experienced different patterns throughout the conditions (Figure 13). The number of errors increased from STT, TTT, SCT, TCT, TCI, TTI, STI and SCI for the Occlusion group and from STT, SCT, TCT, TTT, TTI, SCI, STI and TCI for the No Occlusion group. For both groups, the least errors were obtained for the condition with shape and text (STT).

REPETITIONS

The repetitions also had a significant effect on reaction time and these effects are displayed in Figure 14. Reaction time decreased as the number of repetitions increased, which was an expected result. A slight increase in reaction time was experienced from repetition 4 to repetition 5, which was not an expected result as it was anticipated that the decrease in reaction time from repetition 1 through to repetition 8 would be continuous.

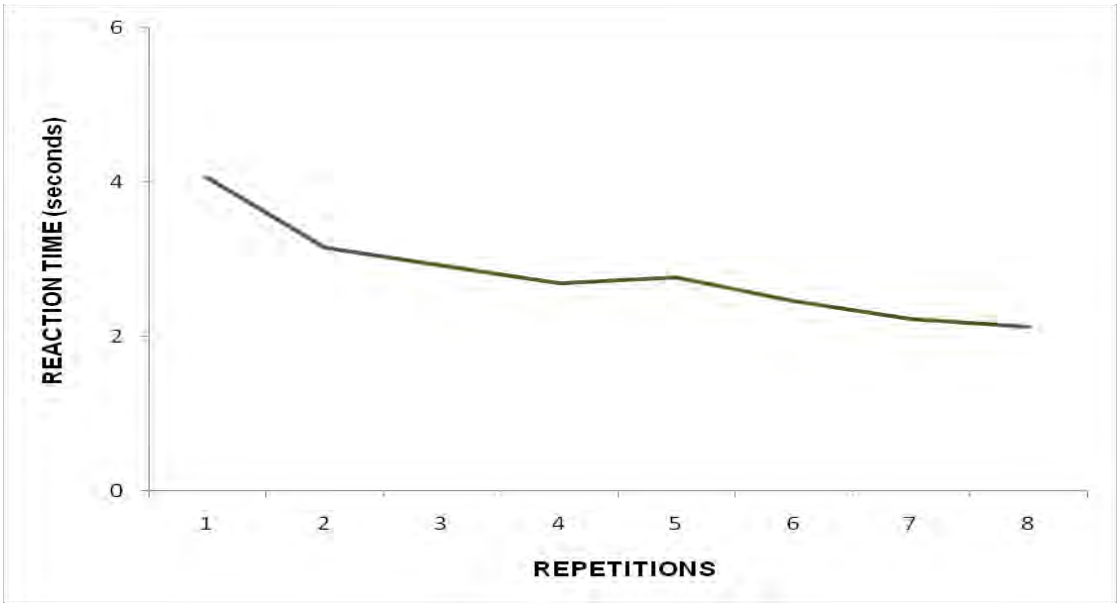


Figure 14: Effects of repetitions on reaction time.

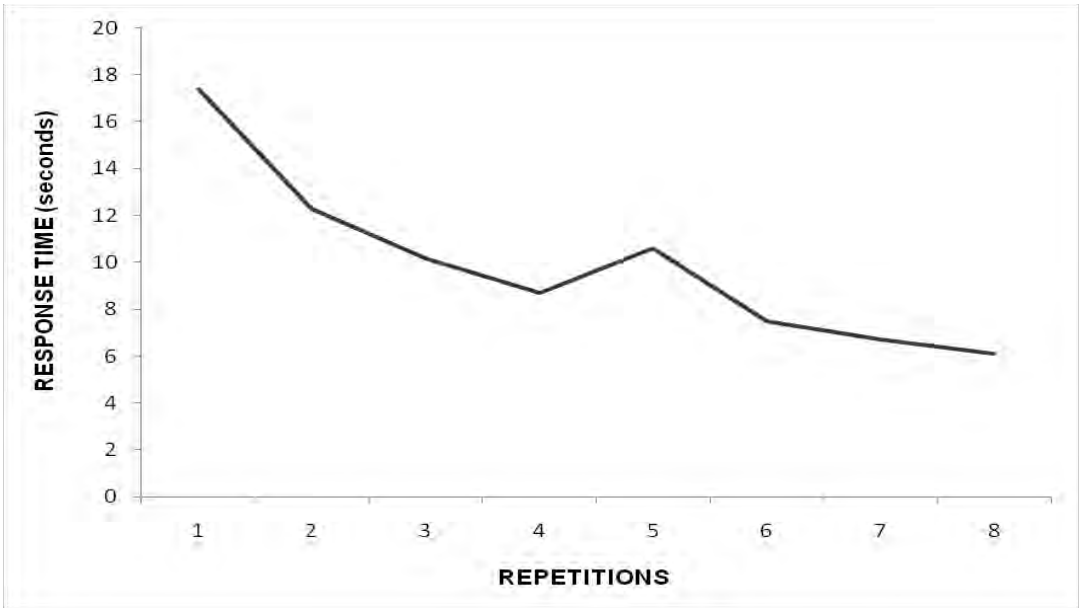


Figure 15: Effects of repetitions on response time.

Figure 15 demonstrates that the response time decreased over the eight repetitions; however as with reaction time, an increase in response time occurred from repetition 4 to repetition 5, which was not an expected result.

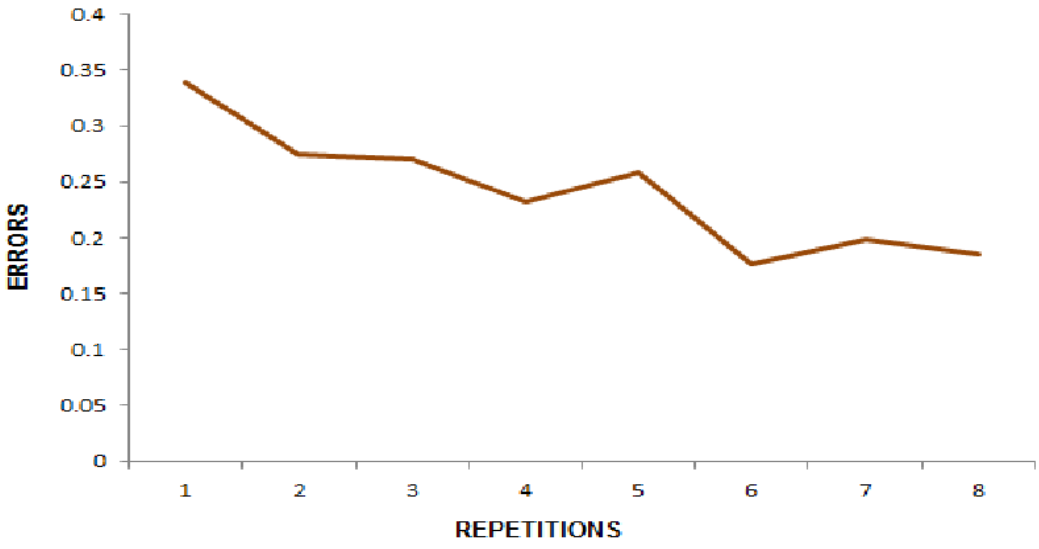


Figure 16: Effects of the repetitions on the error rate.

The number of errors decreased from the first repetition to the last, as seen in Figure 16. The highest number of errors was obtained for repetition 1 with fluctuations in the error rate occurring throughout the repetitions. Increases in the number of errors occurred between repetitions 4 and 5 and between repetitions 6 and 7. This was not expected as it was anticipated that a constant decrease in error rate would occur from the first to the last repetition.

Education

Table XII: Statistical results for the effects of education and the repetitions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
Intercept	59999.54	1	59999.54	128.8416	0.000000
REPS*Education	906.91	7,406	129.56	3.5601	0.000995
RESPONSE TIME					
Intercept	757137.9	1	757137.9	177.9050	0.000000
REPS*Education	10575.5	7,406	1510.8	4.3267	0.000123
ERROR RATE					
None					

As seen in Table XII, the effects of education and the repetitions were found to be significant for reaction time and response time, but not for the error rate.

The participants with a higher level of education obtained lower reaction times over the eight repetitions than those with a lower level of education (Figure 17). This finding was expected, as was the decrease in reaction time from the first repetition to the last. The repetitions had the same effect for both participant groups; however the reaction time curve displayed in Figure 17 is more pronounced for the participants with a lower level of education.

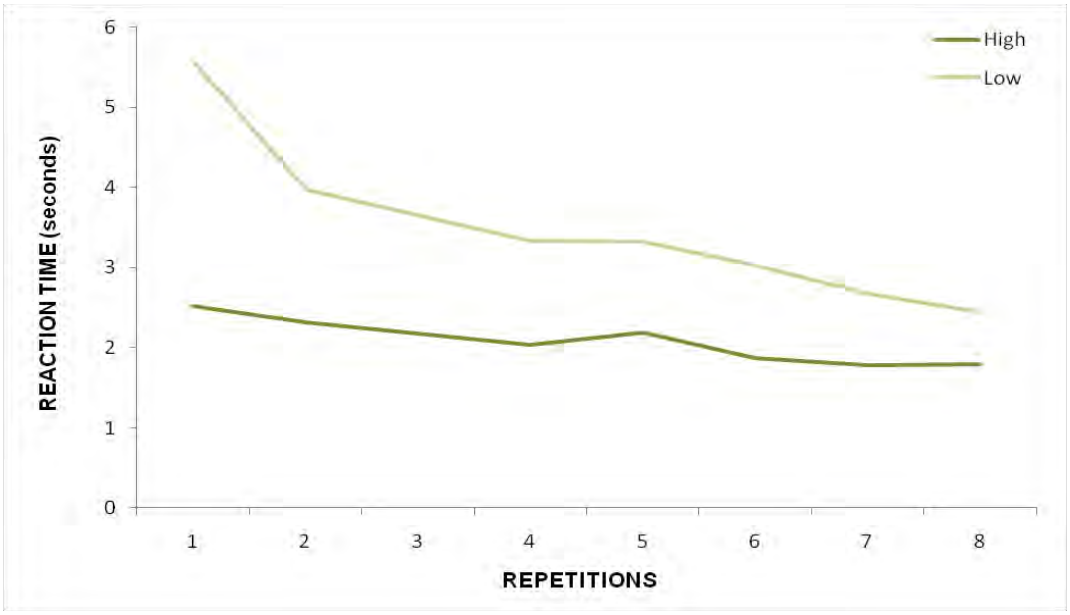


Figure 17: Education effects of repetitions on reaction time.

Figure 17 also shows that the participants with a higher level of education obtained lower reaction times than those with the lower education level. Both groups experienced a statistically significant decrease in reaction time from the first to the second session.

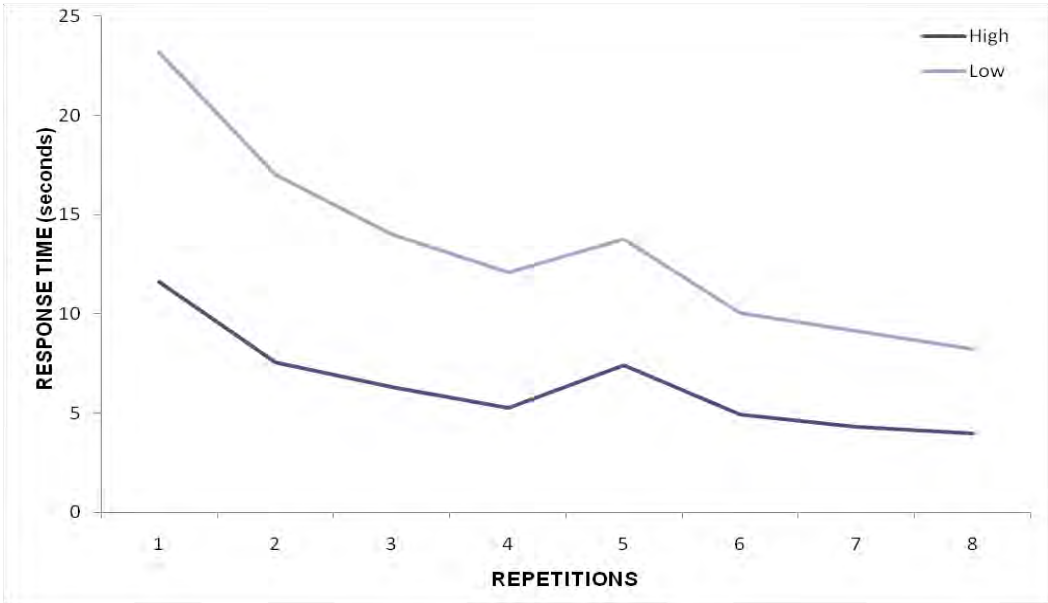


Figure 18: Education effects of the repetitions on response time.

Response time decreased over the eight repetitions for both participant groups, as seen in Figure 18. As expected, the response times obtained by the participants with higher education were significantly lower than those obtained by the participants with lower education levels for all eight repetitions.

Occlusion

Table XIII: Statistical results for the effects of education and the repetitions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
Intercept	59073.24	1	59073.24	122.0820	0.000000
REPS*Occl/No Occl	681.80	7,406	97.40	2.6362	0.011281
RESPONSE TIME					
Intercept	751325.1	1	751325.1	130.6009	0.000000
REPS*Occl/No Occl	8082.2	7,406	1154.6	3.2495	0.002284
ERROR RATE					
Intercept	58384.55	1	58384.55	11576.46	0.000000
REPS*Occl/No Occl	5.48	7, 406	0.78	2.39	0.020911

With respect to education, the repetitions had significant effects on reaction time, response time and error rate, as seen in Table XIII.

The Occlusion group obtained higher reaction times over the repetitions than the No Occlusion group (Figure 19). Despite the higher reaction times, the Occlusion group expereinced the same learning curve as the No Occlusion groups in that both groups incurred a decrease in reaction time over the eight repetitions; however, the learning curve over of the Occlusion group was more pronounced. The effects of the repetitions on reaction time were not the same for both groups. The Occlusion group experienced an increase in reaction time from repetition 4 to repetition 5; whereas the No Occlusion group experienced an increase in reaction time from repetition 2 to repetition 5.

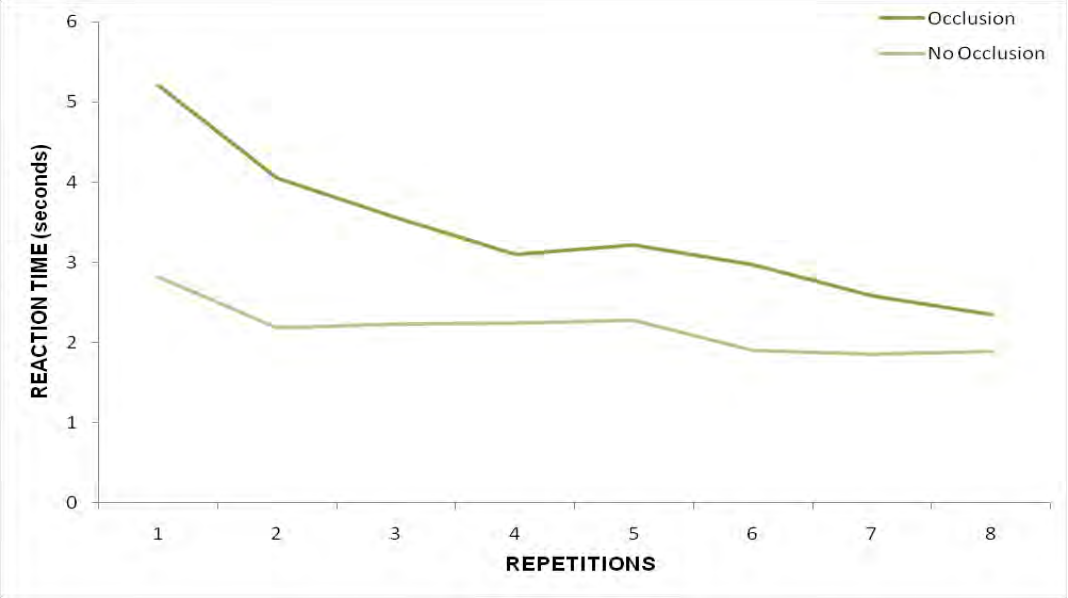


Figure 19: Occlusion effects of repetitions on reaction time.

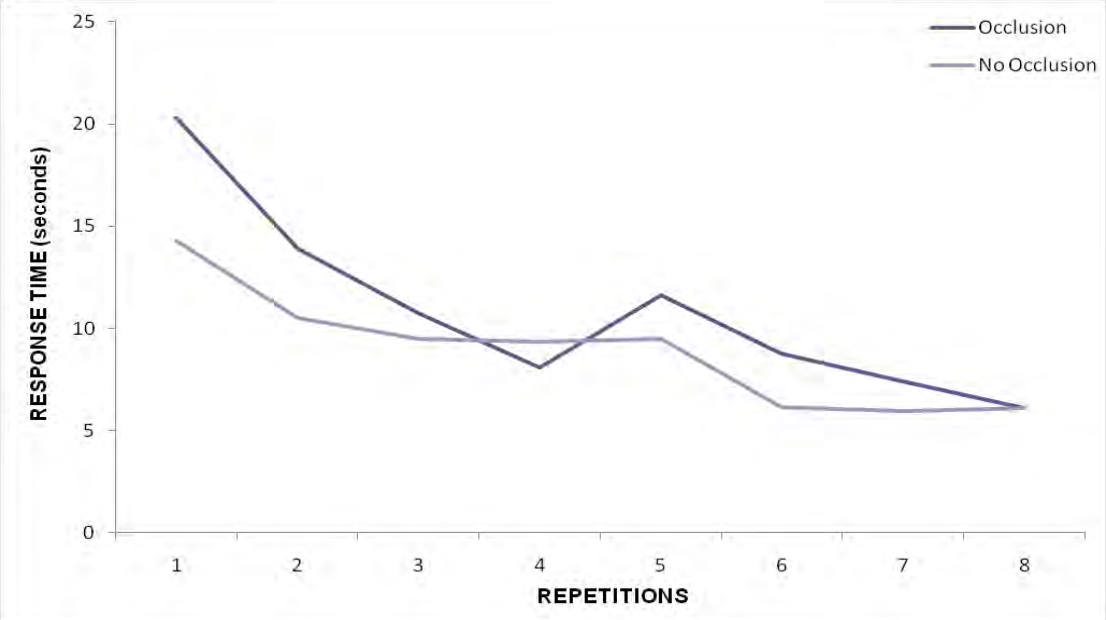


Figure 20: Occlusion effects of the repetitions on response time.

Figure 20 demonstrates that both the Occlusion and No Occlusion groups experienced a decrease in response time from the first repetition to the last; however the repetitions did not have the same effect for both groups. What was also noted what that the response time increased from repetition 4 to repetition 5 for both

groups, but for the No Occlusion group, another increase in response time occurred from repetition 7 to repetition 8.

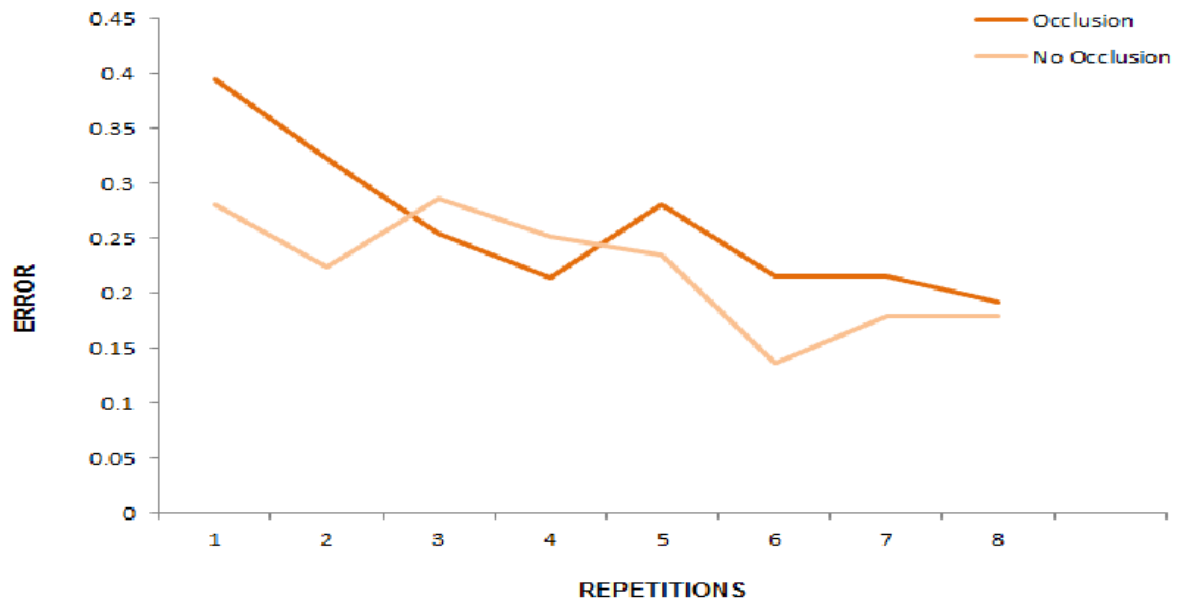


Figure 21: Occlusion effects of the repetitions on error rates.

Figure 21 shows that the number of errors obtained over the eight repetitions decreased for both groups. Overall, the Occlusion group obtained more errors than the No Occlusion group. The repetitions did not have the same effects on the two groups over the eight repetitions and the fluctuations in error rates experienced were different.

SESSIONS

The general effects of the sessions on reaction time are diplayed in Figure 22. As seen, reaction time decreased significantly from the first session to the second session, which was a predicted result.

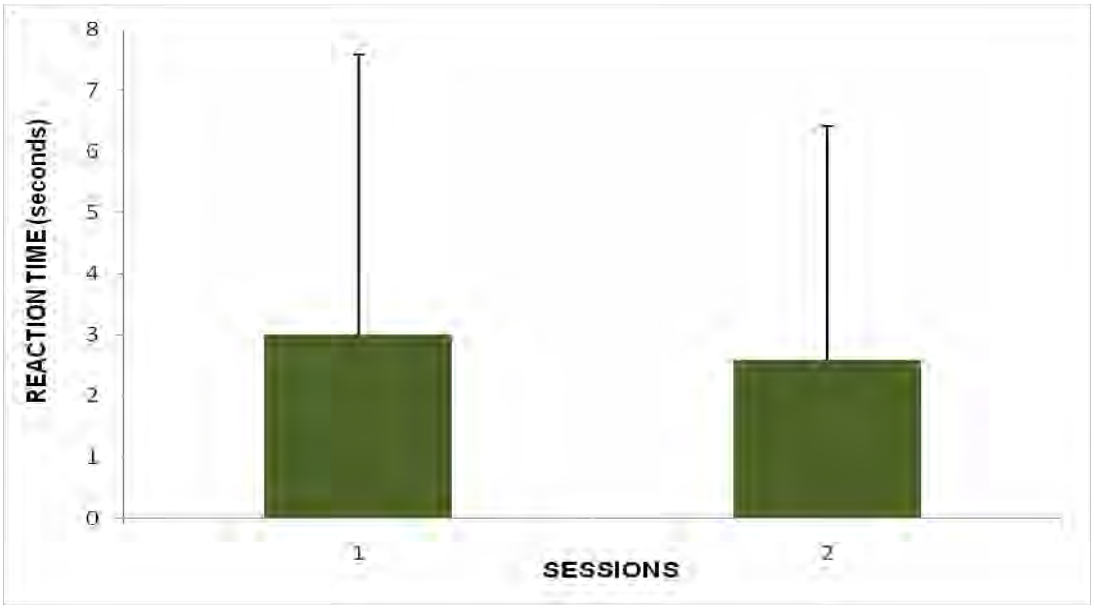


Figure 22: Effects of the sessions on reaction time.

Figure 23 displays the effects of the sessions on response time. As was with reaction time, the response time obtained in the second session was significantly lower than that obtained in the first session.

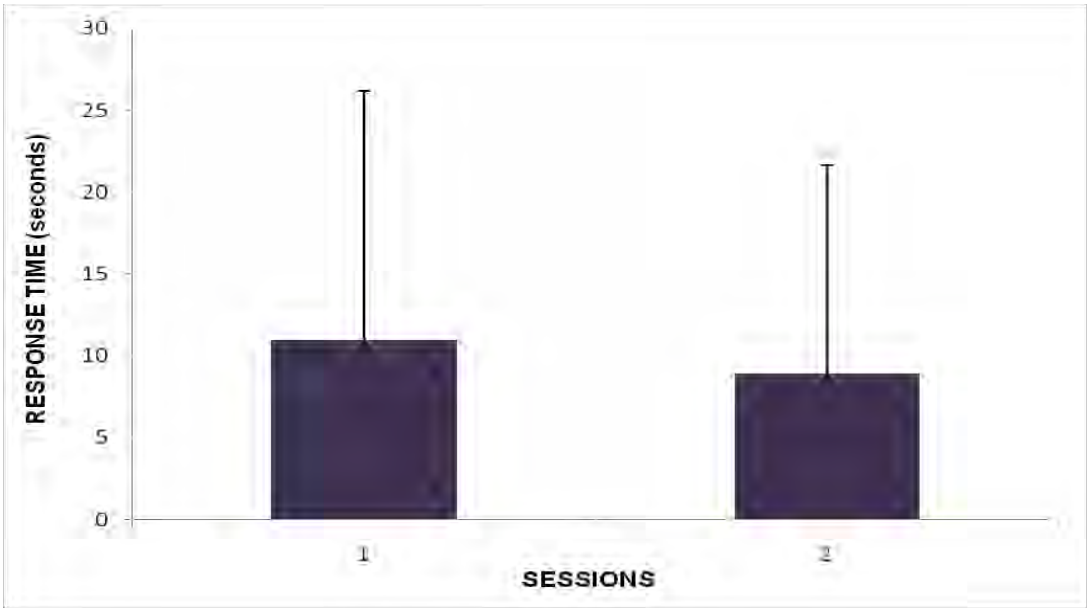


Figure 23: Effects of sessions on response time.

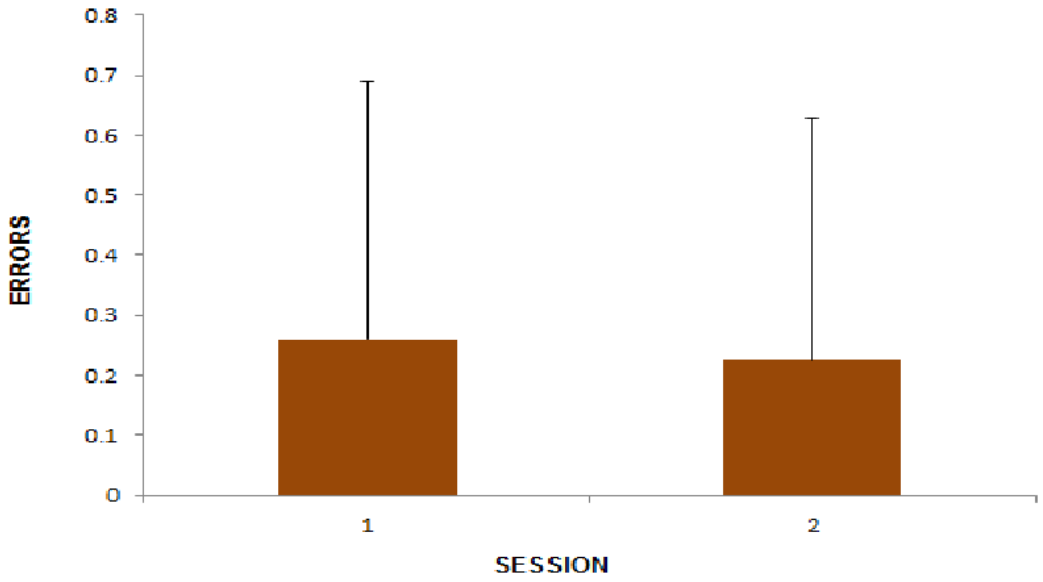


Figure 24: Effects of the sessions on the error rate.

As seen in Figure 24, the number of errors decreased from the first session to the second session.

Education

Table XIV: Statistical results for the effects of education and the sessions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
Intercept	59999.54	1	59999.54	128.8416	0.000000
SESS*Education	52.97	1,58	52.97	5.4049	0.023602
RESPONSE TIME					
Intercept	757137.9	1	757137.9	177.9050	0.000000
SESS*Education	679.8	1,58	679.8	6.3156	0.014769
ERROR RATE					
None					

No statistical effects of the sessions and education were found for the error rate; but were found for reaction time and response time.

As seen in Figure 25, the high education group obtained lower reaction times for both sessions than the participants with the lower education did. Both participant

groups did however experience a decrease in reaction time from session 1 to session 2.

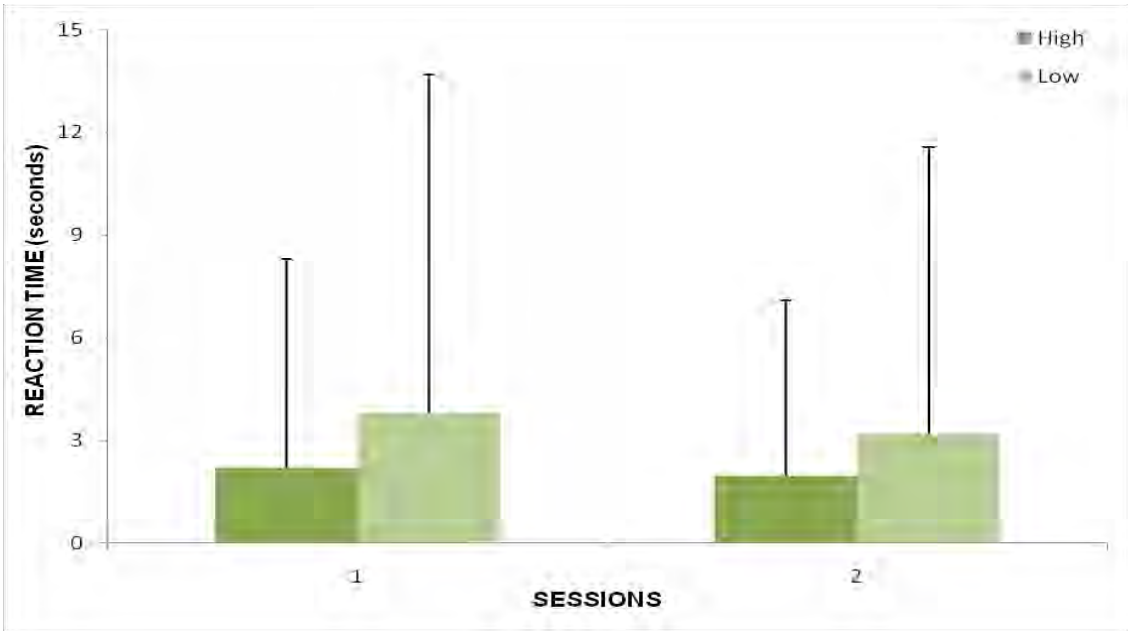


Figure 25: Education effects of the sessions on reaction time.

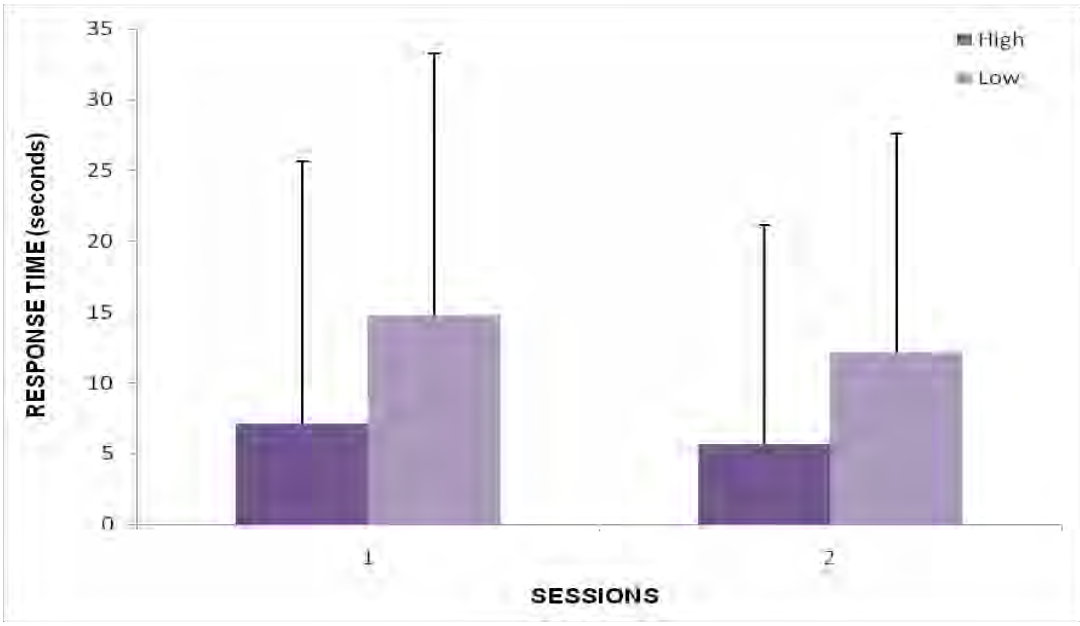


Figure 26: Education effects of the sessions on response time.

Figure 26 demonstrates that the response times obtained for the second session were significantly lower than those obtained for the first session, regardless of the level of education. The response times incurred by the participants with the higher level of education were significantly lower than those obtained by the participants with the lower education.

Occlusion

Table XV: Statistical results for occlusion and the sessions.

REACTION TIME					
	SS	**Degr. of - Freedom**	**MS**	**F**	**p**
Intercept	59073.24	1	59073.24	122.0820	0.000000
SESS*Occl/No Occl	41.12	1,58	41.12	4.1109	0.047211
RESPONSE TIME					
None					
ERROR RATE					
Intercept	58384.55	1	58384.55	11576.46	0.000000
REPS*Occl/No Occl	5.48	7, 406	0.78	2.39	0.020911
SESS*Occl/No Occl	0.92	1, 58	0.92	4.28	0.043102

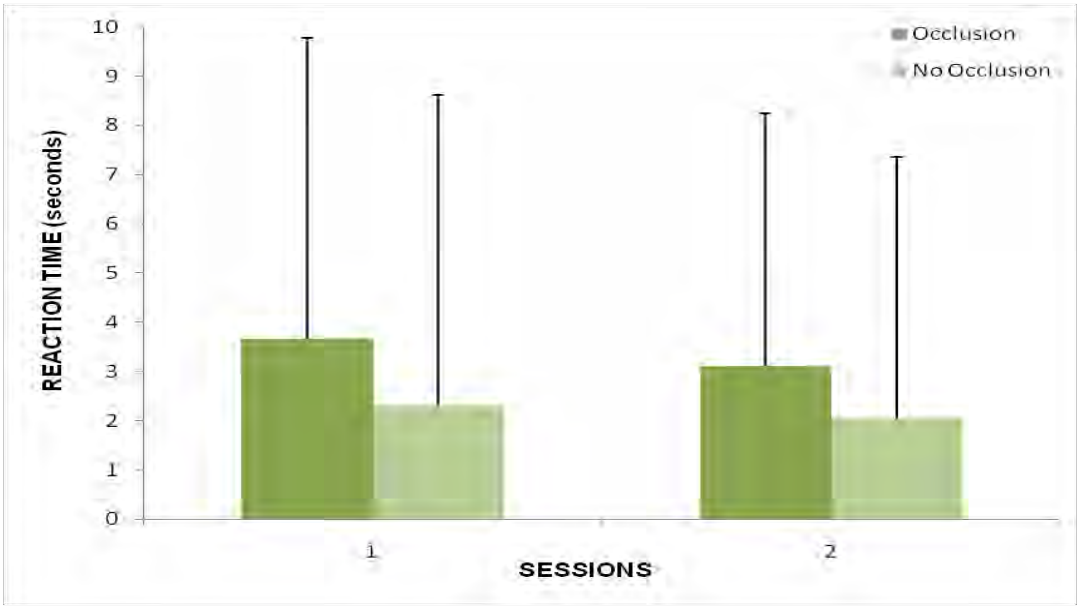


Figure 27: Occlusion effects of the sessions on reaction time.

Both groups experienced decreases in reaction time from the first session to the second session (Figure 27). The Occlusion particiapnt group obtained higher reaction times than the No Occlusion participant group.

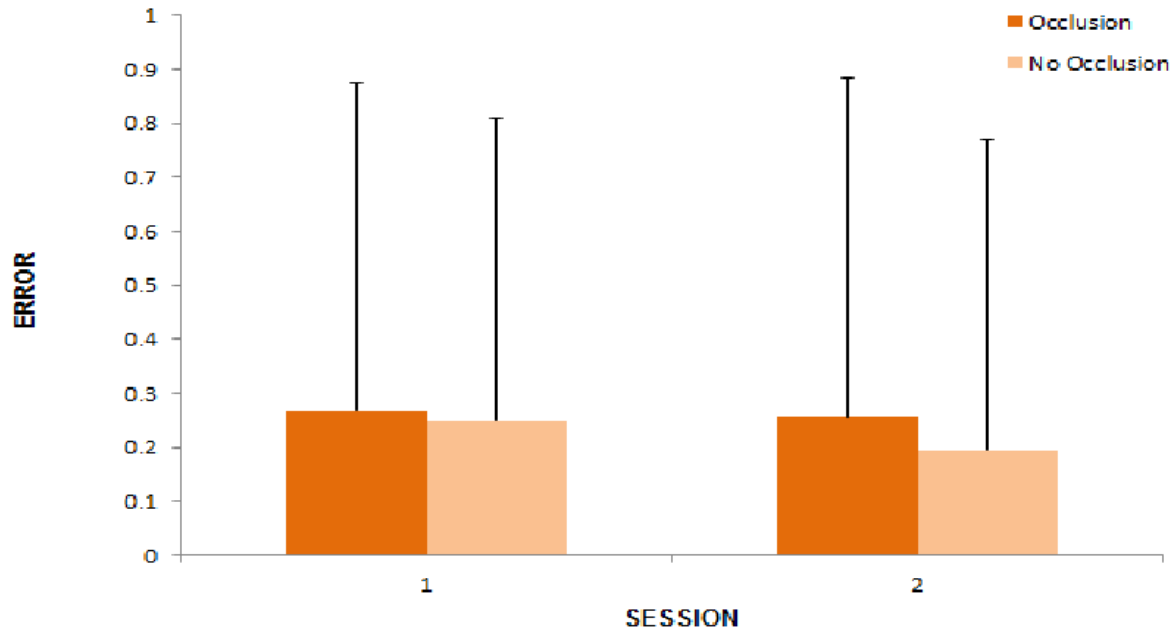


Figure 28: Occlusion effects of the sessions on the error rates.

Both groups experienced decreases in the number of errors incurred from the first session to the second session (Figure 28). The Occlusion group obtained a higher number of errors for both sessions.

CHAPTER V

DISCUSSION

INTRODUCTION

Reaction time, response time and error rates were analyzed to determine if any statistical significances existed between the eight conditions, eight repetitions of the conditions and two testing sessions. Age, education and occlusion were analyzed as covariates to examine whether these variables had an impact on the reaction times, response times and errors incurred between the different participant groups. The performance criteria in response to the conditions, repetitions and sessions were analyzed independently using two-way ANOVAs. Age, education and occlusion were added as covariates after the general effects had been correlated.

GENERAL EFFECTS

As seen in Tables VI, VII and VIII; the effects of the conditions, repetitions and sessions on reaction time, response time and the error rate were found to be statistically significant. The combined effects of the conditions and repetitions, conditions and sessions as well as the conditions, repetitions and sessions were found to be significant for reaction time and the error rate. For response time the combined effects of the conditions and repetitions; conditions and sessions; repetitions and sessions as well as the conditions, repetitions and sessions were found to be significant.

CONDITIONS

It was expected that the signs with TTT would elicit the lowest reaction times as participants would not have to think about what was represented in the signs, but merely read the information displayed. However, this was not the finding for this study as the highest reaction times obtained were for the signs with only text (TTT) and the lowest for the conditions with STT, as seen in Figure 6. This signifies that including only text in the signs proved to be more difficult for participants to read the information. These findings are in contradiction to the statement made by Young

(1998), who reported that hazard information is communicated independently of the associated colours or surround shapes. For this study, it appears that including surround shapes may aid in communicating the hazard information. Displaying the signs using Occlusion could also explain why the signs with merely text resulted in higher reaction times as Occlusion may have resulted in the participants not being able to read the information quickly or having to have the signs displayed repeatedly before starting to answer. Both long text and short text were also used in the signs with text; however the use of long and short text was not found to be significant.

Figure 7 however indicates that the participants took longer recalling signs where no text was present (SCI) and a shorter time where a shape and text were present (STT). There were also more errors recorded for the signs with no text (SCI) and fewer for the signs with a shape and text (STT), as seen in Figure 8. From these results, it appears that when text is present in a sign, it may take longer to start reading and recalling the text. It is interesting to note that the four highest response times obtained were for the conditions containing icons (Figure 7). This finding is not supported by the literature, as authors (Laughery and Young, 1991 and Young, 1991) reported that signs with symbols were found to be understood and interpreted quicker than those without symbols or those with text. It also appears that signs with absolutely no text but purely a shape, icon and colour (SCI) take longer to recall and result in more errors being made. Many factors may have contributed to the longer reactions times, such as the longer text used in some of the signs, but as mentioned previously, the effects of the longer text were not found to be significant. Additional to the use of Occlusion, another reason for these findings may be the different education levels or problems with language. Low comprehension levels caused by education may explain the higher response times for the signs with no text. Rogers *et al*. (2000) assert that little empirical evidence exists to affect person variables when the comprehension of safety signs if discussed; however the intelligence and technical knowledge of users is important and must be considered. It has also been noted in the literature that language and the use of safety words are the biggest problems concerning safety message (Wogalter and Silver, 1995). Another interesting finding is to note is that the condition with STT resulted in the lowest reaction and response times and the least number of errors. Shapes have been used to attract attention to signs (Young, 1988) and the literature regarding the

comprehension of signs with shapes has not been well documented. In this study, it appears that the combination of shapes and text resulted in the fastest time to identify and recall the safety information for the participants, which may suggest that this combination may be ideal for training individuals to remember information correctly.

Age

Age has been shown to have an impact on response time and is reported to be proportional to the magnitude of the age differences (Rogers and Fisk, 1990). The decreases in reaction time for the conditions were not the same for the two age groups; however the young age group had lower reaction times for only five out of the eight conditions (Figure 9). It was expected that the younger participants would obtain lower reaction times for all of the conditions as Rogers and Fisk (1990) maintain that the reaction time of young adults is approximately 20 – 100% faster than that of older adults. For this study, it was calculated that the younger participants reacted 4 – 27% faster than the older participants.

The older age group experienced the highest reaction time for the TTT condition; while the younger age group experienced the highest reaction time for the SCI condition. The signs with TTI produced the lowest reaction times for the older participants while the signs with STT resulted in the lowest reaction times for the younger age group. For response time, the expectation was that the older participants would obtain higher response times for the signs containing text and it is interesting to note that the two conditions that the older participants obtained higher reaction times than their younger counterparts were for the conditions containing predominantly text (TTT and TCT). Craik and Salthouse (1992) reported that older adults experience visual impairments that cause problems with reading and comprehending text message, which may explain the higher reaction times obtained by the older participants for the signs with predominantly text. Despite the differences in reaction time, both age groups experienced similar increases and decreases in reaction time over the eight conditions. This indicated that the conditions had the same effect on reaction time for both groups.

The signs with STT elicited the lowest response times for both age groups, as seen in Figure 10. Unlike with reaction time, the response times were higher for the younger age group for the majority of the conditions (six out of eight conditions). Of these six conditions, four contained icons (TCI, SCI, STI and TTI). Hancock *et al*. (2001) reported that older adults are exposed to safety signs at work and have higher exposure to signs through the use of household products containing icons. This may explain why the older participants obtained lower response times for all the conditions containing icons. The findings of the higher response times for the young participants is in disagreement with the Complexity Hypothesis presented by Rogers and Fisk (1990) that states that older adults require more time in order to perform mental processes. However, Fisk *et al*. (1988) report that the responses of young and old adults differ but for some tasks there still remains the possibility that the function relating to the performance of young and old adults would change with practice. The conditions were permutated throughout the 64 signs; therefore improvement over time could not be clearly seen for the conditions.

Education

Individuals with lower education levels encounter problems when attempting to learn and understand safety information (Hancock *et al*., 2004), which may explain the findings shown in Figure 11. The participants with a lower level of education obtained higher response times than those with a higher level of education, which was an expected result. The conditions did not have the same effect on response time for both education groups as the increases and decreases experienced by the two groups were not the same over the eight conditions. Mosenthal and Kirsch (1999) have reported that attributers that are abstract can be difficult to recall not only for individuals with low education levels, but also those who are highly educated. This may have caused a double burden for a sample group from a South African population, as the education levels are typically low and incorporating abstract attributes in safety signs may only further increase the difficulty.

Occlusion

The decision to use Occlusion was made to attain a true measure of perception and due to the statement of Wogalter and Young (1991), which states that in industries

safety signs are displayed in a number of ways as a result of the increase in technology. The Occlusion group was expected to obtain higher reaction times because the information was flashed continuously and not displayed for an unlimited amount of time. As seen in Figure 12, this was found to be true. Limiting the display time increased the time taken to recall the information and added a level of difficulty to the required task, particularly for the older participants and those with low education levels. This resulted in the participants struggling to see the information in the signs, especially the text. The conditions did not have the same effect on reaction time throughout the conditions for the two groups as the same fluctuations were not experienced over the eight conditions.

Figure 13 illustrates that Occlusion was not found to have the same effect on the error rates obtained by the two groups, but both groups did obtain the lowest errors for the condition with STT. The two groups also obtained the highest errors for the conditions with icons (SCI, STI, TTI and TCI), which suggests that the icons were more difficult to remember correctly in this study, regardless of how the information was displayed. This contradicts the findings of Lesch (2003) who reported that icons were easier to recall than text.

REPETITIONS

A decrease in reaction time (Figure 14) and response time (Figure 15) was experienced from the first repetition to the last. Johnson-Laird (1988) stated that during the course of learning, fairly permanent changes occurs, usually as a result of experience. With reaction time and response time, a learning curve occurred as the repetitions increased. The first exposure to the signs induced the highest reaction and response times and the last exposure elicited the lowest. Therefore, as exposure to the signs increased, participants were able to react and recall the information faster. An increase in exposure may lead to familiarity, which in turn can increase the noticeability of warnings (Rogers *et al*., 2000). Figures 14 and 15 also show that reaction time and response time both increased from repetition 4 to repetition 5. Winocur and Hasher (2004) reported that testing at various times of day can result in tiredness and fatigue, which may have cause the increase at this interval. It may be that participants were tested at a time of day that resulted in the

onset of fatigue or it may be that the task difficulty increased at this point causing the increase in reaction and response times between repetitions 4 and 5. However, these effects were not tested.

Performance has been reported to increase with practice (Newell and Rosenbloom, 1981). This is evident in Figure 16, which indicates that the number of errors decreased as the repetitions increased. There were fluctuations in error rates over the eight repetitions but overall, the first exposure to the signs produced the highest errors. This was an expected result as the repetitions were designed to increase familiarity and therefore decrease the number of errors made throughout the repetitions. Wogalter *et al*. (1992) and Rogers *et al*. (2000) reported that familiarity can increase through a minimum amount of training and experience, which was found to be true for this study.

Education

Reaction time and response time decreased as the number of repetitions increased for both education groups, as seen in Figures 17 and 18. Despite the difference in the level of education, a learning curve was present. Therefore, regardless of education, familiarity still occurred. The repetitions did not have the same effect on reaction time as the learning curves experienced by the two groups were not the same (Figure 17). Figure 18 however shows that for response time, the effects of the repetitions were the same for both groups. The learning curve for the low education group was more pronounced than that of the high education group for both reaction time and response time, suggesting that familiarity or the learning effects for the participants with a lower level of education was more dramatic.

Occlusion

Familiarity can increase through experience (Wogalter *et al*., 1991), which is evident in the results displayed in Figures 19 and 20. Both reaction time and response time decreased from the first repetition to the last, despite the manner in which the signs were displayed (Occlusion or No Occlusion). The learning curve was still present and familiarity still occurred, which shows that it is possible to become familiar with information or an environment no matter how signs are displayed in industries. The

familiarity effect experienced by the two groups was not the same over the eight repetitions for both reaction time and response time. The learning curve experienced by the Occlusion group was more pronounced than that of the No Occlusion group for both reaction time and response time. This indicates that the Occlusion group experienced a more dramatic learning effect, which shows that this group became more familiarized and were able to adjust over time to the manner in which the signs were displayed.

Both groups experienced a decrease in the number of errors, with fluctuations in error rates occurring over the eight repetitions (Figure 21). As with reaction time and response time, it appears that familiarity to the signs occurred despite the manner in which the signs were displayed. While little literature exists on the impact that the display of safety signs has on the reading ability and comprehension, Ayres *et al*. (1989) reported that signs should be adequately conspicuous, brief, understandable and easy to read for the target market which was the manner in which the signs in this study were designed.

SESSIONS

Research has shown that even with a minimum amount of training, improvements in comprehension can occur (Rogers *et al*., 2000). Both reaction time and response time decreased significantly from the first session to the second due to the effects of familiarity (Figures 22 and 23). Even with a period of one week between the testing sessions, familiarity occurred thus supporting the statement of Kieras (1978), that recalling information that has been presented previously is less challenging that learning new information. This has a significant practical implication for training in industries as the comprehension of workers can be improved in a short amount of time as long as the exposure to the required information is frequent. As seen in Figure 24, the number of errors also decreased from the first session to the second. Rogers *et al*. (2000) maintain that the knowledge of the environment becomes more details and accurate as familiarity increases, which supports these findings.

Education

Figures 25 and 26 show that the reaction times and response times obtained during the first session were significantly higher than those obtained during the second session. This further proves that increasing the exposure and experience to information increase familiarity, which in turn can cause less time taken to notice and encode safety information. The participants with the higher education group obtained lower reaction times and response times than the participants with the lower education levels. Education impacts the comprehension of safety information as individuals with low education levels experience problems processing the information presented to them (Kosmidis *et al*., 2006). The increased reaction and response times of the lower education group could also have been caused by language problems as it is more challenging to understand information that is not presented in the native language of individuals (Mosenthal and Kirsch, 1999). This emphasizes the need to consider the native language as well as the education levels of individuals while subjecting them to training or to learning safety information.

Occlusion

When the first session was compared to the second session, the reaction times differed significantly for the two groups. The Occlusion groups obtained higher reaction times than the No Occlusion group for both the sessions, as demonstrated in Figure 27. The number of errors obtained (Figure 28) were also significantly higher for the Occlusion group in both sessions. This suggests that in order for participants to be able to remember the safety information correctly, Occlusion may not be ideal to incorporate in signs as it may lead to difficulty in seeing attributes in signs and identifying them correctly. As discussed previously, exposure to the signs for a brief period of time increased the time taken to notice and recall information and it seem that it may be necessary to ensure that safety information is displayed continuously and does not flash intermittently.

CONCLUSIONS

The signs with STT appeared to elicit better results for the performance of the participants, which may suggest that the combination of shapes and text may be the

ideal combination for displaying safety information. These signs caused the participants to notice and recall the information quicker and also with fewer errors.

The findings also demonstrated that increasing the exposure to the signs may result in increased familiarity and thus decreased errors and faster recall and response times. Increasing familiarity can be done by increasing the number of times the signs are shown to individuals in a training session or by increasing the number of training sessions.

Education has been highlighted as an important factor to consider with respect to learning and recalling safety information. The group with the higher level of education performed better than the lower education group. This highlights the importance of education overall, but also indicates that it is important for comprehending safety information.

While the effects of age are not well documented in the literature, some significant differences between the two age groups were noted in this study. While it was expected that visual impairments and problems with mental processes would cause the older age group to perform poorer than the young age group, this was not the case for all the results obtained. The impact of age on learning and comprehension safety information do not appear clear from the findings of this study. What is evident from the results obtained though is that it may be important to consider age carefully when designing signs and utilizing text in signs.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

Health and safety in industries remains a major problem for ergonomists as well as to the economic climate of the world (Smallman, 2001). It is important for managers to investigate the safety climate of their companies as this indicates how the system is performing and what can be done to alleviate the safety problems (Sgourou *et al*., 2009). The role that education can play in counteracting occupation injuries is being reviewed by health and safety practitioners (Heath, 1982), but the development of training programs to aid in the reduction of injuries and accidents in workplaces is being questioned (Hale, 1984).

There has been a global increase in the research focused on safety signs, but the situation in South Africa remains detrimental. Studies investigating safety signs and comprehension in South Africa are scarce. South Africans are exposed to 11 official languages (Brock-Utne and Holmarsdottir, 2004) and the majority of the population only has basic education skills due to the high level of manual labour in this Industrially Developing Country (IDC) (Scott, 1999). The use of English as the main education language has not helped the situation as there has been an increase in the number of African speaking students attending secondary schools in an attempt to further their education (Heugh, 1999). These factors all need to be considered when designing safety signs as many of the individuals utilizing these signs do not have the same level of reading comprehension (Rogers *et al.*, 2000).

SUMMARY OF PROCEDURES

60 male participants were recruited for this study and were placed into four groups corresponding to their age and level of education. Participants were given two minutes to learn the meanings of three colours, three shapes and three icons. After the participants had learned the required information, they were presented with 64 signs and had to recall the meanings of each of the three attributes present in each sign. Half the participants were exposed to signs “With Occlusion” and the other half

were tested using signs “Without Occlusion”. After a lapse of one week, participants were asked to complete a second session where they were not given any time to relearn the meanings of the attributes. Participants were exposed to the same set of signs they had been tested on the previous week. During both testing sessions, participants were permitted to look at the page with the meanings of the attributes were they not able to remember information present in the sign.

SUMMARY OF RESULTS

The aim of this study was to assess the effects of safety sign attributes on learning and familiarity in participants of differing age and education levels. The reaction time, response time and errors obtained were the variables measured.

Conditions

The signs with only a shape and text resulted in the lowest reaction times, response times and errors rates for the conditions. Age had a significant effect on the results obtained for the conditions for the reaction times and the response times, while education only had a significant impact on response time. The Occlusion group obtained higher reaction times and errors for the conditions than the No Occlusion group.

Repetitions

An increase in the number of repetitions resulted in a decrease in the reaction time, response time and errors obtained. The Occlusion and No Occlusion groups experienced a decrease in reaction time and response time over the eight repetitions. The participants with a lower education level obtained higher reaction times and response times, while the Occlusion group obtained higher reaction times, response times and errors throughout the repetitions than the No Occlusion group. Despite the differences between the education and Occlusion and No Occlusion groups, a learning effect occurred over the eight repetitions illustrating that increased exposure to information resulted in an improvement in performance.

Sessions

The performance measures (reaction time, response time and error rate) were significantly higher for the first session than for the second session. The effect of familiarity significantly improved the results obtained regardless of education and display method (Occlusion and No Occlusion).

RESPONSE TO HYPOTHESIS

It was postulated that differences in the responses would exist between the groups with the different education levels and the groups with the different age levels. It was also hypothesized that the different conditions would produce different results, regardless of age or level of education.

Hypothesis 1: H_o: $\mu_{C1}=\mu_{C2}=\mu_{C3}=\mu_{C4}=\mu_{C5}=\mu_{C6}=\mu_{C7}=\mu_{C8}$

This hypothesis stated that no differences would exist between the responses of all the participants to the conditions of the signs, regardless of age or education level. This hypothesis was rejected as the different conditions elicited significantly different reaction times, response times and error rates for the different participants.

Hypothesis 2: H_o: $\mu_{ResponsesOld}=\mu_{ResponsesYoung}$

This hypothesis stated that no differences would exist for the responses obtained from all the participants, regardless of age. This hypothesis was rejected as the responses obtained for the old participants differed from those obtained for the young participants.

Hypothesis 3: H_o: $\mu_{ResponsesHigh}=\mu_{ResponsesLow}$

This hypothesis stated that no differences would exist for the responses obtained from all the participants, regardless of education level. This hypothesis was rejected as the responses obtained for the participants with a high education level differed from those obtained for the low education level.

CONCLUSIONS

The findings in this study show that different attributes elicit different reaction times, response times and errors obtained when recalling information in safety signs. Traditionally, it is thought that icons are easier and quicker to recall; however it seems that the combination of text and shapes may elicit faster and more accurate recall. Education has an impact on learning and remembering safety information as abstract signs and low comprehension levels may result in problems with comprehending safety information. While the effects of age did not seem clear, it seems that for some safety information, older individuals may experience more difficulty in reading and recalling text as a result of visual impairments.

The reaction times, response times and error rates for the eight conditions differed. Differences were also obtained between the different age and education groups, suggesting that participants with different age and education levels require different amounts of time to learn, notice, encode and recall safety information.

From the results obtained in this study it is apparent that individuals of different age and education levels need to be considered independently when training programs regarding safety information are being administered and when signs are designed. The only significant effects found with respect to age were for the conditions, indicating that age plays a role in the noticing and encoding of text, shapes, colours and icons. Education appeared to be the bigger concern due to the large number different languages are spoken in South Africa and the employment of individuals with basic education that are not able to comprehend the safety information provided to them.

RECOMMENDATIONS

Recommendations for future research in this area are that firstly, the sample size be increased so that the number of participants is proportional to the variables being tested. This may result in the results obtained to be more accurate and practical for the real world scenario. Secondly, it is recommended that females are included in the sample. It is important that results obtained regarding the comprehension of safety information also incorporate the female population as more females are being

employed in industries and it is important to establish the female responses for comprehension studies to investigate whether any gender differences occur. Thirdly, it is recommended that future studies focus on the impact of training programmes designed for safety information and the differences that exist between different education levels. This information is important for an industrially developing country such as South Africa. Lastly, more studies must be conducted within this field as very little literature exists investigating the comprehension of safety information in industrially developing countries where a need for this kind of research clearly exists. With respect to existing training programmes in South African industries, it is recommended that employees are given the adequate time required to learn safety information, taking their education levels into account. Colours, shapes and icons require different amounts of time to learn and recall, therefore these factors should be considered when designing training programs for the South African population.

REFERENCES

Note: Asterisked citations* are secondary sources. These were not directly consulted and are referenced as fully primary sources, indicated in brackets, permit.

Adams A, Bochner S and Bilik L (1998). The effectiveness of warning signs in hazardous work places: cognitive and social determinants. **Applied Ergonomics**, 29(4): 247-254

*American National Standards Institute (ANSI) (1991). **Accredited standard on safety colors, signs, symbols, labels and tags**. Z535.1-5. Washington, DC: National Electrical Manufacturers Association (see Wolff and Wogalter, 1998)

*Atkinson RC and Shiffrin RM (1968). Human memory: A proposed system and its control processes. In KW Spence and JT Spence (eds), **The psychology of learning and motivation (Vol. 2).** Orlando, FL: Academic Press (see Reed, 1992)

Ayres TJ, Gross MM, Wood CT, Horst DP, Beyer RR and Robinson JN (1989). What is a warning and when will it work? In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 1-5

*Baddeley AD and Hitch G (1974). Working memory. In G Bower (ed): **The Psychology of Learning and Motivation**, Volume 8. London: Academic Press (see Johnson-Laird, 1988)

*Barlow T and Wogalter MS (1991). Increasing the surface area on small product containers to facilitate communication of label information and warnings. **Interface**, 7: 88-93 (see Rogers *et al.*, 2000)

Berkman P, Heinik J, Habot B and Burke M (1999). Accuracy of recall in elderly patients to telephone support calls. **Archives of Gerontology and Geriatrics**, 28: 125-130

*Birren JE (1965). Age changes in speed of behavior: Its central nature and physiological correlates. In AT Welford and JE Birren (eds): **Behavior, aging and the nervous system**. Springfield, IL: Charles C Thomas (see Rogers and Fisk, 1990)

Braun CC and Silver NC (1995). Interaction of signal word and colour on warning labels: differences in perceived hazard and behavioural compliance. **Ergonomics**, 38(11): 2207-2220

*Braun CC, Greeno B and Silver NC (1998). Differences in behavioural compliance as a function of warning colour. In: **Proceedings of the Human Factors and Ergonomics Society 38th Annual Meetings**, pp. 379-383 (see Duarte and Rebelo, 2005)

*Braun CC and Shaver EF (1999). Warning sign components and hazard perceptions. In: **Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting,** pp. 878-882 (see Duarte and Rebelo, 2005)

*Broadbent DE (1984). The Maltese cross: a new simplistic model for memory. **Behavioural and Brain Sciences**, 7: 55-94 (see Johnson-Laird, 1988)

Brock-Utne B and Holmarsdottir HB (2004). Language policies and practices in Tanzania and South Africa: problems and challenges. **International Journal of Educational Development**, 24: 67-83

*Brown LM, Dosemeci M, Blair A and Burmeister L (1991). Comparability of data obtained from farmers and surrogate respondents on use of agricultural pesticides. **American Journal of Epidemiology**, 134: 348-355 (see Berkman*et al.*, 1999)

*Bruyas MP, Le Breton B and Pauzié A (1998). Guidelines. Ergonomics guidelines for the design of pictorial information. **International Journal of Industrial Ergonomics**, 21: 407-413 (see Duarte and Rebelo, 2005)

Cahill MC (1976). Design features of graphic symbols varying in interpretability. **Perceptual and Motor Skills**, 42: 647-653

*Castro-Caldas A, Petersson KM, Reis A, Stone-Elander S and Ingvar M (1998). The illiterate brain: Learning to read and write during childhood influences the functional organization of the adult brain. **Brain**, 121: 1053-1063 (see Kosmidis*et al.*, 2006)

*Cerella J, Poon LW and Williams DH (1980). Age and the complexity hypothesis. In LW Poon (ed): **Aging in the 1980's**. Washington, DC: APA Publishing, pp. 332-340 (see Rogers and Fisk, 1990)

*Cerella J (1985). Information processing rates in the elderly. **Psychological Bulletin**, 98: 67-83 (see Rogers and Fisk, 1990)

Chapanis A (1994). Hazards associated with three signal words and four colours on warning signs. **Ergonomics**, 37(2): 265-275

*Cheatham DB and Wogalter MS (1999). Connoted hazard and perceived conspicuity of warning configuration. In: **Proceedings of Human Factors and Ergonomics Society 43rd Annual Meeting**, pp. 883-887 (see Duarte and Rebelo, 2005)

*Collins BL (1983). Evaluation of mine-safety symbols. In: **Proceedings of the Human Factors Society 27th Annual Meeting**. Santa Monica, California: The Human Factors Society, pp. 947-949 (see Young, 1998)

*Cohen A (1977). Factors in successful occupational safety programs. **Journal of Safety Research**, 15: 141-151 (see Glendon and Litherland, 2001)

*Coughlin SS (1990). Recall bias in epidemiologic studies. **Journal of Clinical Epidemiology**, 43: 87-91 (see Berkman *et al.*, 1999)

*Cowan N (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information-processing system. **Psychological Bulletin**, 104: 163-191 (see Silver and Wogalter, 1989)

*Craik FIM and Salthouse TA (1992).**The handbook of aging and cognition**. Hillsdale, NJ: Erlbaum (see Hancock *et al.*, 2004)

Davies S, Haines H, Norris B and Wilson JR (1997). Safety Pictograms: Are they getting the Message Across? **Applied Ergonomics***,* 29(1): 15-23

*Dorris AL and Purswell JL (1977). Warnings and human behavior: implications for the design of product warnings. **Journal of Products Liability**, 1: 255-264. (see Purswell *et al.*, 1987)

Dreyfuss H (1972). **Symbol sourcebook: An authorative guide to international graphic symbols**. New York: McGraw-Hill. Pages 26-246

Duarte ME and Rebelo F (2005). Comprehension of safety signs: internal and external variable influences and comprehension difficulties by disabled people. In A Thatcher, J James and A Todd (eds): **Proceedings of the Fourth International Cyberspace Conference on Ergonomics 2005**. Johannesburg: International Ergonomics Association Press

Ecker UKH, Zimmer HD, Groh-Bordin C and Mecklinger A (2007). Context effects on familiarity are familiarity effects of context – An electrophysiological study. **International Journal of Psychophysiology**, 64: 146-156

Edworthy J and Adams A (1996).**Warning design: A research prospective**. London: Taylor & Francis (see Rogers *et al.*, 2000)

Fahle M and Daum I (1997).Visual learning and memory as functions of age. **Neuropsychologica**, 35(12): 1583-1589

*Fisk AD, McGee ND and Giambra LM (1988). The influence of age on consistent and varied semantic category search performance. **Psychology and Aging**, 3: 323-333 (see Rogers and Fisk, 1990)

Gill RT, Barbera C and Precht T (1987). A comparative evaluation of warning label design. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 50-52

*Glenberg AM, Meyer M and Lindem K (1987). Mental models contribute to foregrounding during text comprehension. **Journal of Memory and Language**, 26: 69-83 (see Reed, 1992)

Glendon AI and Litherland DK (2001).Safety climate factors, group differences and safety behaviour in road construction. **Safety Science**, 39: 157-188

Goldenhar LM, Moran SK and Colligan M (2001).Health and safety training in a sample of open-shop construction companies. **Journal of Safety Research**, 32: 237-252

Hakiel SR and Easterby RS (1984). Issues in the design of safety sign systems. In: RS Easterby and HI Zwaga (eds), **Information design: The design and evaluation of signs and printed materials***.* Chichester: John Wiley and Sons, pp. 419-448

Hale AR (1984). Is safety training worthwhile? **Journal of Occupational Accidents**, 6: 17-33

Hancock HE, Rogers WA, Schroeder D and Fisk AD (2004). Safety symbol comprehension: Effects of symbol type, familiarity and age. **Human Factors**, 46(2): 183-195

*Hancock HE, Fisk AD and Rogers WA (2001). Product usage patterns in a diverse sample of all ages. **Ergonomics in Design**, 9(4): 12-18 (see Hancock *et al.*, 2004)

*Hansen AL, Johnsen BH and Thayer JF (2003). Vagal influence on working memory and attention. **International Journal of Psychphysiology**, 48(3): 263-274 (see Luft*et al.*, 2009)

*Haviland SE and Clark HH (1974). What‟s new? Acquiring new information as a process of comprehension. **Journal of Verbal Learning and Verbal Behavior**, 13: 512-521 (see Reed, 1992)

*Health and Safety Executive (1999). **The costs to Britain of workplace accidents and work-related ill-health in 1995-1996**. United Kingdom: HSE Books (see Smallman, 2001)

Heath ED (1982). Worker training and education in occupational safety and health: A report on practice in six industrialized Western nations. Part one of a four-part series. **Journal of Safety Research**, 13: 5-11

Heugh K (1999). Languages, development and reconstructing education in South Africa. **International Journal of Educational Development**, 19: 301-313

Iachini T, Ruotolo F and Ruggiero G (2009).The effects of familiarity and gender on spatial representation of a real environment. **Journal of Environmental Psychology**, 29(2): 227-234

*International Standards Organization (ISO) (1984). **International standards for safety colours and safety signs.** ISO 3864. Geneva, Switzerland: Author (see Duarte and Rebelo, 2005)

Jaynes LS and Boles DB (1990).The effect of symbols on warning compliance. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 91-94

Johnson-Laird PN (1988). **The Computer and the Mind: An Introduction to Cognitive Science**. Cambridge, Massachusetts: Harvard University Press, pp. 28-152

Johnston WA, Griffith D and Wagstaff RR (1972).Speed, Accuracy and Ease of Recall. **Journal of Verbal Learning and Verbal Behavior**, 11: 512-520

*Kieras DE (1978). Good and bad structure in simple paragraphs: Effects on apparent theme, reading time, and recall. **Journal of Verbal Learning and Verbal Behavior**, 17: 13-28 (see Reed, 1992)

Kline PB, Braun CC, Peterson N and Silver NC (1993). Impact of color on warnings research. In: **Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting**. Santa Monica, California: The Human Factors Society, pp. 940-943

Kosmidis MR, Tsapkini K and Folia V (2006). Lexical processing in illiteracy: Effect of literacy or education? **Cortex**, 42: 1021-1027

*Lane RD, McRae K, Reiman EM, Chen K, Ahern GL and Thayer JF (2009). Neural correlates of heart rate variability during emotion. **Neuroimage**, 44(1): 213-222 (see Luft*et al.*, 2009)

Langley MM, Cleary AM, Kostic BN and Woods JA (2008). Picture recognition without picture identification: A method for assessing the role of perceptual information in familiarity-based picture recognition. **Acta Psychologica**, 127: 103-113

Laughery KR and Brelsford JW (1991).Receiver characteristics in safety communications. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 120-124

*Laughery KR and Young SL (1991). Consumer product warnings: Design factors that influence noticeability. In: **Proceedings of the 11th Congress of the International Ergonomics Association**. London: Taylor and Francis, pp. 1104-1106 (see Rogers *et al.*, 2000)

Laughery KR (2006). Safety Communications: Warnings. **Applied Ergonomics**, 37(4): 467-478

Leonard SD, Matthews D and Karnes EW (1986). How Does the Population Interpret Warning Signals? In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 140-144

Lesch MF (2003). Comprehension and memory for warning symbols: Age-related differences and impact of training. **Journal of Safety Research**, 34(5): 495-505

Lesch MF (2008a). A comparison of two training methods for improving warning symbol comprehension. **Applied Ergonomics**, 39(2): 135-143

Lesch MF (2008b). Warning symbols as reminders of hazards: Impact of training. **Accident and Analysis Prevention, Article in Press**

*Lesgold AM, Roth SF and Curtis ME (1979). Foregrounding effects in discourse comprehension. **Journal of Verbal Learning and Verbal Behavior**, 18: 291-308 (see Reed, 1992)

*Light LL (1991). Memory and aging: four hypotheses in search of data. **Annual Review of Psychology**, 42: 333-376 (see Fahle and Daum, 1997)

*Loring BA and Wiklund ME (1988). Improving swimming pool warning signs. In: **Proceedings of the Human Factors Society 32nd Annual Meeting**. Santa Monica, California: Human Factors and Ergonomics Society, pp. 910-914 (see Rogers *et al.*, 2000)

Luft CDB, Takase E and Darby D (2009). Heart rate variability and cognitive function: Effects of physical effort. **Biological Psychology**, 82: 186-191

Mansoor LE and Dowse R (2004). Design and evaluation of a new pharmaceutical pictogram sequence to convey medicine usage. **Ergonomics SA**, 2: 29-41

*Mikulecky L (1982). Job literacy: The relationship between school preparation and workplace actuality. **Reading Research Quarterly**, 17: 400-419 (see Mosenthal and Kirsch, 1989)

*Miller GA (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. **Psychological Review**, 63: 81-97 (see Reed, 1992)

*Mohn G and van Hof-van Duin J (1991). Development of spatial vision. In DM Regan (ed): **Vision and Visual Dysfunction. Volume 10, Spatial Vision**. London: Macmillan, pp. 179-211 (see Fahle and Daum, 1997)

*Moscovitch M and Winocur G (1992). The neuropsychology of memory and aging. In FIM Craik and TA Salthouse (eds): **The Handbook of Aging and Cognition**. Hillsdale: Erlbaum, pp. 315-372 (see Fahle and Daum, 1997)

Mosenthal PB and Kirsch IS (1989). Designing effective adult literacy programs. **Poetics**, 18: 239-256

Moss SM and Sanders AF (1973). The effect of an additional task on recall accuracy in serial short term memory: Preemption of rehearsal or acquisition? **Acta Psychologica**, 37: 303-313

*Newell A and Rosenbloom PS (1981). Mechanisms of skill acquisition and the law of practice. In JR Anderson (ed): **Cognitive skills and their acquisition**. Hillsdale, NJ: Erlbaum (see Rogers and Fisk, 1990)

Nitsch H (2005). International Safety Signs. URL: http://www.geonit.com/produkte/PDF/safety.pdf. Last accessed: 22 September 2008

Ortiz J, Resnick ML and Kengskool K (2000). The effects of familiarity and risk perception on workplace warning compliance. In: **Proceedings of the IEA 2000/HFES 2000 Congress**, pp. 826-829

*Paivio A, Rogers TB and Smythe PC (1968). Why are pictures easier to recall than words? **Psychonomic Science**, 11: 137-138 (see Jaynes and Boles, 1990)

*Park SB, Lee BC and Jeong KS (2007). Standardized tests of heart rate variability for autonomic function tests in healthy Koreans. **International Journal of Neuroscience**, 117(12): 1707-1717 (see Luft*et al.*, 2009)

*Provenzo EF, Jr (1986). **Beyond the Gutenberg galaxy: Microcomputers and the emergence of the post-typographic culture**. New York: Columbia University Press (see Mosenthal and Kirsch, 1989)

Purswell JL, Krenek RF and Dorris A (1987). Warning effectiveness: what do we need to know. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993.** Santa Monica: Human Factors and Ergonomics Society, pp. 174-178

Ratcliff R and Rouder JN (1998). Modeling response times for two-choice decisions. **Psychological Science**, 9(5): 347-356

*Reed SK and Johnsen JA (1975). Detection of parts in patterns and images. **Memory and Recognition**, 3: 569-575 (see Reed, 1992)

Reed SK (1992). **Cognition: Theory and Applications**. Third Edition. California: Brooks/Cole Publishing Company, pp.

*Rhodes TP, Frantz JP and Miller JM (1990). Emerging methodologies for the assessment of safety related products communication. In: **Proceedings of the Human Factors and Ergonomics Society 34th Annual Meeting**. Santa Monica, CA: Human Factors and Ergonomics Society, pp. 998-1002 (see Ortiz *et al.*, 2000)

*Robinett F and Hughes A (1984). Visual alerts to machinery hazards: A design case study. In R Easterby and H Zwaga (eds): **Information Design: The Design and Evaluation of Signs and Printed Materials.** Chicester: John Wiley and Sons, pp. 405-417 (see Young and Wogalter, 1988)

Rogers WA and Fisk AD (1990). A reconsideration of age-related reaction time slowing from a learning perspective: Age-related slowing is not just complexity based. **Learning and Individual Differences**, 2(2): 161-179

Rogers WA, Lamson N and Rousseau GK (2000).Warning Research: An Integrative Perspective. **Human Factors**, 42(1): 102-139

*Routh DA (1971). Independence of the modality effect and amount of silent rehearsal in immediate serial recall. **Journal of Verbal Learning and Verbal Behavior**, 10: 213-218 (see Moss and Sanders, 1973)

*Salthouse TA (1982). **Adult cognition: an experimental psychology of human aging.** New York: Springer-Verlag (see Rogers and Fisk, 1990)

*Schneider W and Fisk AD (1982). Degree of consistent training: Improvements in search performance and automatic process development. **Perception and Psychophysics**, 31: 160-166 (see Rogers and Fisk, 1990)

*Schroder HM (1970). Safety performance measurement.**Journal of Safety Research**, 2: 188-195 (see Glendon and Litherland, 2001)

Sgourou S, Katsakiori P, Goutsos S and ManatakisEm.(2009). Assessment of selected safety performance evaluation methods in regards to their conceptual, methodological and practical characteristics. **Safety Science**, Article in Press.

*Shepard RN (1967). Recognition memory for words, sentences, and pictures. **Journal of Verbal Learning and Verbal Behaviour**, 6: 156-163 (see Reed, 1992)

*Slapater FJ (1950). Age norms of refraction and vision. **Archives of Opthalmology**, 43: 446-479 (see Fahle and Daum, 1997)

Smallman C (2001). The reality of “Revitalising Health and Safety”. **Journal of Safety Research**, 32: 391-439

*Smith MJ, Cohen HH, Cohen A and Cleveland RJ (1978). Characteristics of successful safety programs. **Journal of Safety Research**, 10: 5-15 (see Glendon and Litherland, 2001)

Standards Bulletin (1997).**South African Bureau of Standards**, pp. 3

Scott PA (1999). The effect of a work-conditioning programme on manual labourers in South African industry .**International Journal of Industrial Ergonomics**, 24: 253-259

Silver NC and Wogalter MS (1989).Broadening the range of signal words. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 186-190

*Teichner W and Krebs M (1972). The laws of simple visual reaction time. **Psychological Review**, 79: 344-358 (see Wickens, 1984)

Turner P (2008). Being-with: A study of familiarity. **Interacting with Computers**, 20: 447-454

*Welford AT (1977). Motor performance. In JE Buren and KW Schaie (eds): ***Handbook of the psychology of aging***. Second Edition. New York: Van Nostrand Reinhold (see Rogers and Fisk, 1990)

*West RL and Crook TH (1990). Age differences in everyday memory: Laboratory analogues of telephone number recall. **Psychology and Aging**, 5: 520-529 (see Berkman *et al.*, 1999)

Wickens CD (1984). **Engineering Psychology and Human Performance**. USA: Scott, Foresman and Company, pp. 197-231

Winocur G and Hasher L (2004).Age and time-of-day effects on learning and memory in non-matching-to-sample test.**Neurobiology of Aging**, 25: 1107-1115

*Wiseman S, Macleod SM and Lootsteen PJ (1985). Picture recognition improces with subsequent verbal information. **Journal of Experimental Psychology: Learning, Memory and Cognition**, 11: 588-595 (see Wogalter and Sojourner, 1997)

Wogalter MS, Desaulniers DR and Godfrey SS (1985).Perceived Effectiveness of Environmental Warnings. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 215-219

*Wogalter MS, Breslford JW, Desaulniers DR and Laughery KR (1991). Consumer product warning: The role of hazard perception. **Journal of Safety Research**, 22: 71-82 (see Ortiz *et al.*, 2000)

Wogalter MS and Young (1991).Behavioural compliance to voice and print warnings. **Ergonomics**, 34(1): 79-89

Wogalter MS, Kalsher MJ and Racicot BM (1992).The influence of location and pictorials on behavioral compliance to warnings. In SK Laughery, MS Wogalter and

SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 230-234

Wogalter MS, Racicot BM, Kalsher MJ and Simpson SN (1993).Behavioral Compliance to Personalized Warning Signs and the Role of Perceived Relevance. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 239-243

Wogalter MS, Jarrard SW and Simpson SN (1994).Influence of Warning Label Signal Words on Perceived Hazard Level. **Human Factors**, 36(3): 547-556

*Wogalter MS, Magurno AB, Carter AW, Swindell JA, Vigilante WJ and Daurity JC (1995). Hazard associations of warning header components. In **Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting**. Santa Monica, California: The Human Factors and Ergonomics Society, pp. 979-983 (see Young, 1998)

Wogalter MS and Silver NC (1995). Warning signal words: connoted strength and understandability by children, elders and non-native English speakers. **Ergonomics**, 38(11): 2188-2206

Wogalter MS and Sojourner RJ (1997).Comprehension and Retention of Safety Pictorials. **Ergonomics**, 40(5): 531-542

Wolff JS and Wogalter MS (1998). Comprehension of Pictorial Symbols: Effects of Context and Test Method. **Human Factors**, 40(2): 173-186

*Woodworth RS and Schlossberg H (1965). **Experimental psychology**. New York: Holt, Rinehart & Winston (see Wickens, 1984)

Young SL and Wogalter MS (1988). Memory of instruction manual warnings: Effect of pictorial icons and conspicuous print. In SK Laughery, MS Wogalter and SL Young (eds): **Human Factors Perspectives on Warnings: Selections from Human Factors and Ergonomics Society Annual Meetings 1980-1993**. Santa Monica: Human Factors and Ergonomics Society, pp. 254-258

* Young SL (1991). Increasing the noticeability of warnings: Effects of pictorial, color, signal icon and border. In: **Proceedings of the Human Factors Society 35th Annual Meeting**. Santa Monica, California: Human Factors and Ergonomics Society, pp. 580-584 (see Rogers *et al.*, 2000)

Young SL (1998). Connotation of hazard for signal words and their associated panels. **Applied Ergonomics**, 29(2): 101-110

*Zhang G and Simon HA (1985). STM capacity for Chinese words and idioms: chunking and acoustical loop hypotheses. **Memory and Cognition**, 13: 193-210 (see Johnson-Laird, 1988)

APPENDICES

APPENDIX A: GENERAL INFORMATION

1) Equipment Checklist
2) Letter to Participant
3) Participant Consent Form
4) Details of Testing Permutation
5) Details of Participant Permutation
6) Order of Procedures

1) EQUIPMENT CHECKLIST

ADMINISTRATION

Letter to Participant

Informed Consent Form

Explanation Page

Participant Data Sheet

STATIONERY

Pens/Pencils/Eraser/Ruler

DATA COLLECTION EQUIPMENT

Computer

Video Camera

Tripod

Stopwatch

2) LETTER TO PARTICIPANT

Dear_____

Thank you for volunteering to participate in the study titled:

"EFFECTS OF AGE AND EDUCATION ON LEARNING SAFETY SIGN COMPONENTS AND THE IMPACT ON FAMILIARITY WITH THE SIGNS"

This letter serves to inform you about the nature of the study you volunteered to participate in. This study will investigate the attributes of safety signs and how they influence the design of safety signs, as well as familiarity and learning.

Familiarity is defined as how familiar people become with certain objects, environments or situations and is vital in industries because the more familiar workers are with their environments and the signs, the more aware they are of and the more protected they are against dangers that may occur in the workplace. This study aims to find out how the different attributes of safety signs, such as colours, shapes, icons and text, interact.

Through varying these attributes it may be possible to decrease the amount of learning time and increase familiarity. From this study it is hoped that some guidelines can be developed for the design of safety signs that could hopefully lead to signs being designed that could increase the familiarity of workers with their environments.

For this study, participants will be given a set of codes that they will be asked to learn in a designated amount of time. When the learning phase is complete, participants will be asked to recall a certain number of signs. The participants will

then be given a week until the next session, when they will be asked to recall another set of signs. The last session will occur a week later when participants will be asked to recall the signs for the last time. The experimenter will provide feedback and will be recording the number of signs that are recalled correctly.

The sessions will be recorded using a video camera and using this footage, the reaction time and accuracy of recall will be calculated. The participants" faces will not be recorded, just their voices and their hands using the computer.

The benefits of this study are that firstly, participants that participate in the study can assess their own memory skills as feedback will be provided to participants that require it. Secondly, the information provided by this study will provide data on the ability of employees in South African industries to recall safety related information. Employers and Ergonomics specialists in industries can utilise this information to mould their training programs to ensure that the individuals that are exposed to certain safety information are provided with the adequate time to learn and become familiar with the information.

Thank you,

Inga Dambuza

(Human Kinetics and Ergonomics Masters student)

3) PARTICIPANT CONSENT FORM

RHODES UNIVERSITY

DEPARTMENT OF HUMAN KINETICS AND ERGONOMICS

I, _____, have been fully informed of the research project titled **"EFFECTS OF AGE AND EDUCATION ON LEARNING SAFETY SIGN COMPONENTS AND THE IMPACT ON FAMILIARITY WITH THE SIGNS"**, and I give my full consent to be a participant in this study.

I am fully aware of the procedures involved, as well as the fact that my participation in this study will be recorded using a video camera, as explained to me both verbally and in writing. In agreeing to participate in this study, I waive any recourse against the researcher or Rhodes University, in the event of any personal injuries sustained. This waiver shall be binding upon my heirs and legal representatives.

I have read, and understood, the information sheet accompanying this form and any questions I have had, have been adequately answered. I realize the importance of reporting signs or symptoms indicating any abnormalities or distress and I am aware I can withdraw from the study at any time. I am aware that my anonymity will be protected at all times and agree that the information collected may be used and published for statistical or scientific purposes.

_____	_____	_____
PARTICIPANT (Print Name)	SIGNED	DATE
_____	_____	_____
RESEARCHER (Print Name)	SIGNED	DATE
_____	_____	_____
WITNESS (Print Name)	SIGNED	DATE

4) DETAILS OF TESTING PERMUTATION

NO OCCLUSION

SIGN NUMBER	REPETITION	CONDITION	SIGN NUMBER	REPETITION	CONDITION
1	**1**	5	**33**	**5**	8
2		1	**34**		5
3		2	**35**		2
4		3	**36**		1
5		4	**37**		3
6		8	**38**		7
7		7	**39**		4
8		6	**40**		6
9	**2**	7	**41**	**6**	7
10		1	**42**		6
11		6	**43**		5
12		8	**44**		4
13		4	**45**		2
14		2	**46**		3
15		5	**47**		8
16		3	**48**		1
17	**3**	6	**49**	**7**	6
18		8	**50**		3
19		4	**51**		8
20		3	**52**		5
21		1	**53**		2
22		2	**54**		1
23		5	**55**		4
24		7	**56**		7
25	**4**	3	**57**	**8**	3
26		7	**58**		2
27		5	**59**		6
28		2	**60**		4
29		4	**61**		8
30		6	**62**		1
31		8	**63**		7
32		1	**64**		5

OCCLUSION

SIGN NUMBER	REPETITION	CONDITION	SIGN NUMBER	REPETITION	CONDITION
1	**1**	1	**33**	**5**	1
2		3	**34**		2
3		5	**35**		8
4		4	**36**		5
5		7	**37**		4
6		2	**38**		3
7		8	**39**		6
8		6	**40**		7
9	**2**	4	**41**	**6**	5
10		1	**42**		4
11		5	**43**		8
12		7	**44**		7
13		6	**45**		2
14		3	**46**		3
15		2	**47**		1
16		8	**48**		6
17	**3**	5	**49**	**7**	6
18		1	**50**		1
19		8	**51**		8
20		2	**52**		4
21		7	**53**		5
22		6	**54**		2
23		3	**55**		3
24		4	**56**		7
25	**4**	4	**57**	**8**	2
26		6	**58**		5
27		1	**59**		3
28		8	**60**		6
29		3	**61**		7
30		7	**62**		1
31		5	**63**		4
32		2	**64**		8

5) DETAILS OF PARTICIPANT PERMUTATION

PARTICIPANT NUMBER	TEST SIGNS	PARTICIPANT NUMBER	TEST SIGNS
1	No Occlusion	**33**	No Occlusion
2	Occlusion	**34**	Occlusion
3	No Occlusion	**35**	No Occlusion
4	Occlusion	**36**	Occlusion
5	No Occlusion	**37**	No Occlusion
6	Occlusion	**38**	Occlusion
7	No Occlusion	**39**	No Occlusion
8	Occlusion	**40**	Occlusion
9	No Occlusion	**41**	No Occlusion
10	Occlusion	**42**	Occlusion
11	No Occlusion	**43**	No Occlusion
12	Occlusion	**44**	Occlusion
13	No Occlusion	**45**	No Occlusion
14	Occlusion	**46**	Occlusion
15	No Occlusion	**47**	No Occlusion
16	Occlusion	**48**	Occlusion
17	No Occlusion	**49**	No Occlusion
18	Occlusion	**50**	Occlusion
19	No Occlusion	**51**	No Occlusion
20	Occlusion	**52**	Occlusion
21	No Occlusion	**53**	No Occlusion
22	Occlusion	**54**	Occlusion
23	No Occlusion	**55**	No Occlusion
24	Occlusion	**56**	Occlusion
25	No Occlusion	**57**	No Occlusion
26	Occlusion	**58**	Occlusion
27	No Occlusion	**59**	No Occlusion
28	Occlusion	**60**	Occlusion
29	No Occlusion	**61**	No Occlusion
30	Occlusion	**62**	Occlusion
31	No Occlusion	**63**	No Occlusion
32	Occlusion	**64**	Occlusion

6) ORDER OF PROCEDURES

SESSION 1:

1. Welcome
2. Seat participant
3. Introduce participant to witness
4. Ask demographic information (age, highest level of education)
5. Describe project, protocol and equipment
6. Give Letter to Participant and Consent Form to participant
7. Ask witness to leave
8. Explain explanation page and protocol

Explanation Page:

I will give you a page with three colours, three shapes and three symbols on. Each of these has a safety related meaning; therefore there are nine variables and nine meanings that you must learn. I will give you two minutes to learn the nine variables and meanings. When the two minutes is over, I will take back the explanation page and we will start testing. If at any point during the testing you cannot remember what the variable means, you can ask to see the explanation page once you have recalled all the other variables in the sign that you can remember.

Protocol:

Each sign has one colour, one shape and one symbol. You will be expected to recall the three different variables in the sign before we move onto the next sign. Please recall the variables orally and please speak clearly and loudly. In some signs, one variable has been omitted. When this is so, text has been used in place of the variable. You will be expected to read the text out loud. In some signs, long sentences have been used. When this is so, please do not read the whole sentence out loud, but rather find the word or words in that sentence that were variables on the explanation page that you had to learn. For example, if you have learned that “RED” means “STOP”, every time you see the word “STOP” written in text, you must say “STOP” out loud. If however, the word is in a sentence such as “Please do not STOP at the yellow line”, do not read the whole sentence out loud, but rather just say the word “STOP”. There are two different sets of signs and these contain exactly the

same number of short and long text, however, one set of signs flashes and the other set doesn‟t. If you are in the group with the signs that flash, I will show you the sign over and over again until you have recalled everything in the sign. Just start recalling the variables in the sign as soon as you see them.

9. Give participant explanation page
10. Start stopwatch
11. After two minutes is up, take explanation page back
12. Switch on video camera and start slideshow with signs
13. When set of signs is finished, switch off camera and slideshow
14. Organise a time for next session

SESSION 2:

1. Welcome
2. Seat participant
3. Switch video camera on
4. Start slideshow (no learning phase)
5. When set of signs is finished, switch off camera and slideshow
6. Ask participant how learned signs, how remembered signs and which groups was easiest and hardest to learn

APPENDIX B: DATA COLLECTION

1) Instructions to Participants Prior to Testing
2) Explanation Page
3) Data Collection Sheets

1) INSTRUCTIONS TO PARTICIPANTS PRIOR TO TESTING

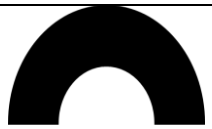
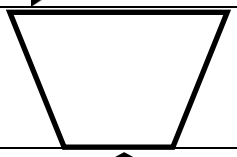
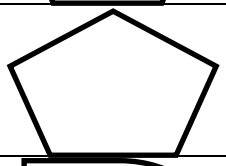
Please refrain from engaging in the following activities 24 hours before the testing session. Please inform the researcher on the day of testing if you partake in any of these practices, as they may affect the accuracy of the results obtained:

1. Do not drink alcohol 24 hours before testing.
2. Do not take any medication that may impair your memory

Thank you,

Inga Dambuza

2) EXPLANATION PAGE

VARIABLE:	MEANING:
	Broken Glass
	Hot Surface
	Jerky Machinery
	Keep Distant
	Do Not Touch
	Get Assistance
PURPLE	Danger
PINK	Warning
BROWN	Caution

3) DATA COLLECTION SHEET

DATE:_____ PARTICIPANT NUMBER:_____ OCCL/NO

OCCL:_____

SIGN NUMBER	REACTION TIME	RESPONSE TIME	RIGHT/WRONG			EXPLANATION PAGE USED
			COLOUR	SHAPE	ICON	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						

DATE:_____ PARTICIPANT NUMBER:_____ OCCL/NO

OCCL:_____

SIGN NUMBER	REACTION TIME	RESPONSE TIME	RIGHT/WRONG			EXPLANATION PAGE USED
			COLOUR	SHAPE	ICON	
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						
61						
62						
63						
64						

APPENDIX C: SUMMARY REPORTS

1) 3-Factorial ANOVA Tables
2) Example of Reaction Time Data
3) Example of Response Time Data
4) Example of Error Rate Data

1) 3 FACTORIAL ANOVA TABLES

REACTION TIME

General Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	59999.54	1,59	59999.54	114.7128	0.000000
COND	467.07	7,413	66.72	3.2194	0.002466
REPS	2522.67	7,413	360.38	9.4909	0.000000
SESS	321.89	1,59	321.89	30.5651	0.000001
COND*REPS	1499.58	49,2891	30.60	4.1390	0.000000
COND*SESS	378.34	7,413	54.05	6.9173	0.000000
REPS*SESS	35.85	7,413	5.12	0.6192	0.740181
COND*REPS*SESS	1577.37	49,2891	32.19	4.2884	0.000000

Age Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	59999.54	1	59999.54	112.9717	0.000000
Age	55.50	1,58	55.50	0.1045	0.747658
COND	467.07	7	66.72	3.2920	0.002040
COND*Age	330.75	7,406	47.25	2.3312	0.024245
REPS	2522.67	7	360.38	9.5119	0.000000
REPS*Age	299.81	7,406	42.83	1.1304	0.342837
SESS	321.89	1	321.89	30.1414	0.000001
SESS*Age	1.95	1,58	1.95	0.1822	0.671103
COND*REPS	1499.58	49	30.60	4.1381	0.000000
COND*REPS*Age	357.48	49,2842	7.30	0.9865	0.500376
COND*SESS	378.34	7	54.05	6.8850	0.000000
COND*SESS*Age	39.79	7,406	5.68	0.7241	0.651655
REPS*SESS	35.85	7	5.12	0.6120	0.746079
REPS*SESS*Age	18.80	7,406	2.69	0.3209	0.944487
COND*REPS*SESS	1577.37	49	32.19	4.3363	0.000000
COND*REPS*SESS*Age	603.62	49,2842	12.32	1.6594	0.002829

Education Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	59999.54	1	59999.54	128.8416	0.000000
Education	3849.75	1,58	3849.75	8.2669	0.005637
COND	467.07	7	66.72	3.2315	0.002396
COND*Education	176.47	7,406	25.21	1.2210	0.289787
REPS	2522.67	7	360.38	9.9027	0.000000
REPS*Education	906.91	7,406	129.56	3.5601	0.000995

SESS	321.89	1	321.89	32.8471	0.000000
SESS*Education	52.97	1,58	52.97	5.4049	0.023602
COND*REPS	1499.58	49	30.60	4.1737	0.000000
COND*REPS*Education	536.57	49,2842	10.95	1.4934	0.015139
COND*SESS	378.34	7	54.05	7.0274	0.000000
COND*SESS*Education	104.40	7,406	14.91	1.9391	0.062225
REPS*SESS	35.85	7	5.12	0.6253	0.735042
REPS*SESS*Education	91.05	7,406	13.01	1.5881	0.137121
COND*REPS*SESS	1577.37	49	32.19	4.3790	0.000000
COND*REPS*SESS*Education	809.23	49,2842	16.51	2.2465	0.000002

Occlusion/No Occlusion

	SS	Degr. of - Freedom	MS	F	p
Intercept	59073.24	1	59073.24	122.0820	0.000000
Occlusion/No Occlusion	2794.31	1,58	2794.31	5.7748	0.019477
COND	447.11	7	63.87	3.2824	0.002093
COND*Occlusion/No Occlusion	659.34	7,406	94.19	4.8405	0.000030
REPS	2437.29	7	348.18	9.4240	0.000000
REPS*Occlusion/No Occlusion	681.80	7,406	97.40	2.6362	0.011281
SESS	313.91	1	313.91	31.3792	0.000001
SESS*Occlusion/No Occlusion	41.12	1,58	41.12	4.1109	0.047211
COND*REPS	1450.02	49	29.59	4.0913	0.000000
COND*REPS*Occlusion/No Occlusion	819.67	49,2842	16.73	2.3128	0.000001
COND*SESS	366.80	7	52.40	6.9413	0.000000
COND*SESS*Occlusion/No Occlusion	162.07	7,406	23.15	3.0670	0.003699
REPS*SESS	34.48	7	4.93	0.6224	0.737507
REPS*SESS*Occlusion/No Occlusion	202.91	7,406	28.99	3.6624	0.000755
COND*REPS*SESS	1519.79	49	31.02	4.3030	0.000000
COND*REPS*SESS*Occlusion/No Occlusion	1216.35	49,2842	24.82	3.4438	0.000000

RESPONSE TIME

General Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	757137.9	1,59	757137.9	130.9844	0.000000
COND	19771.9	7,413	2824.6	12.6141	0.000000
REPS	90508.2	7,413	12929.7	35.0528	0.000000
SESS	7994.8	1,59	7994.8	68.1386	0.000000
COND*REPS	12871.2	49,2891	262.7	2.2524	0.000002
COND*SESS	5988.2	7,413	855.5	7.0040	0.000000
REPS*SESS	5580.9	7,413	797.3	5.1060	0.000014
COND*REPS*SESS	18703.6	49,2891	381.7	3.6816	0.000000

Age Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	759750.1	1	759750.1	130.5638	0.000000
Age	3540.1	1,58	3540.1	0.6084	0.438575
COND	20125.9	7	2875.1	13.5110	0.000000
COND*Age	6082.4	7,406	868.9	4.0832	0.000240
Error	86396.6	406	212.8		
REPS*Age	2877.9	7,406	411.1	1.1168	0.351417
SESS	8085.9	1	8085.9	70.6044	0.000000
SESS*Age	280.1	1,58	280.1	2.4460	0.123266
COND*REPS	12806.9	49	261.4	2.2414	0.000002
COND*REPS*Age	5758.4	49,2842	117.5	1.0078	0.458634
COND*SESS	5871.0	7	838.7	6.8732	0.000000
COND*SESS*Age	900.2	7,406	128.6	1.0538	0.392850
REPS*SESS	5790.1	7	827.2	5.5074	0.000005
REPS*SESS*Age	3511.5	7,406	501.6	3.3401	0.001795
COND*REPS*SESS	18603.5	49	379.7	3.7120	0.000000
COND*REPS*SESS*Age	9056.2	49,2842	184.8	1.8070	0.000541

Education Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	757137.9	1	757137.9	177.9050	0.000000
Education	94202.1	1,58	94202.1	22.1347	0.000016
COND	19771.9	7	2824.6	12.9083	0.000000
COND*Education	3638.9	7,406	519.8	2.3757	0.021719
REPS	90508.2	7	12929.7	37.0293	0.000000
REPS*Education	10575.5	7,406	1510.8	4.3267	0.000123
SESS	7994.8	1	7994.8	74.2776	0.000000
SESS*Education	679.8	1,58	679.8	6.3156	0.014769

COND*REPS	12871.2	49	262.7	2.2497	0.000002
COND*REPS*Education	5326.7	49,2842	108.7	0.9310	0.610471
COND*SESS	5988.2	7	855.5	7.1092	0.000000
COND*SESS*Education	1588.8	7,406	227.0	1.8862	0.070351
REPS*SESS	5580.9	7	797.3	5.1371	0.000013
REPS*SESS*Education	1477.7	7,406	211.1	1.3602	0.220701
COND*REPS*SESS	18703.6	49	381.7	3.7235	0.000000
COND*REPS*SESS*Education	8394.4	49,2842	171.3	1.6712	0.002493

Occlusion/No Occlusion

	SS	Degr. of - Freedom	MS	F	p
Intercept	751325.1	1	751325.1	130.6009	0.000000
Occlusion/No Occlusion	7377.4	1,58	7377.4	1.2824	0.262114
COND	19824.7	7	2832.1	12.7948	0.000000
COND*Occlusion/No Occlusion	2611.9	7,406	373.1	1.6857	0.110750
REPS	88977.4	7	12711.1	35.7738	0.000000
REPS*Occlusion/No Occlusion	8082.2	7,406	1154.6	3.2495	0.002284
SESS	8010.5	1	8010.5	67.2822	0.000000
SESS*Occlusion/No Occlusion	17.1	1,58	17.1	0.1437	0.706022
COND*REPS	13095.5	49	267.3	2.4048	0.000000
COND*REPS*Occlusion/No Occlusion	21322.1	49,2842	435.1	3.9156	0.000000
COND*SESS	6030.5	7	861.5	7.3091	0.000000
COND*SESS*Occlusion/No Occlusion	2589.8	7,406	370.0	3.1389	0.003061
REPS*SESS	5597.7	7	799.7	5.7986	0.000002
REPS*SESS*Occlusion/No Occlusion	8498.1	7,406	1214.0	8.8031	0.000000
COND*REPS*SESS	18613.6	49	379.9	3.8671	0.000000
COND*REPS*SESS*Occlusion/No Occlusion	20564.5	49,2842	419.7	4.2724	0.000000

ERROR RATES

General Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	58421.50	1, 59	58421.50	11663.32	0.000000
COND	23.03	7, 413	3.29	12.46	0.000000
REPS	20.26	7, 413	2.89	8.64	0.000000
SESS	2.00	1, 59	2.00	8.79	0.004361
COND*REPS	22.22	49, 2891	0.45	2.57	0.000000
COND*SESS	2.84	7, 413	0.41	2.16	0.036727
REPS*SESS	1.90	7, 413	0.27	1.38	0.213741
COND*REPS*SESS	16.14	49, 2981	0.33	1.82	0.000453

Age Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	58421.50	1	58421.50	11465.96	0.000000
Age	0.01	1, 58	0.01	0.00	0.967880
COND	23.03	7	3.29	12.51	0.000000
COND*Age	2.29	7, 406	0.33	1.24	0.277443
REPS	20.26	7	2.89	8.56	0.000000
REPS*Age	1.03	7, 406	0.15	0.44	0.879713
SESS	2.00	1	2.00	8.70	0.004582
SESS*Age	0.09	1, 58	0.09	0.38	0.538696
COND*REPS	22.22	49	0.45	2.58	0.000000
COND*REPS*Age	9.89	49, 2842	0.20	1.15	0.226298
COND*SESS	2.84	7	0.41	2.15	0.038092
COND*SESS*Age	0.79	7, 406	0.11	0.60	0.756787
REPS*SESS	1.90	7	0.27	1.39	0.208944
REPS*SESS*Age	2.03	7, 406	0.29	1.49	0.170422
COND*REPS*SESS	16.14	49	0.33	1.84	0.000375
COND*REPS*SESS*Age	13.37	49, 2842	0.27	1.52	0.011471

Education Effects

	SS	Degr. of - Freedom	MS	F	p
Intercept	58421.50	1	58421.50	14029.17	0.000000
Education	54.00	1, 58	54.00	12.97	0.000658
COND	23.03	7	3.29	12.56	0.000000
COND*Education	2.68	7, 406	0.38	1.46	0.178796
REPS	20.26	7	2.89	8.54	0.000000
REPS*Education	0.69	7, 406	0.10	0.29	0.957160
SESS	2.00	1	2.00	8.64	0.004708
SESS*Education	0.00	1, 58	0.00	0.00	0.962343

COND*REPS	22.22	49	0.45	2.58	0.000000
COND*REPS*Education	10.57	49, 2842	0.22	1.23	0.134463
COND*SESS	2.84	7	0.41	2.16	0.036885
COND*SESS*Education	1.27	7, 406	0.18	0.96	0.457354
REPS*SESS	1.90	7	0.27	1.37	0.216258
REPS*SESS*Education	1.05	7, 406	0.15	0.76	0.623721
COND*REPS*SESS	16.14	49	0.33	1.82	0.000476
COND*REPS*SESS*Education	7.70	49, 2842	0.16	0.87	0.731597

Occlusion/No Occlusion

	SS	Degr. of - Freedom	MS	F	p
Intercept	58384.55	1	58384.55	11576.46	0.000000
Occlusion/No Occlusion	3.01	1, 58	3.01	0.60	0.442605
COND	22.54	7	3.22	12.51	0.000000
COND*Occlusion/No Occlusion	4.50	7, 406	0.64	2.50	0.016042
REPS	20.01	7	2.86	8.74	0.000000
REPS*Occlusion/No Occlusion	5.48	7, 406	0.78	2.39	0.020911
SESS	2.09	1	2.09	9.69	0.002870
SESS*Occlusion/No Occlusion	0.92	1, 58	0.92	4.28	0.043102
COND*REPS	22.55	49	0.46	2.69	0.000000
COND*REPS*Occlusion/No Occlusion	23.64	49, 2842	0.48	2.82	0.000000
COND*SESS	3.00	7	0.43	2.40	0.020446
COND*SESS*Occlusion/No Occlusion	5.13	7, 406	0.73	4.11	0.000226
REPS*SESS	1.95	7	0.28	1.50	0.165007
REPS*SESS*Occlusion/No Occlusion	5.92	7, 406	0.85	4.56	0.000065
COND*REPS*SESS	16.29	49	0.33	1.89	0.000194
COND*REPS*SESS*Occlusion/No Occlusion	23.72	49, 2842	0.48	2.76	0.000000

2) EXAMPLE OF REACTION TIME DATA

C1,S1,R1	C1,S1,R2	C1,S1,R3	C1,S1,R4	C1,S1,R5	C1,S1,R6	C1,S1,R7	C1,S1,R8
2.28	1.10	1.01	0.96	1.32	0.97	2.74	1.31
18.05	1.22	1.44	1.53	2.61	1.17	1.14	1.09
1.50	1.16	1.09	1.70	0.89	1.00	1.85	0.92
3.01	1.30	0.87	0.89	0.77	0.84	0.80	0.94
6.13	1.70	3.08	1.43	1.62	1.48	1.39	1.27
1.34	5.81	5.87	1.00	1.75	1.84	1.16	1.56
7.40	2.47	3.40	1.72	3.34	4.03	5.07	2.13
5.38	1.97	1.09	1.45	1.43	1.69	0.94	1.03
1.44	1.87	2.56	2.25	1.75	1.29	1.57	1.07
1.44	5.97	1.69	1.22	1.72	2.59	1.13	1.47
1.78	2.15	1.25	5.18	3.56	1.63	2.09	1.25
2.28	13.13	10.03	1.91	9.00	5.16	3.88	5.13
2.37	1.69	4.12	5.25	4.50	2.19	3.34	1.47
1.53	1.62	5.69	23.56	21.28	17.50	9.78	15.44
2.03	1.53	3.72	1.71	1.88	1.66	2.31	1.28
3.64	1.22	2.00	1.82	2.08	1.44	1.55	1.27
9.68	1.79	7.75	2.10	1.93	1.45	1.21	1.72
1.51	1.73	1.12	1.22	1.46	1.62	1.00	2.60
1.36	0.93	0.86	0.81	0.71	1.11	0.80	0.99
2.67	1.32	1.98	1.39	1.42	1.85	2.28	1.18
23.61	3.71	1.58	1.23	0.88	0.87	0.94	0.80
1.63	2.05	1.23	1.03	1.29	1.12	1.22	1.05
14.30	1.16	1.71	2.66	2.87	1.42	2.44	2.22
1.30	2.04	1.34	1.06	1.04	1.42	2.00	1.08
8.14	1.14	2.04	0.82	0.70	0.69	0.84	0.82
1.52	0.94	1.17	0.90	0.97	0.94	1.64	0.93
9.48	1.14	1.25	2.33	1.20	1.22	9.73	3.81
2.51	1.03	1.29	0.99	1.47	1.72	0.93	0.79
2.88	1.17	0.87	0.94	3.84	0.65	0.77	0.70
1.45	1.10	1.23	1.26	1.47	1.26	3.23	1.20
2.02	1.43	4.02	2.71	3.45	1.78	5.03	1.40
7.98	25.47	18.50	21.71	4.18	5.46	6.63	3.58
1.53	1.58	3.92	2.67	3.41	1.84	5.00	1.39
2.33	10.17	1.40	1.92	1.80	1.57	1.02	1.08
3.61	2.49	6.21	2.90	2.98	2.37	2.37	2.32
17.82	10.73	8.44	5.54	1.41	1.29	1.18	5.53
1.91	1.28	1.77	2.48	1.79	9.47	1.68	1.31
18.08	1.58	1.70	1.43	1.74	1.67	1.39	2.46
1.83	1.30	2.57	2.03	2.77	1.87	1.50	1.25
2.88	22.49	20.73	16.91	16.88	2.86	18.23	14.28
1.25	1.57	2.15	3.92	1.99	2.05	2.73	1.69
2.62	9.30	5.14	7.22	4.79	4.55	4.84	9.51
1.10	1.93	1.96	2.15	3.47	1.78	1.50	2.90
9.03	6.88	1.43	1.27	1.48	1.84	1.43	1.50
1.44	11.68	1.22	3.09	1.50	1.50	1.06	1.56
9.35	4.30	2.41	2.26	2.31	3.19	2.85	1.58
18.09	6.83	5.85	3.81	4.04	3.93	3.12	2.89
4.37	1.61	3.20	1.53	2.47	1.92	1.56	2.02
9.14	9.07	1.70	1.28	3.40	3.68	3.06	3.22
3.81	1.49	1.81	1.50	1.45	2.14	1.75	1.53
8.46	1.09	1.25	1.35	0.94	1.13	1.09	1.05
29.26	3.03	4.76	2.72	3.20	5.96	3.01	2.01
22.33	8.55	11.16	8.63	7.70	4.94	6.62	6.25
12.57	2.01	3.89	2.31	2.50	2.33	2.19	2.00
5.89	2.78	1.19	1.13	3.16	2.89	1.04	0.81
11.83	2.66	1.72	1.50	2.27	3.75	1.12	7.30

3) EXAMPLE OF RESPONSE TIME DATA

C4,S1,R1	C4,S1,R2	C4,S1,R3	C4,S1,R4	C4,S1,R5	C4,S1,R6	C4,S1,R7	C4,S1,R8
5.10	1.32	1.55	2.43	1.69	1.91	3.12	3.40
3.99	8.07	7.52	3.48	4.89	2.12	3.48	2.28
27.39	7.54	4.68	10.67	14.49	3.06	12.10	14.75
23.26	4.41	2.60	11.61	4.01	3.25	20.58	5.48
9.34	5.38	6.33	5.35	9.88	5.57	7.77	4.41
32.37	10.41	9.50	2.81	10.65	25.94	16.69	3.40
4.19	2.59	9.13	8.00	20.78	2.53	4.29	1.97
22.94	5.56	32.69	22.82	2.38	4.75	10.41	37.25
8.03	9.60	2.40	4.34	7.28	5.09	4.54	3.65
17.97	20.93	24.75	2.66	37.10	11.59	14.81	13.19
22.09	18.23	20.60	6.63	9.38	22.65	28.81	3.72
18.56	20.56	2.75	11.25	24.97	2.50	8.68	2.18
15.78	7.91	4.50	5.59	18.78	4.66	43.00	21.54
9.19	2.94	3.69	44.91	6.22	2.75	10.06	6.31
1.88	3.22	2.03	3.44	2.65	2.87	4.35	1.81
24.93	2.27	1.74	3.08	2.88	1.41	3.01	1.65
17.80	16.63	6.84	14.23	25.88	2.80	7.05	7.75
19.56	2.76	19.21	4.94	3.91	3.55	7.11	2.94
8.77	1.82	1.91	2.12	1.64	1.22	2.10	2.42
16.67	3.52	1.39	1.30	1.41	3.13	1.95	1.44
3.60	1.75	1.38	1.50	1.35	1.93	4.77	2.75
40.81	2.24	2.23	1.65	2.27	1.89	2.15	3.85
11.85	5.01	3.46	6.20	3.38	6.03	5.74	5.24
2.93	2.03	2.75	1.77	1.95	2.23	2.23	1.54
77.48	48.14	15.34	6.69	7.77	11.88	5.82	4.80
5.34	3.41	2.22	1.35	2.22	2.44	3.44	1.91
10.06	20.88	20.88	2.30	40.33	17.22	5.55	3.11
2.44	2.28	1.26	2.23	1.93	1.19	2.10	1.79
22.51	2.23	2.91	4.16	2.36	2.78	6.39	2.23
7.82	3.92	2.13	2.34	2.67	3.03	1.94	3.46
9.82	17.76	84.88	11.26	20.60	25.73	75.87	6.62
14.47	1.26	6.29	2.52	1.99	2.17	4.56	3.48
9.80	17.87	84.81	11.17	19.36	25.72	75.87	6.70
9.45	5.70	1.98	23.37	4.40	4.10	13.52	6.83
13.16	14.67	5.40	6.94	7.01	18.27	43.04	5.78
42.71	16.09	11.19	7.25	6.00	1.87	34.71	4.10
5.98	42.11	3.80	6.77	4.43	5.73	7.39	2.20
37.99	14.70	24.08	8.22	30.66	28.12	12.52	8.45
2.78	2.28	3.10	3.48	3.90	7.76	2.48	1.99
4.02	33.98	4.71	19.42	12.19	12.13	3.12	16.95
8.14	17.04	25.15	6.70	12.47	8.47	15.12	4.57
13.88	16.78	1.32	3.23	28.99	9.66	1.90	5.55
18.19	26.78	6.38	14.62	11.35	7.82	22.69	8.22
39.13	19.49	3.98	11.72	6.98	15.90	9.64	7.78
11.59	5.78	6.57	11.00	14.53	3.25	17.69	8.91
69.02	50.30	22.59	5.88	6.04	10.09	11.24	3.75
110.30	78.87	68.70	39.01	39.34	69.00	34.91	7.39
44.94	9.40	41.14	12.31	37.40	62.87	7.85	39.49
76.00	11.29	110.03	52.66	7.51	12.90	15.29	25.47
27.62	3.00	2.05	49.41	11.36	24.34	54.59	8.95
15.73	14.91	11.41	4.84	29.86	33.42	7.85	20.04
74.41	51.23	24.53	8.96	29.78	46.60	56.79	24.57
198.11	70.52	20.98	15.76	52.39	49.24	34.68	21.36
25.43	27.90	14.10	19.66	20.97	32.31	50.30	24.75
16.19	28.54	4.71	10.53	8.68	7.83	13.65	21.59
29.27	12.82	6.86	3.10	2.27	3.80	3.11	2.26

4) EXAMPLE OF ERROR RATE DATA

C8S1R1	C8S1R2	C8S1R3	C8S1R4	C8S1R5	C8S1R6	C8S1R7	C8S1R8	C8S2R1	C8S2R2	C8S2R3	C8S2R4	C8S2R5	C8S2R6	C8S2R7
3	2	3	3	3	3	3	3	3	3	2	3	3	3	3
3	3	3	3	3	2	2	2	3	3	3	3	3	3	2
3	3	3	3	3	3	3	3	2	3	3	2	3	2	3
3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
3	3	2	2	2	3	3	3	3	3	3	2	3	2	3
2	2	3	3	3	3	3	2	3	3	3	3	2	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	2	1	0	2	2	3	2	2	2	2	3	3	2	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	2	1	3	3	3	3	3	2	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	3	2	3	2	2	2	2	2	2	1	3	2	1	3
2	3	2	3	3	2	3	3	2	3	3	3	3	2	3
3	2	3	2	3	3	3	3	3	2	2	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	2	3	3	3	3	3	3
3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
3	2	2	3	2	3	3	3	2	3	2	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	2	2	3	3	3	3	3	3	3	3	3	2	3	3
2	3	3	3	3	3	2	3	2	3	3	3	3	3	3
3	3	3	3	2	2	3	3	3	2	3	2	2	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	2
2	2	2	3	3	2	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
3	3	3	3	3	3	2	3	3	2	3	3	3	3	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	2	3	2	2	1	3	2	3	3	3	2	3
2	2	3	3	2	3	3	3	3	3	2	3	3	3	3
3	3	3	2	3	2	2	1	3	2	3	3	3	2	3
2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	2	2	2	3	3	3	2	3
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	2	3	3	3	3	3	3	2	2	3	2	3	3	3
1	2	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	3	2	3	3	3	2	3	3	3	3	3	2	3
3	3	2	3	2	2	3	3	3	3	1	2	3	3	3
3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
3	3	3	3	3	3	3	3	2	2	2	1	3	3	3
2	2	2	1	3	3	3	3	1	3	3	3	3	3	3
3	3	1	3	2	3	3	3	2	2	3	3	3	2	3
2	2	2	3	2	3	2	3	3	3	3	3	3	2	2
3	3	3	3	2	2	2	3	2	3	3	2	3	3	3
3	3	2	2	3	2	2	3	2	2	3	3	3	3	2
2	1	2	2	1	2	1	1	2	2	2	1	2	2	3
3	2	3	2	3	2	1	3	2	3	2	3	3	2	2
3	2	2	3	3	3	3	3	3	3	3	3	3	3	3
3	3	2	2	2	2	2	2	3	3	2	3	2	3	3
2	3	3	3	3	3	3	3	3	2	3	3	3	2	3
2	2	3	2	3	1	1	2	1	2	3	2	3	2	1
1	2	2	2	3	2	2	3	3	2	2	2	3	3	2
3	2	3	3	2	3	3	3	3	2	2	3	3	3	3