

The effect of emotional states on learning visual skills

by

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Chapter 1

Introduction to the Study

1.1 Introduction

One of the most important senses in the human body is vision, which is the primary source of processing external information. Adequate visual skills are necessary for tasks such as reading and writing (Du Toit et al., 2011).

The visual skills that are most often researched and worked on within sporting environments and performance contexts are eye dominance, visual acuity, pursuit tracking, vergence (the ability to retain binocular vision while crossing and uncrossing the eyes), eye-hand coordination, sequencing, focusing and visualisation (Du Toit et al., 2011). These visual skills interact with one another and work together to bring about optimal vision (Du Toit et al., 2011). These visual skills are normally developed by providing sports vision exercises (Du Toit et al., 2006). These exercises are performance-oriented vision care programmes which involve the enhancement, protection, correction, evaluation and education of an athlete's vision. Sports vision exercises are administered to athletes to improve their performance by improving their visual skills (Du Toit, Krüger & Neves, 2007).

It is believed that sports vision exercises help athletes, since an athlete's visual performance is a significant element of excellence in sport. In addition, because many sporting activities are hindered by poor vision, it is of vital importance for athletes to receive training that includes sports vision exercises in order to excel in their sport (Du Toit, Van Vuuren, Van Heerden & De Wet, 2006). It has been shown in certain studies that sports vision training does improve visual skills in athletes. For example, Wilson and Falkel (2004) reported that sports vision exercises enhance eye movement efficiency and elicit a beneficial psychological response, while Du Toit, Krüger, Chamane, Campher and Crafford (2009) established that sports vision training does enhance performance and gives athletes an advantage over their rivals.

Athletes, however, are just one of the groups that can benefit from sports vision exercises. Administering sports vision exercises to a non-athlete population such as students may have significant benefits if the students' visual skills could be improved, as these skills are a necessary

component of academic achievement (Du Toit, Krüger, Chamane, Campher & Crafford, 2009). It is widely recognised that the ability to read and write competently plays a central role in academic achievement. Students require optimal vision to be able to read and write efficiently. Efficiency in reading and writing enables students to effectively look through a large amount of literature to find the appropriate information to use in assignments. This makes it possible to comply with certain academic requirements, and the prescribed study material can be learned more quickly. All of this will in turn improve academic achievement (Du Toit et al., 2011). Improving students' visual skills may lead to an increase in their cognitive performance and learning, both of which are vital for academic performance (Du Toit et al., 2009).

A study conducted by Maples (2003) revealed that inefficient visual skills negatively affect a student's learning, and that if the visual skills of students are improved it is possible that academic scores and performance may increase as well. It is possible that improving visual skills could make an important contribution to solving the problem of academic under-achievement (Maples, 2003). At present, however, students do not receive visual skills training. This is because a learning institution such as a university or school is geared towards educating students and preparing them for future careers. Apart from administering or encouraging eye tests resulting in corrective care, learning institutions do not focus on improving visual skills.

Another problem with teaching visual skills to students is related to the fact that students' ability to learn such skills may be impacted upon by various emotional states (Janelle, 2002). Before one can determine whether sports vision exercises can enhance a student's academic performance by improving his/her visual skills, one needs to account for factors such as emotional states that may impact on the learning of such skills. As such, it is reasonable to propose a connection between emotional states and the learning of visual skills. Research (Janelle, 2002; Henderson & Wilson, 1991) has indicated that anxiety and curiosity are the two emotional states which in particular may have an impact on the learning of visual skills. Janelle (2002) has noted that anxiety decreases a person's ability to learn visual skills whereas curiosity increases an individual's ability to learn visual skills (Henderson & Wilson, 1991).

Anxiety is a negative emotional state which interferes with the learning of visual skills. This is because increased anxiety can trigger physical problems such as the tightening of the body's muscles, which in turn causes fatigue (Potgieter, 2003). Anxiety also causes feelings of panic, confusion, dizziness and depression, and can reduce a person's tolerance of setbacks, pain and discomfort, and cause a person to give up more easily than when not anxious (Potgieter, 2003). A

further effect of anxiety is to reduce visual skills (Janelle, 2002). This is because an increase in anxiety causes a narrowing in attentional focus. When attention narrows beyond an optimal point it produces a tunneling effect, and as a result some relevant cues are eliminated, which causes a decline or deterioration in performance (Easterbrook, 1959). Anxiety also affects attentional processes by causing the person to focus his/her attention internally rather than externally. The individual becomes preoccupied with his/her own negative feelings and thoughts instead of concentrating on the task at hand (Potgieter, 2003).

Curiosity, which has an inverse correlation with anxiety (Voss & Keller, 1983), has been linked to intelligence. It is thought that people who display marked curiosity are more intelligent (Henderson & Wilson, 1991). Because of this link, it is proposed that the presence of curiosity would facilitate the learning of visual skills (Henderson & Wilson, 1991). People who display high curiosity are expected to show a greater improvement in their visual skills, as higher curiosity may result in the increased use of visual search strategies and more exploratory visual behaviour (Daffner, Scinto, Weintraub, Guinessey & Mesulam, 1992).

1.2 The Problem Statement

It is widely recognised that, within an educational setting, individual students exhibit different degrees of learning potential in relation to different tasks (Maples, 2003). If a non-athlete population such as students could also receive the same benefit that athletes get from sports vision exercises, then these students would have a method of improving their visual skills, and in turn improving their academic performance. This is so because in most cases visual skills are a vital component of academic achievement. In addition, Du Toit et al. (2011) have demonstrated that adequate visual skills are necessary for reading and writing, which are fundamental components of learning.

Before one can establish whether sports vision exercises can improve a student's academic performance by enhancing his/her visual skills, one must take into account the presence of emotional states such as anxiety and curiosity. It was previously indicated that both these emotional states have an impact on the learning of visual skills. Since little research has been conducted on the relationship between the learning of visual skills and the presence of these two emotional states,

one needs to determine the extent of the effect that anxiety and curiosity will have on the learning of visual skills.

Previous studies have examined the positive impact that sports vision exercises have on the visual skills of adults and children with visual defects (Hazel, 1995). However, there are very few studies which focus on the effect that sports vision exercises have on non-athletes with corrected to normal or normal vision (Du Toit et al., 2011). In addition, little is known about the effect that anxiety and curiosity may have on the learning of visual skills. As there has been no extensive research done on the effect that anxiety and curiosity may have on visual skills and the learning thereof, this study is exploratory in nature and could open up a new avenue of exploration into visual skills and sports vision exercises, and how to effectively administer these exercises. This exploratory research will add to the existing body of knowledge which emphasises the link between curiosity and intelligence. This study will also attempt to establish a link between curiosity and an increased ability to learn visual skills, and anxiety and a decreased ability to learn visual skills, after receiving sports vision exercises.

Although academic performance will not be measured, the results of the research may be used in future studies to implement programmes into the University curriculum which could provide visual skills training. Further research could follow to determine how to optimally deliver visual skills training to students.

1.3 Research Aims

The primary aim of this study was to determine whether anxiety and curiosity have an impact on a student's ability to learn visual skills directly after receiving sports vision exercises for 12 weeks.

To determine whether there are relationships between anxiety, curiosity and visual skills, and what the extent of these relationships is, the following secondary aims were formulated:

- To determine whether sports vision exercises improve the visual skills of second-year physiology students at the tertiary institution.

In order to measure this particular aim, the following hypotheses were set:

H₀: There is no relationship between sports vision exercises and the improvement of visual skills among second-year physiology students at the tertiary institution.

H₁: There is a statistically significant relationship between sports vision exercises and the improvement of visual skills among second-year physiology students at the tertiary institution.

- To determine whether anxiety influences the learning of visual skills after receiving sports vision exercises.

In order to measure this particular aim, the following hypotheses were set:

H₀: There is no relationship between anxiety and the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: There is a statistically significant relationship between anxiety and the learning of visual skills among second-year physiology students at the tertiary institution.

H₀: Anxiety is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: Anxiety is a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

- To determine whether curiosity influences the learning of visual skills after receiving sports vision exercises.

In order to measure this particular aim, the following hypotheses were set:

H₀: There is no relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution.

H_1 : There is a statistically significant relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution.

H_0 : Curiosity is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

H_1 : Curiosity is a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

1.4 Proposed Structure of the Study

Chapter 1 introduced the study and the key concepts under investigation. Following this, the problem statement and research aims were discussed.

In chapter 2, all the constructs under investigation were defined and discussed in full. The way in which the constructs relate to one another was indicated, and the reasons for studying these particular sets of constructs were provided.

The emphasis in chapter 3 was on describing the research design chosen for the study, and the reasons for choosing it were given. The sampling method and the sample (an in-depth description of the individuals in the sample) were discussed in detail. Brief discussions were also presented on the measures used for data collection and the data collection process, as well as the type of statistics used to analyse the data.

In chapter 4, the statistical processes used to analyse the data were discussed in greater depth. In addition, the findings of the research were stated. This chapter consists of the statistical output derived from data collected from the research participants.

Chapter 5 discusses the results with reference to the literature as presented in chapter 2. The limitations of the present study are discussed, and recommendations for future research are made. A conclusion on the results of the study is also provided. Each chapter will be ended off with a conclusion.

1.5 Conclusion

Good visual skills are essential components in achieving educational, economic and social success and independence (Marshall, Meetz & Harmon, 2010). A need has been identified to determine whether the visual skills of students can be improved through sports vision exercises, and whether the potential benefits derived from these sports vision exercises could be influenced by emotional states such as anxiety and curiosity.

The following chapter presents an overview of the past and current literature on the constructs of visual skills, sports vision exercises, anxiety and curiosity. The potential influence of anxiety and curiosity on visual skills is explored, and the efficacy of sports vision exercises in improving visual skills is discussed.

Chapter 2

Literature Review

2.1 Introduction

Vision plays an extremely important role in our everyday lives and adequate visual skills are necessary for tasks such as reading and writing (Du Toit et al., 2011). Visual exploration is propelled by two key factors, namely our own individual intentions and interests, and the stimuli within our environment (Risko, Anderson, Lanthier & Kingstone, 2012). Stress and anxiety are unavoidable elements of everyday life, and may negatively affect visual skills (Janelle, 2002). Curiosity, on the other hand, could positively impact visual skills (Daffner et al., 1992) because higher curiosity may result in more visual exploration, increased use of visual search strategies and more exploratory visual behaviour.

Certain visual skills can be improved by sports vision exercises, which may lead to an improvement in cognitive and motor performance as well as enhancing learning abilities in an academic environment (Du Toit et al., 2011). In this chapter, visual skills and what these skills entail are discussed. A description of sports vision exercises and the efficacy of these exercises are then provided. A discussion of emotional states is presented, centering particularly on what the constructs of anxiety and curiosity are, and the interaction between emotional states and visual skills. In addition, what the literature reveals concerning anxiety and visual skills and curiosity and visual skills will be explored. Individual differences in eye movements and how these may relate to curiosity are discussed. In addition, a discussion is presented on the link between curiosity and intelligence in an individual, as well as the more recently discovered molecular link between curiosity and intelligence. Finally, the effect of vision on academic performance is discussed.

2.2 Visual Skills

The eye is an organ that reacts to light for numerous purposes. The human eye is a conscious sense organ and allows vision. Cone and rod cells in the retina permit vision and conscious light perception, including depth perception and colour differentiation. The eye can

distinguish approximately 10 million colours (Judd & Wyszecki, 1975). The optic nerve is the part of the human eye that transmits visual information from the eyes to the brain. The optic nerve is located at the back of the eye, and is composed of approximately one million thread-like nerve fibres which originate from the retina (Schuster, 2005).

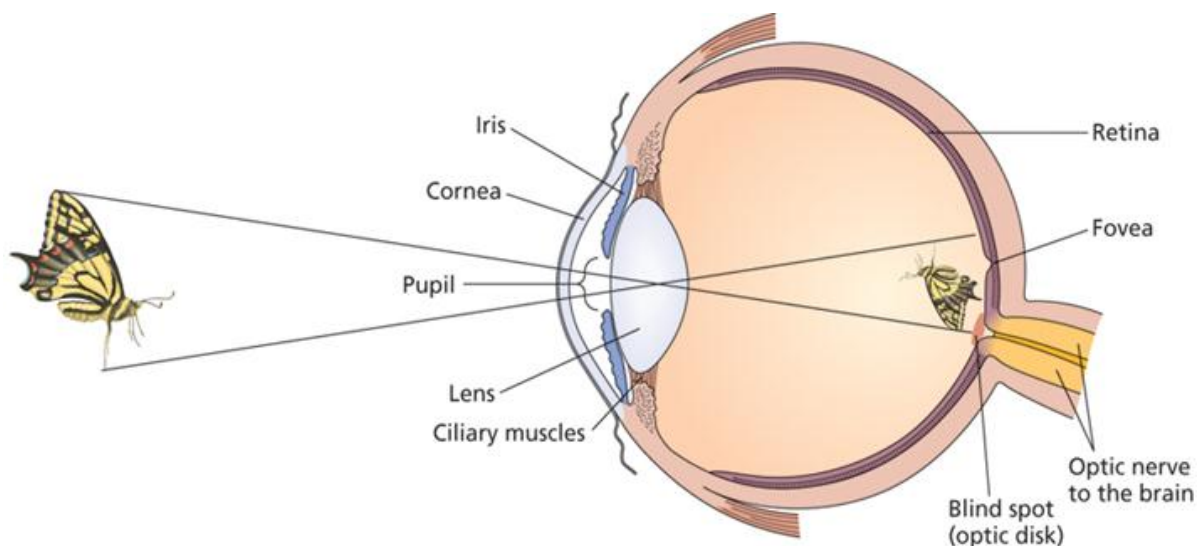


Figure 2.1 Diagram of the human eye (Passer et al., 2009).

Vision refers to the process whereby light is reflected from various objects present in our environment and transformed into a mental picture (Molia, Rubin & Kohn, 1998). The relationship between vision and visual skills can be described as follows: good vision includes much more than just being able to see clearly without using glasses or contact lenses. Good vision involves not only visual acuity, or clearness of sight (the sharpness of vision that is measured by an eye chart test), but also includes many other important visual skills such as how well a person can coordinate his or her eyes at close range, as required for reading, how successfully he/she can follow a line of print or sentence without losing his/her place, how effectively an individual can adjust focus changes from far to near distances, and how efficiently a person can make sense of and understand what they see. Visual skills can be divided into two types, which are both equally important (Buys, 2002). The first type of visual skill is related to the optometric properties and physical differences in sight that are involved in vision. The second type of visual skill involves the greater use of the pathways involved in the integration and analysis of visual information, as well as the planning and execution of a motor response (Buys, 2002). Visual pathways comprise pathways that transmit visual

information from the retina to the brain (Berg, Tymoczko & Stryer, 2002). The visual skills that are most often researched and worked on within sporting environments and performance contexts are eye dominance, visual acuity, pursuit tracking, vergence (the ability to retain binocular vision while crossing and uncrossing the eyes), eye-hand coordination, sequencing, focusing and visualisation (Du Toit et al., 2011).

2.2.1 Eye dominance.

Eye dominance refers to the fact that one eye processes and transmits information more rapidly than the other eye (Du Toit et al., 2011). The world is viewed by us through two, laterally separated eyes, and for the majority of people the images from the two eyes are blended into a collective binocular view. With both eyes open, people who have normal binocular vision have no awareness that one eye is contributing more to the collective binocular view (Yang, Blake & McDonald, 2010). Only when normal binocular vision is disturbed is a person liable to favour one eye over the other. Nevertheless, when tested in a laboratory or clinic, individuals with normal binocular vision act as if they have a dominant or favoured eye (Yang et al., 2010). The notion of eye dominance is firmly established in the clinical literature and provides the foundation for a variety of clinical decisions, which include contact lens wear, cataract surgery and monovision treatment (Westin, Wick & Harrist, 2000). With monovision treatment, a person wears a contact lens on one eye to correct distance vision, and on the other eye the individual will wear a contact lens to correct near vision. The contact lens that is used for distance vision is normally worn on the dominant eye. At present, both the basis and the importance of eye dominance, be it sensory or motor, are poorly understood. Since it appears that eye dominance is not determined by a more accurate or reliable input from one eye, or more effective cortical processing of input from the other eye, there remains the prospect that its basis can be found in the nature of the interaction which takes place between the eyes when both eyes are operating together, as is the situation in every-day viewing (Li et al., 2010).

2.2.2 Visual acuity.

Another visual skill, visual acuity, is an approximation of the visual system's ability to resolve or determine fine details. Visual acuity approximations are recorded and measured by

assessing and quantifying the ability of the eye to recognise and resolve letters of varying shapes and sizes. This approximation is a vital component or element in the battery of tests that are performed to determine a patient's adequacy of optical correction and refractive error; these tests also serve as a principal indicator of ocular health status (Chen, Norazman & Buari, 2012). Optical correction refers to the use of contact lenses or eyeglasses to correct refractive errors by refocusing light rays on the retina in order to compensate for or counteract the shape of the eye. Refractive error refers to an error in the focusing of light by the human eye, and is a common reason for decreased visual acuity. Ocular health status refers to the health status of the eye and its organ system. Various types of visual acuity test charts are available, such as the conventional Snellen chart. This chart is based on surrounding lighting, perception, visual cues, contrast, interaction and different pattern designs. The visual acuity chart assesses the visual system's minimum angle of resolution, which is the smallest target estimate that a person is capable of resolving or determining (Chen et al., 2012). Dynamic visual acuity is commonly defined as the capability of the visual system to determine detail when there is movement between the observer and the target (Erickson et al., 2011). Static visual acuity refers to the ability to clearly see a static object, thereby enabling the discrimination and identification of an object at a certain distance (Du Toit et al., 2011).

2.2.3 Pursuit tracking.

Pursuit tracking refers to the capability of a person's eyes to follow a certain object through space (Du Toit et al., 2011). There are two forms of pursuit eye tracking, specifically, visual fixation and smooth pursuit tracking. Gaze is maintained on a stationary target during visual fixation (Gooding, Miller & Kwapil, 2000). Both visual fixation and smooth pursuit eye tracking are measures of the pursuit tracking subsystem, and saccades disturb the overall quality of these two measures. In smooth pursuit eye tracking, a person's eyes visually follow a target that is moving slowly by matching inhibiting saccades and the velocity of the target (Leigh & Zee, 1991). Abnormal smooth pursuit tracking is often characterised by an increased amplitude and/or frequency of intrusive saccadic movements, which results in gaze deviation. Saccadic eye movements are the jump or rapid movement of the eyes (Du Toit et al., 2011). Both visual fixation and smooth pursuit eye tracking abnormalities have been suggested as possible markers of a schizophrenia diathesis. Diathesis refers specifically to a genetic predisposition toward a diseased or abnormal condition, or more broadly to a vulnerability which arises from early childhood development (Gooding et al., 2000).

Saccadic eye movements move the fovea quickly to a peripheral auditory or visual target, while smooth pursuit eye movements retain the image near the fovea of a moving target that is focused on. The fovea (see figure 2.1) refers to a part of the eye that is responsible for foveal vision, or sharp central vision, which is essential in humans for driving, watching television, reading or any other activity in which visual detail is of central importance (Grossberg, Srihasam & Bullock, 2012). Tracking a moving stimulus or target usually involves a period of smooth pursuit with an ensuing catch-up saccade, which results in the person's eye being brought close to the position of the stimulus or target (Lisberger, 1998).

2.2.4 Sequencing.

Sequencing is the ability to arrange visual information (Du Toit et al., 2011). As the visual system has restricted computational resources, it is essential to limit detailed processing to particular aspects of the input. Consequently, people alternate saccades, or rapid eye jumps, from an area of input to another area of fixation, while the information is acquired. This selection process is a vital mechanism that is driven by different areas of the brain (Veneri et al., 2011). Sequencing, cognitive set maintenance, cognitive set shifting, concept formation and planning are cognitive abilities that are associated with the executive functions of the brain (Lezak, 1983). Executive function refers to the ability of a person to retain an appropriate problem-solving set in order to attain a future goal. Executive functioning includes behaviours such as flexibility of action and thought, organised searching, set maintenance, inhibition of dominant but irrelevant responses, impulse control and planning (Ozonoff, Pennington & Rogers, 1991).

One of the psychological assessment measures that can be used to measure sequencing ability is the Picture Arrangement (PA) subtest, which forms a part of the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981). The WAIS-R contains 10 items and measures executive function, assessing goal-directed thought and sequencing ability. In the Picture Arrangement Task, the person is given cards which describe a part of a story. The cards are given to the person in a standardised and incorrect sequence, and the person is required to arrange the cards provided in the correct sequence, and within a specific time interval, which may vary between one and two minutes (Wechsler, 1981).

2.2.5 Vergence.

As mentioned in 1.1 and 2.2, the ability to retain binocular vision (ability to retain visual focus on a target or object with both eyes, thus creating a single visual image) while crossing as well as uncrossing the eyes is referred to as vergence (Du Toit et al., 2011). Vergence has a short latency (delayed transmission) and is, by definition, binocular. Vergence refers to the differences found in the positions of both eyes. This type of eye movement is assumed to be brought about by binocularly processed visual skills and is sensitive to binocular disparity. Binocular disparity refers to the slight difference that exists in the positions of both retinal images that stems from the slight difference in the viewpoints of both eyes (Masson, Yang & Miles, 2002). With regard to vergence, binocular disparity is a sufficient stimulus to generate the response (Busetini, FitzGibbon & Miles, 2001).

Vergence rotates a person's eyes in opposite directions in order to allow for bifoveal fixation. These eye movements are frequently classified into four subtypes. Accommodative vergence refers to the vergence system's response to blur-driven accommodation. Proximal vergence indicates the vergence response to the observed or perceived nearness of a target. Tonic vergence refers to the angle of vergence that is present in the absence of visual stimuli, and disparity vergence is directed or driven by retinal disparity (McDaniel & Fogt, 2010). Retinal/binocular disparity refers to the difference that exists between the visual images perceived by each eye, due to the different angles at which the world is viewed by each eye. Retinal/binocular disparity is vital for depth perception. Each eye receives a marginally different image or perspective. However, two separate images are not seen by the individual. The images overlap or intersect at the centre, and these images are combined by the brain into one seamless view (McDaniel & Fogt, 2010).

2.2.6 Eye-hand coordination.

Eye-hand coordination involves the brain's ability to receive and examine visual information and then react to this information with coordinated motor movements of the hand (Du Toit et al., 2011). Eye-hand coordination refers to the coordinated control of hand movement with eye movement, and the procedure that is followed to process visual input in order to guide grasping and reaching, accompanied by the utilisation of proprioception of a person's hands in order to guide

the eyes (Rand & Stelmach, 2010). Proprioception refers to an individual's sense of the position of their body parts relative to the rest of their body. Simply put, eye-hand coordination is the coordination of hand movements and vision in order to execute a task. Manual aiming movements necessitate the highly integrated coordination of hand and eye movements and the sensorimotor processing of on-going target location and hand movements (Rand & Stelmach, 2010). The current theory explaining sensorimotor transformation for reaching towards a target suggests that the target location is stored and perceived within an eye-centred context or frame of reference. The eye-centred frame of the target locations is re-mapped each time the eyes move or shift to a new target (Henriques, Klier, Smith, Lowy & Crawford, 1998). The eye-centred frame seems to be predominant and to be utilised even when the position of the target for which one is reaching is perceived by a sensory modality other than vision, for example, audition. Consequently, a sequence of sensorimotor transformations is believed to occur from the eye-centred frame to the hand-centred, body-centred and head-centred frames for reaching (Pouget, Ducom, Torri & Bavelier, 2002). For a specific hand movement towards a target to take place, different spatial dimensions of the target location, such as distance and direction, have to be processed (Rand & Stelmach, 2010).

2.2.7 Focusing.

Focusing refers to bringing one's eyes into a state such that an object is brought into focus, allowing the observer to clearly see what the object is. The act of focusing involves adapting one's eyes to the current level of light until one is able to see clearly (Erickson et al., 2011). People with normal vision have the ability to use both eyes together, and each eye independently, to quickly bring a target of visual interest into clear and sharp focus. This act is performed rapidly and subconsciously, and places no strain on the normal visual system. In both children and adults with eye focusing problems, the visual system and eyes do not focus properly. Frequently the blurred image can be brought into focus by intense concentration, but this places a large amount of stress on the visual system (Erickson et al., 2011). Focusing is also referred to as accommodation, or accommodative function (Griffin, 1982). Symptoms of accommodative dysfunction (focusing problems) are normally associated with close work activities and reading, and include avoidance of near activities, loss of concentration, tired eyes, burning or watering of the eyes, headaches and blurred vision during close work activities (Scheiman et al., 2011).

Attentional focusing refers to the capability to adjust or alter the size of attentional focus that is directed towards an object in the visual space. Attentional focusing is separate from orienting. Attentional focusing can occur without orienting, whereas orienting can simultaneously activate attentional focusing. Orienting refers to the capability to shift the attentional focus in visual space. The processing mechanisms of attentional focusing and orienting of visuo-spatial attention are used independently in visual search tasks, subject to the task demands (Fu, Caggiano, Greenwood & Parasuraman, 2005).

2.2.8 Visualisation.

Visualisation refers to a mental image that is comparable or similar to a visual image or visual perception. Visualising implies that one positively and actively accesses a visual target to make it visual or visible (Okamoto, 2006).

Saliency detection is a primary mechanism through which visual attention is facilitated. Saliency refers to the quality or state of an object that stands out in relation to other neighbouring objects. A good visualisation directs the observer's attention towards the relevant aspects of the visual image and representation. Consequently, the spread of saliency over a visualisation image comprises a vital measure of the quality and merit of the visualisation (Janicke & Chen, 2010).

2.3 Sports Vision Exercises

Sports vision exercises relate to visual skills in that sports vision exercises are used as a technique to improve an athlete's visual skills. These sports vision exercises are administered to athletes to improve their performance and give them a competitive edge (Du Toit et al., 2011). In the sports industry, an array of visual training techniques and procedures exist to enhance and improve an athlete's performance. Sport has become a multifaceted science which utilises technology to study several aspects of sport that have gone unnoticed or been overlooked thus far. An athlete's visual performance is a significant predictor of excellence in sport, as many sporting activities are hindered by poor vision (Du Toit et al., 2007^a).

Motor skill instruction teaches people fundamental motor skills. These motor skills help individuals to manipulate their environment, control their bodies, and form complex movement patterns and skills that are involved in recreational activities and sports (Goodway, Crowe & Ward, 2003). Motor skill instruction has benefited from an area of sports science research which focuses on sports vision (Knudson & Kluka, 1997). Sports vision is a region of study that combines neuroanatomy, sports psychology, biomechanics, motor learning and vision science as they correlate with visual or perceptual motor performance. When planning daily practice sessions, sports vision exercises can be incorporated into the regular practice sessions and activities of athletes (Knudson & Kluka, 1997).

Sports vision is not confined to the visual system; it also relies on a network of different systems, such as the skeletal muscles, the somatic and central nervous systems and the brain. Together, this network operates to maintain visual concentration, short-term memory, visual anticipation, depth perception, peripheral awareness and hand-eye coordination (Thompson, Dilda & Creem-Regehr, 2007). These aspects are necessary for total sports vision, and are the focus in many sports vision exercises. Under-development in any of these areas significantly affects sports vision and consequently sports performance will be negatively affected (Du Toit et al., 2006).

The aim of sports vision exercises is to exercise the visual coordination of the athlete, and to help the athlete to gain knowledge of the necessary motor responses, which includes what the eyes instruct the body to do, and how the body should react in response to a certain visual stimulus. There are numerous aspects that should be explored when training and developing an athlete for participation in sport. An important ability that sportsmen require, particularly those that play team sports, is awareness, or peripheral vision. This form of vision permits athletes to be aware of their surrounding environment and what is happening in it, without actually looking around (Du Toit et al., 2007^b).

A fundamental component of sports vision exercises is to load or stress the visual proprioceptive, visual motor and visual systems to better prepare an athlete for competition (Wilson & Falkel, 2004). “Visual proprioceptive” refers to visual information concerning an individual’s own body movements relative to the environment. Proprioception describes information which typically arises from peripheral mechanoreceptors which play a role in joint stability, joint position sense, the conscious sensation of movement and postural control. A mechanoreceptor refers to a sensory receptor which responds to mechanical distortion or pressure. Proprioception plays a fundamental role in motor performance and sensorimotor integration (Brindle, Mizelle,

Lebiedowska & Miller, Stanhope, 2009), and involves coordinating inputs to create awareness of a person's own movement and body position in space. In this case, the focus is on integrating perceptual (particularly visual) information which specifies body movement with kinesthetic and/or proprioceptive information for such movement. Visual input is integrated with proprioceptive and kinesthetic information to create an awareness of body position (Schmuckler, 1995).

Sports vision exercises are performance oriented, complete vision care programmes which involve the enhancement, protection, correction, evaluation and education of an athlete's vision. Developments in this field of sports vision have emphasised areas that can possibly improve visual performance, namely: training to improve the visual skills that are essential for athletic excellence, and evaluation and screening of athletes for certain visual skills that are related to their sport and vision (pursuits, saccades and peripheral awareness) (Du Toit et al., 2009). Three basic assumptions of sports vision training are that i) athletes have superior visual skills compared to non-athletes, ii) visual abilities are trainable and iii) the training of these visual abilities can be transferred to the athlete's performance. It is possible for the visual system to be trained to respond more rapidly to certain stimuli by utilising specific techniques and exercises (Du Toit et al., 2006).

The potential benefits that sports vision exercises have for athletes relates to the fact that an athlete's visual performance is a significant element of excellence in sport, and because many sporting activities are hindered by poor vision, it is of vital importance for athletes to have training that includes these sports vision exercises in order to excel at their sport. Under-developed visual skills may significantly affect sports vision and consequently have a negative effect on sports performance (Du Toit et al., 2006).

2.3.1 Benefits of sports vision exercises for students.

Sports vision exercises are used as a technique to enhance an athlete's performance, and have been shown to take athletes to the next level of competition. Sports vision exercises are safe and have beneficial effects on athletes. These sports vision exercises enhance eye movement efficiency and elicit a beneficial psychological response (Wilson & Falkel, 2004). There are, however, some sceptics who question whether sports vision exercises improve vision. In a study conducted by Abernethy and Wood (2001) on young participants undertaking visual training to determine the efficacy of two generalised visual training programmes in improving motor and visual performance for racquet sports, no evidence was found to support the claim that visual

training programmes led to advancements in motor performance or vision, above and beyond the improvements which were a result of test familiarity. According to Abernethy and Wood (2001), the fundamental failure of the visual training programmes is that they endeavour to train basic and general visual factors, and it is recommended that generalised visual training programmes be utilised with caution. However, this study was conducted in 2001, and since then it has been established that sports vision training does enhance performance and gives athletes an advantage over their rivals (Du Toit et al., 2009).

Regarding sports vision assessment in athletes, Du Toit et al. (2009) assert that sportsmen will have an immense advantage over their competitors owing to improvements in their visual skills as a result of sports vision training programmes. These training programmes can help to improve and train an athlete's hand-eye coordination, visual coordination and anticipation, and increase focus and concentration. The study conducted by Du Toit et al. (2009) used a sample size of 48. It is proposed that these principles could be applied in similar assessments of non-athletes, and the visual system could be trained to respond faster to specific stimuli by making use of certain exercises and techniques. Du Toit et al. (2009) recommend that further studies conducted on this topic should use a larger sample size to evaluate visual skills more extensively. As a result of this suggestion, sports vision training has been broadened to incorporate other target populations where it is known that sport vision exercises could benefit the population.

Reed-Jones, Dorgo, Hitchings and Bader (2012) conducted a study to investigate the efficacy of agility and visual training for mobility and balance in senior adults living independent in the community when implemented in conjunction with the basic physical activity that is recommended for older adults. Flexibility, cardiovascular endurance and muscular strength only account for a portion of a person's ability to avoid falls that result from contact with an obstacle. Visual information concerning an obstacle and self-motion play a large role in the ability to avoid obstacles successfully, and visual training can be incorporated into agility and fall prevention training programmes. The results of this study imply that obstacle avoidance is improved by visual training above and beyond the gains that are observed with fitness training alone. While agility training may enhance older adults' reflexes as well as their ability to perform rapid body movements that enable effective balance control, visual training may enhance processing of visual information related to obstacle avoidance, attention and visual processing (Reed-Jones et al., 2012).

According to Herman and Retish (1989), another group of people that could benefit from visual training are students. These researchers believe that successful visual training could help students to develop efficient and mature movement patterns. The effect that vision therapy has on several deficient visual dysfunctions has been investigated by numerous researchers. Hoffman and Rouse (1987) and Suchoff and Petito (1986) indicate that substantial improvement in binocular vision, accommodation, efficiency and eye movement can be attained through vision therapy programmes. These studies support the effectiveness of vision therapy for several competencies that play a part in an efficient visual system. This has been applied in non-athlete populations where studies show that the correct treatment can improve and enhance perceptual skills, and this improvement positively affects mathematics and reading achievement (Herman & Retish, 1989). Herman and Retish's (1989) findings thus demonstrate that vision exercises may have significant benefits for students. The visual skills discussed in 2.2.1 to 2.2.8 could be improved by training students using sports vision exercises, which would lead to an improvement in learning abilities, and cognitive and motor performance. This improvement in learning and cognitive abilities is significant for students since they are both vital components of academic performance (Du Toit et al., 2009). Despite the known benefits of visual skills training, students unfortunately do not receive it. In 2.3.2, an elaborate discussion will be provided to show that visual skills are a necessary component of academic achievement.

2.3.2 The relationship between visual skills and academic performance.

A study conducted by Maples (2003) revealed that inefficient visual skills negatively affect a student's learning, and that if the visual skills of students are improved it is possible that academic scores and performance may improve as well. In earlier research, Maples (2001) established the importance of visual skills in predicting academic performance. The symptoms associated with deficient visual skills can be measured and vision can be modified using optometric techniques (Maples, 2003). It is possible that improving visual skills could make an important contribution to solving the problem of academic under-achievement and could thereby significantly improve academic performance (Maples, 2003). Good visual skills are essential components in achieving educational, economic and social success as well as independence (Marshall, et al., 2010). If a person has any visual impairments which are undetected and are therefore not corrected, this could increase the potential for academic dropout and poor academic performance (Marshall, et al., 2010).

Although in general the literature supports the belief that a deficit in visual efficiency skills may have a negative influence on school performance, this topic remains the subject of much controversy. The reason for this controversy is that, because their research has yielded conflicting results, some of the researchers in this area disagree on whether a deficit in visual efficiency skills negatively influences school performance. Due to the lack of adequate data concerning the possible influence that visual deficits may have on an individual's performance in assessments of higher level visual-information processing, Goldstand, Koslowe and Parush (2005) decided to conduct a study to address the problem. Their study compared visual-information processing and visual skills among children with and without mild academic and reading problems and examined the occurrence of visual deficits among these children. Their results showed that visual function differentiates significantly between children with and without mild academic problems. Significant differences were also discovered in visual-perceptual scores for the two groups. These researchers' findings strongly suggest that when basic visual skills are not functioning optimally, reading ability and overall academic functioning are negatively influenced.

Visual impairments, however, are not the only visual aspect that may influence academic performance. Kavale (1982) discovered that visual perception is an important correlate of reading achievement or accomplishment. He further noted that reading achievement is an excellent predictor of reading performance in school. Another important discovery with regard to the relationship between visual skills and performance was made by Schneck (2001). He determined that visual-information processing, which consists of visual-motor integration and visual perception, plays a significant role in certain facets of academic performance (Schneck, 2001). Kavale (1982) and Schneck's (2001) notions were later confirmed by the research findings of Goldstand et al. (2005). These researchers compared children without academic and reading problems to children with mild academic and reading problems. The two groups were compared with one another regarding their visual skills and ability to process visual information. The results showed significant differences between the two groups with regard to academic problems and their ability to visually process information. These researchers' findings strongly suggest that when the basic visual skills are not functioning optimally, this may have implications for reading ability and overall academic functioning.

In yet another study conducted by Chen, Bleything and Lim (2011), it was learned that children who achieve average and above-average academic results showed a visual performance profile that is different from that of children with low academic achievement. The former also had a

better pass rate on visual tests measuring visual-analysis skills and visual-spatial/visual-motor integration (the ability of a person to coordinate what he/she sees with his/her body movements, such as, controlling a pencil to form precise strokes), ocular motor balance (which involves the eye muscles working together to ensure that the eyes are coordinated and balanced, to bring about optimal vision) and visual acuity (referred to in 2.2.2). These researchers concluded that it is more likely that children with low academic achievement will exhibit problems in visual-motor integration, ocular motor balance, visual acuity and most elements of visual analysis skills. These findings support the idea that visual performance is central to learning and is therefore of primary concern in academic achievement (Chen et al., 2011). Moore (1996) was therefore correct when he stated that “vision is our most important sense for learning, memory, and interacting with our environment” (p. 16).

When considering the effect of vision training programmes on an individual’s visual skills, one must keep in mind the potential effect that emotional states such as anxiety and curiosity may have on the learning of these visual skills. This is an important consideration as anxiety (Maples, 2003) and curiosity (Saab et al., 2009) have been identified as potentially having the biggest influence on the learning of visual skills.

2.4 Emotional States and Visual Skills

Emotions are one of the most pervasive and central aspects of human experience. People experience a broad range of emotions, ranging from the satisfaction of completing a simple task, to the grief that is experienced when a loved one passes away (Ortony, Clore & Collins, 1988). Emotions are widely considered to be states of action readiness, which supports the idea that one of the main functions of emotion is to prepare a person for action (Schupp, Junghofer, Weike & Hamm, 2003).

Emotional states can include a state of unhappiness, which is a state that is characterised by emotions which range from mild discontentment through to deep grief, or a state of embarrassment or happiness. Emotional states can be split into two bipolar continuums: arousal (low versus high) and valence (negative versus positive). Arousal is a psychological and physiological state of being reactive to stimuli or being awake. It includes the activation of the endocrine system, the autonomic nervous system and the reticular activating system found in the brain stem, leading to increased

blood pressure and heart rate, and a condition of mobility, sensory alertness and readiness to respond (Lapidus & Schmolling, 1975). Valence refers to the dislike or aversion (negative valence) or attractiveness (positive valence) associated with a situation, object or event. The emotions of fear and anger have negative valence, whereas joy has positive valence (Dunn & Schweitzer, 2005). Inducing particular arousal and valence states can influence the way individuals process and store information (Brunyé, Mahoney, Augustyn & Taylor, 2009). As a result, it is believed that emotional states could play a large role in several situations which require a person to execute complex spatial tasks. An example is a soldier attempting to plan a mission in a degraded and remote environment, or a paramedic trying to navigate to the location of an emergency. The emotional states evoked by a person's circumstances and tasks may affect their ability to think and learn about environments and consequently execute complex spatial tasks (Brunyé et al., 2009). The two examples provided above, which concern emotional states and spatial tasks, provide an illustration of how emotional states can interfere with the execution of certain activities on a broader level, and with this in mind we can focus our attention on how emotional states can interfere with the learning of visual skills.

Examples of emotional states are anxiety, curiosity, anger, depression, happiness, disgust, fearfulness, sadness, and surprise. As was mentioned in 2.3.2, emotional states can impact on visual skills either positively or negatively. The emotional states of anxiety and curiosity have been identified as potentially having the biggest influence on the learning of visual skills. It is hypothesised that anxiety will negatively impact on the learning of visual skills, whereas curiosity will positively impact on the learning of visual skills. Since anxiety and curiosity are the emotional states that will be monitored within the context of the present study, an in-depth discussion will follow on each of these constructs and how they relate to visual skills.

2.4.1 Anxiety.

Anxiety can be considered to be a part and potential result of stress, characterised by a situation of conditioned activation in which feelings and thoughts of uncertainty, concern and worry dominate (Woodman & Hardy, 2001). According to Martens, Burton, Vealey, Bump and Smith (1990), anxiety consists of two components. The first component is a cognitive component which refers to the person's thoughts. Cognitive anxiety refers to the mental component of anxiety which is caused by negative self-evaluation or negative expectations concerning success. Cognitive

anxiety is characterised by unpleasant visual imagery, negative self-talk and worry. Examples of the cognitive component of anxiety are concerns, worries and negative thoughts. The second component of anxiety is the somatic component which refers to physiological arousal symptoms. Examples of these symptoms are palpitations, increased heart rate, perspiration, churning of the stomach, tension, dry mouth, clammy hands, etcetera (Powell & Enright, 1990; Rowan & Eayrs, 1987). Anxiety can be additionally divided into state and trait dimensions (Martens et al., 1990).

2.4.1.1. State anxiety.

State anxiety is context-specific and relatively transient (Martens et al., 1990). State anxiety is a transitory emotion which is characterised by consciously perceived feelings of tension, dread and apprehension and physiological arousal (Spielberger, 1966). State anxiety refers to the intensity of subjective feelings of worry, nervousness, apprehension and tension at a specific time, with the associated arousal or activation of the autonomic nervous system. When conducting a psychological test to measure an individual's state anxiety, such as the State-Trait Personality Inventory (STPI), respondents are asked to report the intensity of the anxiety they are feeling right at that particular moment (Spielberger & Reheiser, 2009).

2.4.1.2 Trait anxiety.

Spielberger (1966) refers to trait anxiety as a person's predisposition to respond anxiously to any type of situation. Martens et al. (1990) describe trait anxiety as general, enduring and dispositional. Trait anxiety is defined as relatively stable individual differences relating to how prone people are to experience anxiety. This proneness to anxiety is reflected in the incidence of previously manifested anxiety states, and the likelihood that feelings of state anxiety will be experienced by the person in the future (Spielberger & Reheiser, 2009). As is the case with state anxiety, the STPI also has a subscale that measures trait anxiety. When conducting the STPI, respondents are asked to report how they generally feel by assessing the frequency with which the anxiety-related symptoms, cognitions and feelings are experienced (Spielberger & Reheiser, 2009).

2.4.1.3 Anxiety and visual skills.

Visual attention (the restriction of visual processing to a single item at a time) plays a critical role in sporting expertise (Janelle, 2002). Visual attention is an essential visual skill that can be taught to athlete and non-athlete populations through sports vision exercises. For athlete and non-athlete populations, it is vital to be able to restrict your visual processing to one item at a time in order to focus and concentrate on certain items in the environment. According to Potgieter (2003), visual attention is interlinked with a process known as visual search strategy. Visual search strategy involves the practice of locating a target item among other distractor items in a visual environment that is often cluttered (Williams & Elliott, 1999).

Emerging evidence reveals that when people are anxious, gaze behaviour tendencies are consistently altered, leading to ineffective and inefficient visual search strategies (Janelle, 2002). Visual search strategies are therefore negatively affected by anxiety (Janelle, 2002). According to Boot, Becic and Kramer (2009), this could be attributed to the fact that when a person is anxious, limitations are experienced regarding the cognitive and physical processing of information related to the location of a target. As a result of these limitations, attention that is required for focus is diverted to irrelevant scenes. In addition to the difficulty people who are anxious experience with focusing on a specific target, it has been discovered that individuals become more distractible under conditions of high anxiety and are, yet again, inclined to focus on potentially irrelevant or threatening cues (Eubank, Collins & Smith, 2000). In order to understand these processes, researchers have investigated the mechanisms underlying attentional variability, which is believed to be the result of increasing anxiety (Janelle, 2002).

Attentional variability refers to the attention-related changes that take place when differences occur in emotional states such as anxiety. When a person experiences anxiety, the changes that occur in his/her attention levels result in impaired performance. Once changes in attention levels take place, certain attentional mechanisms are affected. Because of this, information that is task-relevant might be ignored while information that is task-irrelevant is attended to (Janelle, 2002). Janelle, Singer and Williams (1999) conducted research to 1) determine how shifts in attentional parameters may be affected by changes in arousal and anxiety, and 2) to examine attentional narrowing and distraction in a dual-task motor racing simulation. Students were randomly assigned to one of six groups: central anxiety, central control, relevant anxiety, relevant control, distraction anxiety and distraction control. A driving task was performed by those in central

conditions while the other four groups had to identify peripheral lights as well as drive the vehicle used as part of the study. Irrelevant peripheral lights were incorporated into the distraction conditions. Participants in the groups experiencing anxiety-inducing conditions were subjected to increasing levels of anxiety by means of a time-to-event paradigm (a process of testing an athlete 48 hours, then 24 hours, then two hours and lastly five minutes before the start of a competition). Measures of performance, visual search patterns, arousal and cognitive anxiety were recorded. With greater levels of anxiety, the identification of peripheral lights became less accurate and slower, and significant reductions in performance occurred in peripheral and central tasks. Furthermore, in the distraction anxiety group, visual search patterns were found to be more eccentric. In sum, it was found that as arousal and anxiety increased, the response time needed to identify the presence of relevant cues also increased. Results indicated that drivers who were extremely anxious experienced an altered capacity to acquire peripheral information and cues at the perceptual level (Janelle et al., 1999).

The investigations conducted by Janelle et al. (1999), Murray and Janelle (2003) and Williams and Elliott (1999) revealed that attentional narrowing occurs as a result of anxiety and is exhibited by a reduction in variability in the visual search patterns. When anxiety increases, important information which is available exclusively in the peripheral visual field might not be detected (Janelle et al., 1999; Murray & Janelle, 2003; Williams & Elliott, 1999).

One can therefore conclude that when people are experiencing anxiety, their ability to perform certain visual tasks deteriorates, and the higher the level of anxiety experienced, the more the person's visual ability deteriorates. When anxiety increases, information present in the visual field might be missed or overlooked. Thus, anxiety has a negative effect on a person's visual skills, and on their ability to pick up on certain cues or focus on specific targets in their visual field. Figure 2.2 illustrates the negative relationship between anxiety and visual skills. From the graph it can be seen that as anxiety increases, visual skills decrease.

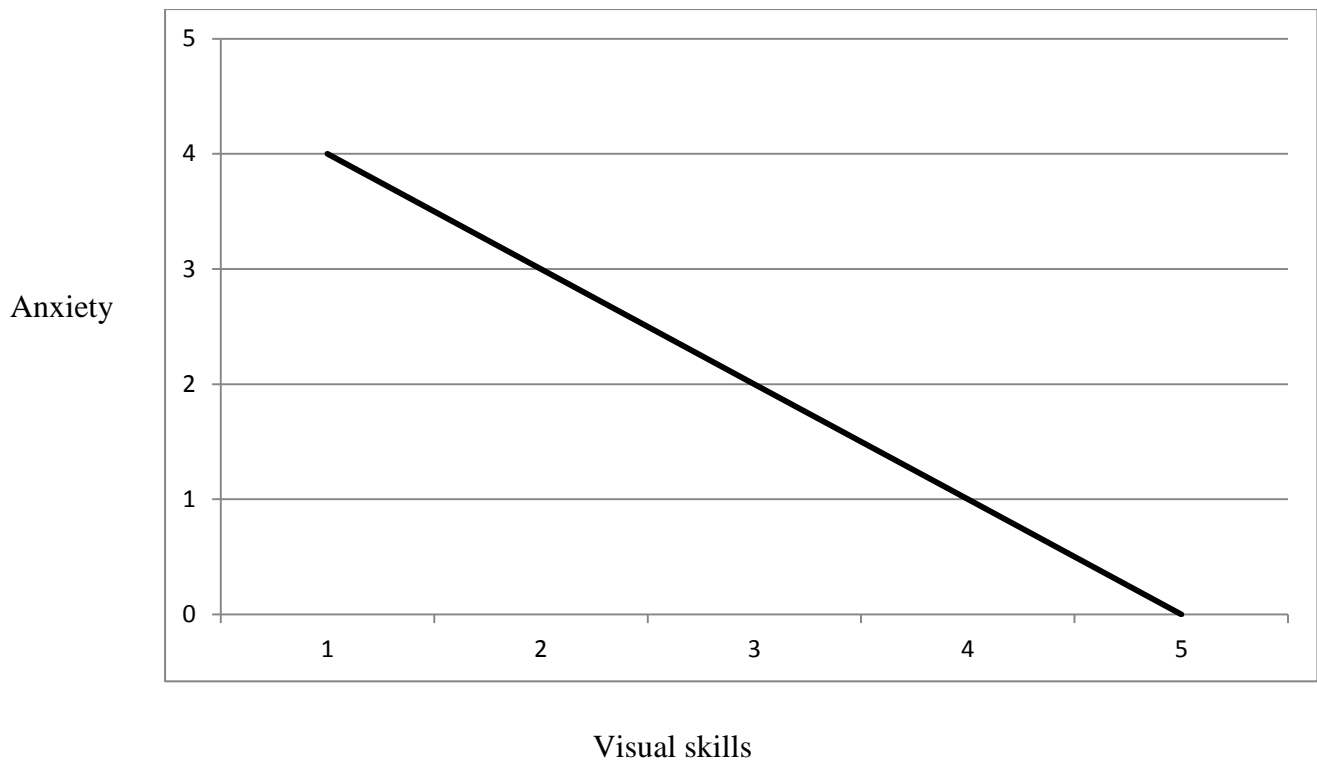


Figure 2.2 Relationship between anxiety and visual skills

In addition, the ability to pinpoint peripheral stimuli is compromised as the attentional field narrows, resulting in an escalation of fixations towards peripheral locations (Janelle et al., 1999). Figure 2.3 illustrates the positive relationship between narrowing attentional field and fixations towards peripheral locations. From the graph it can be seen that as the narrowing of the attentional field increases, fixations towards peripheral locations also increase.

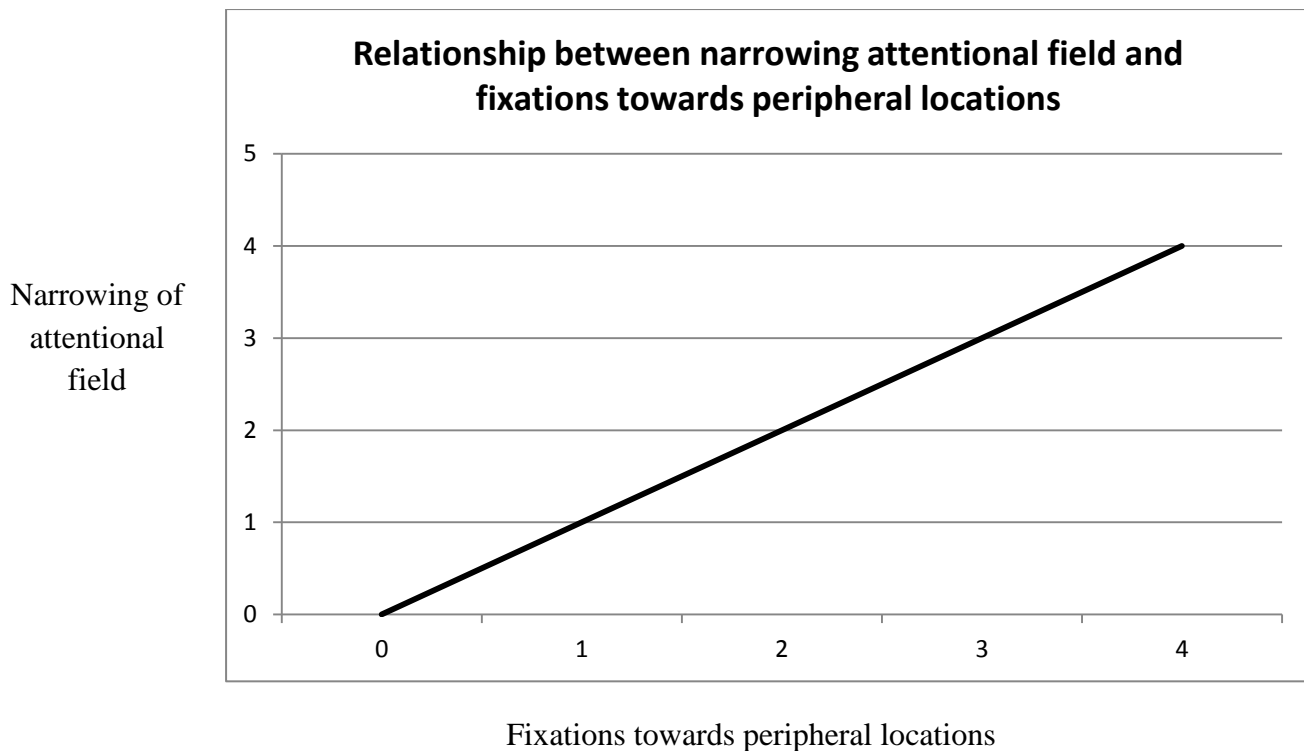


Figure 2.3 Relationship between attentional field and fixations towards peripheral locations

The results of an experiment conducted by Behan and Wilson (2008) revealed that the quiet eye period, which refers to a specific visuomotor strategy (Vickers, 1996), is susceptible to increases in anxiety. Visuomotor relates to connections between motor and visual processes, and concerns motor activity that is dependent on or involves sight. Quiet eye can be described as the tracking gaze or final fixation directed to a single object or location in the visuomotor workspace that is within (or less than) three degrees of visual angle for a minimum of 100 milliseconds. With the quiet eye there is an onset that happens before the final movement has taken place in the motor task, and an offset that happens when the tracking or fixation deviates off the target (location or object) by more than three degrees of visual angle for a period longer than 100 milliseconds (Vickers, Rodrigues & Edworthy, 2000). Figure 2.4 illustrates the negative relationship between anxiety and the quiet eye period. The graph shows that as anxiety increases, there is a decrease in the duration of the quiet eye period.

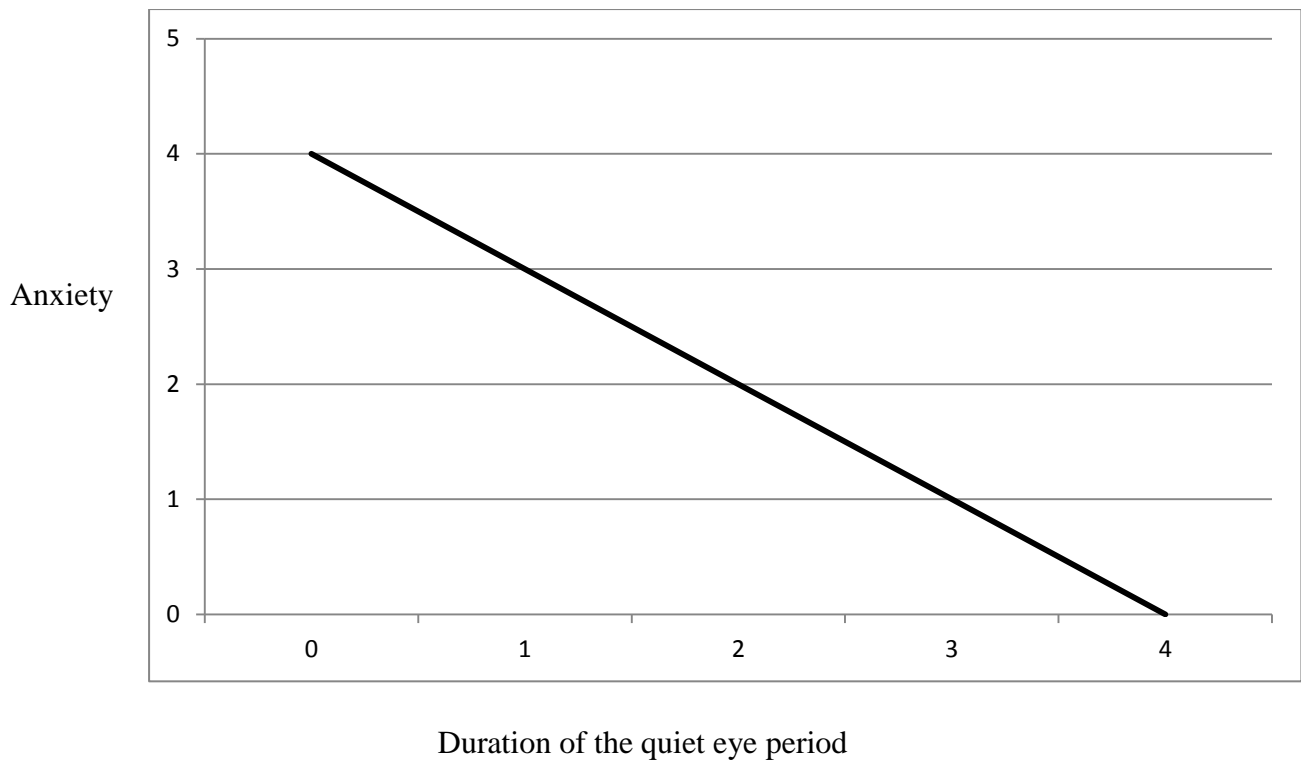


Figure 2.4 Relationship between anxiety and the quiet eye period

Behan and Wilson (2008) discovered that pressure manipulation alters gaze behaviour. In addition, decreases in the duration of the quiet eye period become apparent under high anxiety. In their experiment, under conditions of raised cognitive anxiety, optimum visual orientation was altered, as was indicated by changes in the duration of the quiet eye period. It is suggested that the precursors of cognitive anxiety are those factors within the competitive environment that affect an athlete's expectation of success. Cognitive anxiety occurs whenever an athlete's expectations of success become negative, which explains why athletes often begin worrying several days before a competition. Cognitive anxiety is strongly and consistently related to performance. There is a negative relationship between cognitive anxiety and performance; an increase in cognitive anxiety results in a decline in performance (Burton, 1988). The change in visual orientation caused by an increase in anxiety may lead to inferior performance on a specific task at hand that requires visual skills and visual ability in order to succeed and perform the task effectively (Behan & Wilson, 2008).

Since it has been established that when people's anxiety levels increase, their visual search strategies become ineffective, one can conclude that anxiety would also have a negative impact on the learning of visual skills. Visual search strategies would also be negatively affected by anxiety.

This is because when a person is anxious they become more distractible and turn their attention to irrelevant cues in their environment instead of focusing on essential items in their visual field.

2.4.2 Curiosity.

Curiosity, which bears an inverse relationship to anxiety (Voss & Keller, 1983), is defined by Loewenstein (1994) as a desire to gain new sensory experience and knowledge that motivates exploratory behaviour. Curiosity frequently contributes to successful adaptation to stimuli in the environment and effective personal adjustment (Spielberger & Reheiser, 2009). This is so because curiosity is considered to be a resilience factor (Beardslee, 1989). Resilience is a buffering factor which operates as a protective mechanism and which consists of constitutional and environmental factors; it is the ability to restore equilibrium and adapt to one's environment. Resilience is composed of curiosity, self-esteem, self-discipline, self-confidence and control over one's environment (Beardslee, 1989). Curiosity is a desire to know, an intellectual need. Silvia (2008) states that curiosity propels individuals towards discovery and inquiry. Curiosity is closely related to interest, another emotional state that encourages an intrinsic desire to explore and learn (Silvia, 2008). Curiosity has both personality and situational aspects to it (Spielberger and Reheiser, 2009).

2.4.2.1 Trait curiosity.

The personality aspect of curiosity is referred to as trait curiosity (Voss & Keller, 1983). According to Spielberger and Reheiser (2009), trait curiosity refers to individual differences in curiosity that are relatively stable personality traits. When a psychological test to measure a person's trait curiosity is conducted, such as the State-Trait Curiosity Inventory (STCI), respondents are asked to give an account of how they feel at a specific moment. A person with high levels of trait curiosity feels curious more often and experiences higher levels of intensity than a person who is low in trait curiosity (Spielberger & Reheiser, 2009).

2.4.2.2 State curiosity.

The importance of a situation relates to state curiosity, or curiosity as a motivational state (Voss & Keller, 1983). According to Spielberger and Reheiser (2009), state curiosity refers to

curiosity as a transitory emotional state. When conducting the STPI, respondents are asked to give an account of how they generally feel. High levels of state curiosity reveal an intense desire to understand, explore and seek out new characteristics of the environment (Spielberger & Reheiser, 2009).

2.4.2.3 Curiosity and individual differences in eye movements.

Individual differences in eye movements are important because they are related to trait curiosity. Trait curiosity is associated with individual differences in curiosity that are relatively stable personality traits (Spielberger & Reheiser, 2009). It is therefore possible to establish an association between individual differences in curiosity and individual differences in eye movements. People with high levels of trait curiosity feel curious more often, and may therefore also experience increased eye movements in order to explore their surrounding environment. This may relate to visual skills as people who are higher in trait curiosity and have increased eye movements may benefit more from sports vision exercises and may therefore have better visual skills than people lower in trait curiosity and who have fewer eye movements.

As mentioned previously, one of the principal means by which we collect information concerning our environment is by moving our eyes. Visual exploration is propelled by two key factors: our own individual intentions and interests, and the stimuli within our environment. Research examining these two features of attentional guidance has concentrated almost exclusively on factors that are common across people. The study by Risko et al. (2012) followed a different approach, and investigated the role that individual differences in personality play. The study conducted by Risko et al. (2012) investigated whether individual differences in the way people explore real-world views or scenes correlate with the occurrence of trait curiosity. The findings of the study by Risko et al. (2012) revealed that trait curiosity is a reliable and robust predictor of a person's eye movement behaviour in scene-viewing. The results reveal that "who a person is, is related to how they move their eyes" (p. 86). Risko et al.'s finding that the perceptual curiosity of an individual predicts the extent to which they will explore various scenes provides strong support for the idea that a person's characteristics are associated with the way the eyes are moved.

In one of the early studies of individual differences in eye movements conducted by Noton and Stark (1971), it was discovered that people are inclined to show distinctive patterns of eye

movements while viewing the same line drawings of various objects. However, there seemed to be insufficient consistency within an individual when viewing different images. As a result, Noton and Stark (1971) came to the conclusion that an “explanation in terms of eye movement habits independent of the pattern viewed was rejected” (p. 940). This lack of verification for stimulus-independent differences in individuals in looking patterns is in contrast with recent work. Particularly, studies conducted by Andrews and Coppola (1999), Rayner, Li, Williams, Cave and Well (2007) and Castelhana and Henderson (2008) have discovered that both the frequency and the size of saccades within and across several tasks, co-varied considerably within individuals. Saccades are small jerky and rapid movements of the eye, particularly as the eyes jump from one specific point to another, for example when one is reading. Furthermore, it was uncovered by Underwood, Foulsham and Humphrey (2009) that across two different scenes, a person’s scan pattern was more alike than one would have expected it to be by chance. Altogether, these results reveal stable stimulus-independent individual differences in eye movement behaviour (Risko et al., 2012).

In line with the recent discoveries discussed in 2.4.2.3, it is evident that there are differences between people in their eye movement behaviour, which lend support to the idea that trait curiosity has an influence on eye movements, and thus on visual skills. A person who displays high levels of trait curiosity may have better visual skills as a result of the increased eye movements they use to explore their surrounding environment, and may have a better ability to learn visual skills, thus benefiting more from sports vision exercises.

2.4.2.4 Curiosity and visual skills.

The experience of curiosity can be thought of as a positive emotional vital sign. The reason for this is that curiosity could be perceived as a motivator of exploratory behaviour that frequently contributes to successful adaptation to stimuli in the environment. This often results in effective personal adjustment to the person’s environment. Although the above is widely acknowledged, little research has been conducted on the evaluation of curiosity (Spielberger & Reheiser, 2009).

Some of the research that has been conducted on the evaluation of curiosity has investigated the relationship between curiosity and eye movements in patients suffering from Alzheimer’s disease. A clinical study of Alzheimer’s disease conducted by Daffner et al. (1992) suggests that

some patients display significantly diminished curiosity early on in the course of the illness. These behavioural changes are particularly difficult to measure experimentally, and were therefore determined by assessing the exploratory eye movements that occur in response to inconsistent and challenging visual stimuli. It was discovered that the participants from the control group spent considerably more time viewing inconsistent stimuli, but the Alzheimer's patients spent considerably less time examining the novel stimuli, and displayed diminished visual exploration. Daffner et al. (1992) concluded that diminished curiosity in Alzheimer's patients could be determined by studying exploratory eye movements. This study demonstrates that curiosity does have an effect on vision and can be measured.

In light of the above findings it is concluded that visual exploration and the way people move their eyes are related to curiosity. It is further postulated that higher curiosity levels would result in more visual exploration, increased use of visual search strategies and more exploratory visual behaviour. This relates to visual skills in that higher curiosity levels may facilitate better visual skills. This can be achieved through increased visual search strategies and the motivation to explore the environment, which may in turn also facilitate the learning of visual skills.

2.4.2.5 The link between curiosity and intelligence.

It is commonly believed that curiosity and intelligence go together (Henderson & Wilson, 1991). The more powerful the motive of curiosity is in an individual, the greater the motivation will be to acquire skills, habits, techniques and concepts to satisfy this motive. Some people require a higher level of stimulation input to enable optimal intellectual functioning, whereas others favour a relatively low level of input (Saklofske & Zeidner, 1995). The idea that intelligence is influenced by curiosity coincides with theories which propose that responses to novelty in the environment could be a source of developmental continuity in intelligence, beginning in infancy and continuing through adulthood (Saklofske & Zeidner, 1995). Earlier research conducted by Gottfried, Gottfried, Bathurst and Guerin (1994) found that gifted adolescents and children have higher levels of curiosity when compared to a control group. In another study conducted by Cahill-Solis and Witryol (1994), it was noted that novelty preference in children is related to elevated achievement scores in second grade and fifth grade learners. The recent discovery of a molecular link between curiosity and intelligence demonstrates that the notion of a relationship between the two constructs is correct (Saab et al., 2009). The discovery was made after Saab et al. (2009) investigated the way

in which two proteins interact in the dentate gyrus. The latter is associated with spatial navigation and long-term memory. During the study, the researchers increased the ability of brain cells to change the way in which they communicate with each other, which gave the mice used in the experiment superior memory in complicated tasks and a substantial increase in the display of exploratory behaviour. Since behavioural exploration is perceived to be an indicator of curiosity (Raine, Reynolds, Venables & Mednick, 2002), one can conclude that Saab et al. (2009) increased the mice's levels of curiosity. In addition, it was found that some of the brain regions and molecules that control memory and learning also control curiosity. Saab et al. (2009) concluded that when curiosity levels are increased, intelligence is enhanced. They also noted that the inverse also occurred, that if intelligent behaviour is displayed, an increase in curiosity levels is observed.

Since it has been established that there is a link between curiosity and intelligence, one could assume that higher levels of curiosity and intelligence would result in increased visual skills and an increased ability to learn these visual skills. The basis for this conclusion is that because intellectual behaviours such as reading, manipulating and questioning the environment are successful behavioural methods for gratifying an individual's curiosity, it follows that a curious person would be more prone to develop these skills to increase intelligence and general knowledge, and thus more likely to develop their visual skills, as vision is the primary way through which we gather information concerning our environment.

2.5 Conclusion

It has been shown that there are relationships between visual skills and anxiety and curiosity. It now remains to be determined whether these relationships will manifest when visual skills are taught to students and whether they have an impact on a student's ability to learn these visual skills.

In the next chapter, the research design used in the present study will be discussed in detail, as well as the validity of the research design. The research aims and hypotheses will be mentioned again. The sample and the sampling method will be discussed in detail, as well as any ethical considerations that may have arisen during the study. Discussions will be presented on the measures used for data collection and the data collection process. The type of statistics that were used to analyse the data will also be mentioned.

Chapter 3

Methodology

3.1 Introduction

This chapter outlines the research process utilised to investigate whether sports vision exercises improve the visual skills of students, and whether anxiety and curiosity influence the learning of visual skills after receiving sports vision exercises. The research design, validity of the research design, research aims and hypotheses, sample, ethical considerations, measurement instruments, data collection procedure, data analysis and the statistical techniques used are explored in this chapter.

3.2 Research Design

For the purposes of this study, a quantitative research methodology was used. Quantitative research focuses on finding relationships between variables and aims to maximise internal validity. Avoiding false negative or false positive conclusions regarding causal hypotheses is the core of internal validity (Shadish, Cook & Campbell, 2001). Quantitative research also concentrates on the average behaviour of individuals in a population (Whitley, 2002).

A quasi-experiment was conducted to collect data on visual skills and the effects of sports vision exercises on these visual skills. In a quasi-experiment, pre-test observations of the participants are made, after which the treatment is administered to the participants. After the treatment, post-test observations are again made of the participants (Whitley, 2002). The specific type of quasi-experiment used in this study is the interrupted time series quasi-experimental design. In the interrupted time series design, a single-case approach is used whereby a baseline period is followed by an intervention or treatment which interrupts the baseline. This in turn is followed by a period of post-treatment observations (Whitley, 2002). The information regarding the students' visual skills was gathered by administering the visual skills tests discussed in section 3.7.2.

Quasi-experimental research designs make use of various kinds of quasi-experiments which aim to establish causality between a specific intervention and outcome. Quasi-experiments also

attempt to attain naturalism in settings through the manipulation of an independent variable within a natural setting. In addition, existing groups of people are utilised as the participants (Reichardt, 2009). There are several types of quasi-experimental designs, one of which is the within-subjects design with a pre-test and post-test. This was the design of choice for the present study. Within the context of the design, pre-test observations are made for the participants. The treatment is then administered to these participants. Afterwards, post-test observations are made for these participants (Reichardt, 2009).

The major advantage of this interrupted time series quasi-experimental design is the use of pre- and post-test measurements. By using a pre-test, the researcher is able to establish a baseline against which the effects of the treatment can be assessed (Whitley, 2002). By acquiring pre-test measurements of the sample of participants, the researcher is able to evaluate the preliminary comparability of the participants in terms of the dependent variable and related confounds that may exist.

A quasi-experimental design is also useful when it is not ethical or logistically feasible to perform a randomised controlled experiment or trial, and is often used to assess the benefits of particular interventions (Harris et al., 2006). A quasi-experimental design allows competing threats to validity to be ruled out, and often hypotheses worthy of further exploration are suggested (Cook & Campbell, 1979).

With a quasi-experiment, the possibility that there may be alternative explanations for the results must be taken into consideration. In addition, the nature of quasi-experiments is that this design cannot establish causality with certainty. However, there are two steps that can be followed to increase the researcher's confidence that the independent variable did cause the difference. Replication is the first step: the more often we can replicate an effect under different circumstances, the more probable it is that the causal agent was the independent variable. The second step is to have several naturally occurring groups of participants to measure (Whitley, 2002).

An interrupted time series design quasi-experiment that is well designed, and controls for extraneous variables throughout the duration of the quasi-experiment, attrition rates and participant self-selection into the research, is likely to produce a result that is similar to that of a true experiment and to result in similar conclusions concerning the hypotheses being tested (Whitley, 2002). Attrition refers to the failure of participants to complete a study, or a situation where

participants drop out of or withdraw from a study while it is being conducted. If these characteristics are associated with the dependent variable under investigation, one cannot be certain that any differences uncovered between the pre- and post-test are a result of the effects of the independent variable, rather than from differences in participant characteristics (Whitley, 2002).

3.3 Validity of Research Design

Construct validity is crucial since a quasi-experimental design has been chosen. Specifying the populations of settings, persons and times to which a particular relationship applies can help to clarify construct validity issues (Cook & Campbell, 1979). Construct validity in the context of a quasi-experimental design is concerned with the adequacy of operational definitions. Construct validity deals with whether the procedures used to concretely represent the hypothetical constructs under investigation, have in fact correctly represented those constructs (Whitley, 2002). Avoiding false negative or false positive conclusions regarding causal hypotheses is at the core of internal validity (Cook & Campbell, 1979). The research study has addressed issues of confounding variables by using students from the same university and the same degree programme. In addition, a laboratory environment was used. This helps to control for confounding variables such as a different environment, or inconsistency among respondents or testers. The large sample size also increases the internal validity of the study (Cook & Campbell, 1979).

3.4 Research Aims and Hypotheses

As was noted in 1.3, the primary aim of this study was to determine whether anxiety and curiosity have an impact on a student's ability to learn visual skills directly after receiving sports vision exercises for 12 weeks.

To determine whether there are relationships between anxiety, curiosity and visual skills, and what the extent of these relationships is, the following secondary aims were formulated:

- To determine whether sports vision exercises improve the visual skills of second-year physiology students at a tertiary institution.

In order to measure this particular aim, the following hypotheses were set:

H₀: There is no relationship between sports vision exercises and the improvement of visual skills among second-year physiology students at a tertiary institution.

H₁: There is a statistically significant relationship between sports vision exercises and the improvement of visual skills among second-year physiology students at a tertiary institution.

- To determine whether anxiety influences the learning of visual skills after receiving sports vision exercises.

In order to measure this particular aim, the following hypotheses were set:

H₀: There is no relationship between anxiety and the learning of visual skills among second-year physiology students at the tertiary institution.

H₀: Anxiety is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: There is a statistically significant relationship between anxiety and the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: Anxiety is a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

- To determine whether curiosity influences the learning of visual skills after receiving sports vision exercises.

In order to measure this particular aim, the following hypotheses were set:

H₀: There is no relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution.

H₀: Curiosity is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: There is a statistically significant relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: Curiosity is a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

3.5 Sample

For the purposes of the present study, a convenience sample consisting of second-year physiology students from a tertiary institution was chosen and these students were targeted for participation. Convenience sampling is a non-probability sampling method in which the participants are members of a certain group of people that the researcher considers it convenient to draw a sample from, or from which the researcher considers it convenient to collect the data (Özdemira, St. Louis & Topbas, 2011). Convenience samples are usually an inexpensive means of data collection and are easy to acquire (Whitley, 2002).

The sample consisted of second-year physiology students who were enrolled at a South African based tertiary institution at the time of the study. The physiology students who were second-year students in 2012 formed the group of participants that were sampled from. The treatment consisted of the presentation of sports vision training.

The participants received 12 weeks of sports vision training in the form of exercises. The sample size consisted of 204 second-year physiology students. The sample composition for this group comprised both genders, various races and ages ranging from 18 to 37 years of age.

The tertiary institution and participating second-year physiology university students were chosen on the basis of ease of access to research facilities and participants. In addition, these participants also formed part of a study conducted by the Physiology Department. The researcher collaborated with the students' lecturers and members of the Physiology Department in order to promote participation for the present study.

Eye-hand coordination tests were performed before the study commenced to make sure that none of the participants had substantially superior visual skill levels before testing. The eye-hand coordination test consisted of the alternative hand wall toss, in which the participants were requested to stand and face a wall while remaining behind a restraining line that was two metres in length, and hold a ball in their right hand. Following this, the ball was tossed against the wall using an under-arm movement and then caught with the left hand. The ball was then tossed using the left hand and caught using the right hand. This alternative hand wall toss was repeated and the total amount of successful catches that occurred in 30 seconds was noted.

3.5.1 Gender distribution of the participants.

The gender distribution of the participants is displayed in Table 3.1.

Table 3.1

Gender distribution of the participants

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Male	47	23.38	47	23.38
Female	154	76.62	201	100.00

Frequency missing = 3

It is evident that the group of participants consisted of more females (76.62%) than males. Graphically, the gender distribution can be displayed as follows:

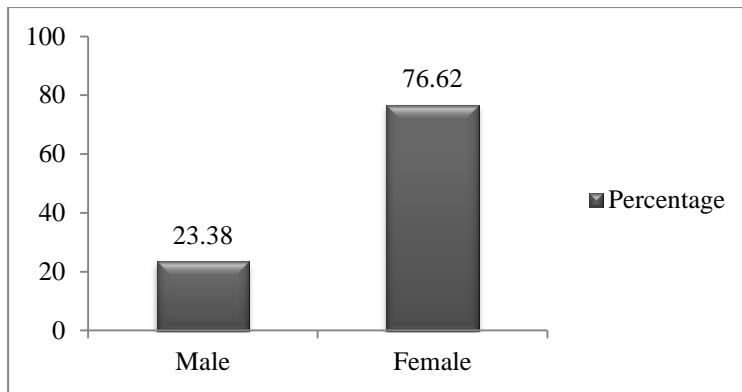


Figure 3.1 Gender distribution of the participants

3.5.2 Race distribution of the participants.

The race distribution of the participants is displayed in Table 3.2.

Table 3.2

Race distribution of the participants

	Frequency	Percentage	Cumulative frequency	Cumulative percentage
Black	56	28.28	56	28.28
Coloured	3	1.52	59	29.80
Indian	7	3.54	66	33.33
Asian	4	2.02	70	35.35
White	128	64.65	198	100.00

Frequency missing = 6

It is evident that the participants consisted of more white students (64.65%) than students from the other race groups.

3.5.3 Age distribution of the participants.

The age distribution of the participants is displayed in Table 3.3.

Table 3.3

Age distribution of the participants

Age	Frequency	Percentage	Cumulative frequency	Cumulative percentage
18	5	2.53	5	2.53
19	65	32.83	70	35.35
20	77	38.89	147	74.24
21	34	17.17	181	91.41
22	6	3.03	187	94.44
23	4	2.02	191	96.46
24	4	2.02	195	98.48
30	1	0.51	196	98.99
36	1	0.51	197	99.49
37	1	0.51	198	100.00

Frequency missing = 6

It is evident that the majority of the participants were either 19 (32.83%) or 20 (38.89%) years old.

3.6 Ethical Considerations

Permission to conduct the study was obtained from the Research Committee of the Faculty of Humanities and all the relevant ethical committees situated at the tertiary institution. The ethical rights of the participants were respected throughout the study. All of the participants received a package that consisted of participant information and informed consent forms. These documents notified them of the purpose, aim and duration of the study. An explanation of procedures to be

followed and of whether any of the procedures involved risk or discomfort was also included. The participants were also informed that their participation in the study was voluntary (see Appendix A). The participants were required to complete an informed consent form, which was signed by the participant, the investigator and a witness. They were also informed that they could withdraw from the study at any stage without any prejudice against them (see Appendix B) (Whitley, 2002). The participants were assured that their identity and the information provided by them would be kept confidential and would be anonymously processed into a research report. The participants' identity was kept confidential by providing them with respondent numbers instead of using their names or student numbers. No deception was used in the study as there was no need to do so (Whitley, 2002). If the participants had any questions on matters which had not been fully explained, they were encouraged to ask the investigator, whose contact details were provided.

3.7 Measurement Instruments

Measurement involves the sets of procedures utilised to allocate numbers to quantify variables. A measurement instrument in a research setting is a device that is used to measure the variables under investigation (Anastasi, 1986). Research measures are also utilised to provide information concerning the mean scores of various groups of people so as to compare groups of individuals on a construct or determine relationships between constructs (Whitley, 2002). Two measurement instruments were selected for data collection in the current study.

3.7.1 The State-Trait Personality Inventory (STPI).

The researcher measured anxiety and curiosity by using the STPI. The STPI was chosen because it seems to be the only instrument that measures anxiety and curiosity simultaneously.

The STPI is a self-administered questionnaire, and the responses are measured by means of a self-report technique. A self-report technique involves respondents' recording their responses in accordance with the questions they read on a questionnaire that a researcher provides them with. These self-report measures can be utilised as a technique for measuring constructs that would otherwise be challenging to obtain with physiological or behavioural measures (Whitley, 2002).

The STPI consists of 80-items which are divided into eight 10-item scales that are used to measure anxiety, curiosity, depression and anger as personality traits and emotional states (Spielberger, Ritterband, Sydeman, Reheiser & Unger, 1995). The wording of each item that is used in the questionnaire to assess state curiosity, depression, anger and anxiety reflects the different levels of intensity of these emotional states. It was considered important when developing the STPI to discard items describing psychosomatic symptoms, which may be the result of medical conditions such as heart disease or physical injury (Spielberger & Reheiser, 2009). The STPI can be easily and swiftly administered and scored in order to measure anger, anxiety, curiosity and depression (Spielberger & Reheiser, 2009).

The STPI has been used expansively with diverse patient populations, as well as with normal adults and adolescents. The administration instructions are easy to follow and brief and the procedures for scoring are objective and fairly uninfluenced by examiner bias. This inventory yields results that contribute to diagnosis, outcome assessment and treatment planning, and has excellent psychometric properties (Spielberger & Reheiser, 2009). The reliability and validity of the STPI are discussed in 3.7.1.1 and 3.7.1.2.

The respondents selected one answer from the response options provided for each of the 80 questions. The response options for State (page 1 of the questionnaire) are as follows: Not at all (1), Somewhat (2), Moderately So (3) and Very Much So (4). The response options for Trait (page 2 of the questionnaire) are as follows: Almost Never (1), Sometimes (2), Often (3) and Almost Always (4).

The unit of measurement for this study during the analysis was a computed average score for anxiety and curiosity. No distinction will therefore be drawn between state and trait anxiety or state and trait curiosity. An average score for anxiety and curiosity was developed because the researcher did not consider it important to examine the distinction between the situation-specific (state) emotional states, and emotional states that are characteristic of the person (trait), and to determine how these influence visual skills. The researcher was interested instead in how anxiety and curiosity overall, thus as a combination of states and traits, influenced the learning of visual skills. Two new variables were thus derived for the data, namely ANXST and CURST.

3.7.1.1 Reliability of the STPI.

Spielberger, Ritterband, Reheiser and Brunner (2003) have performed much research on the STPI with the purpose of establishing its reliability. The information relating to the reliability of the STPI as was documented in the Preliminary Manual for the State-Trait Personality Inventory is illustrated in Table 3.4 (Spielberger et al., 2003).

Table 3.4

Means, standard deviations and alpha coefficients calculated for the STPI (Source: Coetzee, 2005; Spielberger et al., 2003)

Age	18-22		23-32		33+	
Gender	Female	Male	Female	Male	Female	Male
N	180	112	189	138	129	128
Trait anxiety:						
Mean	19.40	19.13	17.99	18.08	17.98	16.27
SD	5.33	4.73	5.03	4.77	5.45	4.70
Alpha coeff	0.92	0.91	0.91	0.91	0.92	0.88
State anxiety:						
Mean	18.42	18.80	18.64	18.68	18.17	16.89
SD	6.26	5.65	6.84	5.49	5.75	5.57
Alpha coeff	0.93	0.91	0.94	0.91	0.93	0.92
Trait curiosity:						
Mean	27.59	26.72	29.00	28.50	28.86	30.45

SD	5.16	5.29	5.79	5.12	5.73	5.64
Alpha coeff	0.96	0.96	0.95	0.96	0.95	0.93
State curiosity:						
Mean	25.54	25.01	26.36	27.44	27.59	29.30
SD	6.51	6.34	6.59	6.30	6.73	6.23
Alpha coeff	0.94	0.94	0.92	0.94	0.93	0.91

In the following section, a discussion will be presented on the research results reported with regard to the validity of the STPI.

3.7.1.2. Validity of the STPI.

Spielberger et al. (2003) conducted a significant amount of research with large sample sizes in order to demonstrate that the instrument is valid. Spielberger et al. (2003) reported in the Preliminary Manual for the State-Trait Personality Inventory that the following statistical procedures had been performed with the purpose of determining the validity of the STPI:

- The scores that were attained from the STPI scales correlated with the scores attained on the State-Trait Anger Inventory (STAgI), as well as the State-Trait Curiosity Inventory (STCI) and the State-Trait Anxiety Inventory (STAI) (Coetzee, 2005).
- When using the STPI for the purposes of navy recruits and college students, inter-correlations were found among the STPI scales (Coetzee, 2005).
- There were correlations found between the scores that were attained on the STPI scales and scores from the MMPI Lie Scale, the Sociopathy Scale and the Eysenck Personality Questionnaire (Coetzee, 2005).

The list of statistical procedures provided above is descriptive of an extensive and comprehensive validity study, and confirms the assumption that the requirements set for predictive validity, content validity and construct validity were adhered to by the STPI. As a result, the STPI is believed to be a valid instrument for measuring anxiety and curiosity (Coetzee, 2005; Spielberger et al., 2003).

3.7.2 Visual skills.

The visual skills of the participants were measured by using a battery of tests which included the following: A Snellen chart was used to establish visual acuity. For this test, the participants had to correctly identify letters of varying sizes using the left eye, the right eye and both eyes (Wilson & Falkel, 2004). The Triangle Method was utilised to establish the dominant eye. This was established by observing which eye can clearly view an object through a triangle, without moving off centre (Wilson & Falkel, 2004). The Tracking Test was used to establish the efficacy of pursuit tracking movements. For this test, the participant was required to read letters from a chart, and the number of letters that are read in one minute was recorded (Wilson & Falkel, 2004).

The Pencil Push-up Test was employed to establish vergence (the ability to retain binocular vision while crossing and uncrossing the eyes). The procedure followed for this test is the following: The distance between the tip of the pencil and the participant's nose is measured once a double image is seen during the test (Wilson & Falkel, 2004). The Sequencing Test was utilised to establish the central nervous system's ability to systematise visual information in a prearranged order. In the Sequencing Test, the participants observed and then repeated several sequences of hand movements, and the number of completed sequences was recorded (Wilson & Falkel, 2004). Eye-hand coordination was tested using the Egg-Carton Catch Test. During the eye-hand coordination test, the time taken in seconds to catch the numbered egg cartons and flip a coin from one to 12 in order was recorded (Wilson & Falkel, 2004). Visualisation skills were evaluated using the Ace to Seven Test. The procedure followed for this test is the following: The participants had to memorise the order of the cards, turn them face down and then turn them over again in the correct order from ace to seven. The time was recorded in seconds for the participants to complete the task (Wilson & Falkel, 2004).

Lastly, focusing was tested using the Near-Far chart in order to assess the eye's ability to focus, and the improvement in the ability to maintain clear vision at varying distances. A large letter chart was positioned on a wall at a certain distance away from the participant, and a small letter chart was secured at nose level, approximately four inches away from the face of the participant. The letters were read from left to right, alternating each letter between the far and near chart. The number of letters which were correctly called out was counted and recorded (Wilson & Falkel, 2004).

3.7.2.1 Visual skills tests: Test-retest reliability.

The reliability of the visual skills tests was measured using test-retest reliability. Consistency across time is a sign of reliability because it is assumed that the traits to be measured are relatively stable across time. Thus, measures with a high level of true score must also be stable across time (Whitley, 2002). Therefore, one method of measuring reliability, also referred to as test-retest reliability, assesses a respondent's scores on one occasion on a particular measure, and then the same respondent's scores on a later occasion on the same measure, and calculates the correlation coefficient for these two assessments. This correlation coefficient signifies the degree of reliability displayed by the measure (Whitley, 2002).

In order to establish reliability, the respondent's scores do not have to be identical on both occasions, as random error causes this outcome to be unlikely. What is required is that a respondent's scores generally fall in a similar rank order: That respondents who obtain high scores on the first occasion also obtain high scores on the second occasion, and that respondents who obtain low scores on the first occasion also obtain low scores on the second occasion (Whitley, 2002).

Pearson's Correlation Coefficients were computed to investigate the relationship between weeks 1 and 12 for the visual skills variables under investigation. The results are displayed in Table 3.5.

Table 3.5

Results from correlation analysis conducted to determine test-retest reliability of the visual skills tests conducted

Visual skills test	Pearson Correlation	Sig. (1 tailed)
Visual Acuity Left	0.481	<.0001
Visual Acuity Right	0.530	<.0001
Visual Acuity Both	0.389	<.0001
Eye dominance	0.498	<.0001
Focusing	0.310	<.0001
Tracking	0.355	<.0001
Eye-hand coordination	0.580	<.0001
Visualisation	-0.061	0.395
Vergence	0.566	<.0001
Sequencing	0.173	0.016

p < 0.05

The results reflected in Table 3.5 tell us that all the visual skills tests, except visualisation, obtained acceptable test-retest reliability scores.

3.8 Data Collection Procedure

The tertiary institution provided a lecture hall for the administration of the STPI, while the Physiology Department provided a laboratory for the administration of the visual skills tests. The sports vision exercises were administered at another laboratory situated at the tertiary institution's sports grounds, and the study took place during the first semester of 2012.

3.8.1 Pre-test.

The participants attended visual skills testing sessions between classes, and a pre-test was administered to the students in this group. In the pre-test, the STPI and the battery of visual skills tests that were discussed in 3.7.2 were used to establish baseline information for their levels of anxiety, curiosity and visual skills.

3.8.2 Treatment.

Following the pre-test, an intervention which consisted of 12 weeks of sports vision exercises was administered to the sample of participants.

The sample of participants received 15 minutes of sports vision exercises, in which the simultaneous ball throw, crossover throw, crucifix ball drop, vertical ball hit and “find the letters” were each performed once on a bi-weekly basis before classes, over a 12-week period. During the simultaneous ball throw, the participants stood two metres apart from each other with their knees bent and their feet apart at shoulder width. One by one, the participants threw two balls at the same time for another participant to catch. This exercise continued for three minutes. During the crossover throw, the participants continued to stand two metres apart from each other with their knees bent and their feet apart at shoulder width. The participants threw two balls at the same time to the other participant’s opposite hands for them to catch. This exercise was also repeated for three minutes. The simultaneous ball throw and crossover throw exercises are intended to improve peripheral vision and concentration (Du Toit, Kruger, Joubert & Lunskey, 2007). During the crucifix ball drop, the participants stood with their knees bent, their feet shoulder width apart and their hands on their knees. The coach stood upright, arms extended towards his/her side, holding a ball in each hand. Following this, the coach dropped one hand, after which the participants were required to move into a squat position and then catch the ball with their palms turned upwards. The benefits of this exercise are that it improves foot movement anticipation, and peripheral awareness (Du Toit et al., 2007). During the vertical ball hit, the participant was instructed to wear a glove bat, and hit a ball vertically while his/her palms were facing upward. This exercise was repeated for three minutes. The benefit received from this exercise was to improve concentration (Du Toit et al., 2007). During “find the letters”, the participants used a computer programme and were required to click on the letters of the alphabet from A to Z. The letters of the alphabet were automatically

mixed and randomly changed position. The benefit of the vertical ball hit and the “find the letters” exercise is to improve concentration (Du Toit et al., 2007).

3.8.3 Post-test.

The treatment was followed by a post-test in which the same battery of visual skills tests as discussed in 3.8.1 were administered to assess whether any changes had occurred in the visual skills of the participants. The post-test measurements included the administration of the STPI to determine levels of anxiety and curiosity.

Using the visual skills tests discussed in 3.7.2, testing was done to determine whether the visual skills of the participants had improved as a result of receiving the sports vision exercises mentioned in 3.8.2.

As previously discussed, the researcher wanted to determine whether the potential benefits gained from these sports vision exercises were influenced by anxiety and curiosity (see section 1.3). An attempt was then made to establish relationships, in that sports vision exercises were expected to cause improvements in visual skills, and anxiety and curiosity were expected to influence the learning of these visual skills.

3.9 Data Analysis

Data from the STPI were used in conjunction with the data collected from the visual skills assessments. The captured data were analysed using SAS® version 9.3 running under windows XP service pack 3 on a desktop computer. The data were not tested to determine the shape of the distribution because the data set was large enough to assume an approximately normal distribution. The reason why an approximately normal distribution can be assumed is the number of observations per week in the data (Whitley, 2002). Following this, parametric statistics were computed for the variables under investigation.

3.10 Statistical Techniques Used

A variety of statistical techniques were used to conduct the analysis in order to confirm or disconfirm the hypotheses. These statistical techniques included left sided/lower tailed t-tests, correlation and stepwise regression analysis.

3.11 Conclusion

This chapter dealt with the methodology that was used in this study. It indicated that a within subjects quasi-experiment with pre- and post-test was used. The sample of participants consisted of students who were enrolled in 2012 for their second-year in physiology. In the quasi-experiment, the participants received 12 weeks of sports vision exercises. Subsequently, a post-test was conducted on the sample of participants to test for any differences in visual skills that may have developed. Included in the pre- and post-test measurement was the STPI, which was administered to the participants in a group setting. The STPI was used to measure the anxiety and curiosity levels of the participants. The results of the STPI were utilised in conjunction with the visual skills tests to determine whether anxiety and curiosity have an influence on the learning of visual skills. In the next chapter, the results produced by the statistical procedures used will be discussed in detail.

Chapter 4

Results

4.1 Introduction

This chapter outlines the variety of statistical techniques used to conduct the analysis, as mentioned in 3.10, in order to confirm or disconfirm the hypotheses set for the study. Included in the statistical techniques used were left-sided/lower tailed t-tests, correlation coefficients and stepwise regression analysis. Only the significant results of these analyses will be presented and discussed.

4.2 Descriptive Statistics

Descriptive statistics were used to describe the characteristics of the sample chosen for this study. They were also used to check the variables for any violation of the assumptions underlying the statistical techniques that were used to address the research questions (Pallant, 2010).

Before discussing the results of the hypotheses testing, the descriptive statistics will first be discussed for all the variables under investigation. The type of descriptive statistics that will be reported are number of participants, the mean, standard deviation, standard error, median, minimum and maximum.

4.2.1 Descriptive statistics for anxiety.

As discussed in 3.7.1, a merged state and trait anxiety score (average anxiety) was used as one of the units of measurement. Table 4.1 provides the descriptive statistics for this score for the sample of participants.

Table 4.1

Descriptive statistics for anxiety in week 1 and week 12

Variable: Anxiety							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	1.98	0.50	0.04	1.95	1.00	3.45
Week 12	198	2.07	0.49	0.03	2.10	1.00	3.55

In the following section, the descriptive statistics for curiosity will be reported.

4.2.2 Descriptive statistics for curiosity.

As discussed in 3.7.1, a merged state and trait curiosity score (average curiosity) was used as one of the units of measurement. Table 4.2 provides the descriptive statistics for this score for the sample of participants.

Table 4.2

Descriptive statistics for curiosity in week 1 and week 12

Variable: Curiosity							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	2.56	0.40	0.03	2.55	1.55	3.50
Week 12	198	2.43	0.43	0.03	2.40	1.35	3.55

In the next section, all the visual skill variables under investigation will be reported for the sample of participants with reference to the year and the week.

4.2.3 Descriptive statistics for visual skills.

4.2.3.1 Visual Acuity.

With the assistance of an optometrist, the visual acuity measurements (for e.g. 20/200) were converted into a percentage before statistical analyses were conducted. The new scores are reflected in Table 4.3.

Table 4.3

Visual acuity measurements and their corresponding percentages

Visual acuity measure	Equivalent percentage
20/200	10%
20/160	13%
20/120	17%
20/80	25%
20/70	28%
20/50	40%
20/40	50%
20/35	57%
20/30	67%
20/25	80%
20/20	100%
20/15	133%
20/10	200%

4.2.3.1.1 Visual Acuity Left

Table 4.4

Descriptive statistics for Visual Acuity Left in week 1 and week 12

Variable: Visual Acuity Left							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	98.12	23.52	1.65	100.00	28.00	133.00
Week 12	199	98.77	23.84	1.69	100.00	28.00	133.00

4.2.3.1.2 Visual Acuity Right

Table 4.5

Descriptive statistics for Visual Acuity Right in week 1 and week 12

Variable: Visual Acuity Right							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	96.52	22.87	1.60	100.00	28.00	133.00
Week 12	200	96.87	24.44	1.73	100.00	40.00	133.00

4.2.3.1.3 Visual Acuity Both

Table 4.6

Descriptive statistics for Visual Acuity Both in week 1 and week 12

Variable: Visual Acuity Both							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	109.07	22.81	1.60	100.00	40.00	200.00
Week 12	200	110.82	23.12	1.63	100.00	40.00	200.00

4.2.3.2 Eye Dominance.

Table 4.7

Descriptive statistics for eye dominance in week 1 and week 12

Variable: Eye dominance							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	0.73	0.47	0.03	1.00	0.00	2.00
Week 12	199	0.72	0.47	0.03	1.00	0.00	2.00

4.2.3.3 Focusing.

Table 4.8

Descriptive statistics for focusing in week 1 and week 12

Variable: Focusing							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	45.84	21.98	1.54	49.00	3.00	88.00
Week 12	200	52.91	20.06	1.42	57.50	5.00	92.00

4.2.3.4 Tracking.

Table 4.9

Descriptive statistics for tracking in week 1 and week 12

Variable: Tracking							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	46.32	22.58	1.58	45.50	4.00	100.00
Week 12	200	51.26	22.19	1.57	51.00	7.00	97.00

4.2.3.5 Eye-Hand Coordination.

Table 4.10

Descriptive statistics for eye-hand coordination in week 1 and week 12

Variable: Eye-hand coordination							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	37.73	21.70	1.52	33.10	0	169.69
Week 12	200	32.30	19.27	1.36	28.89	5.44	159.72

4.2.3.6 Visualisation.

Table 4.11

Descriptive statistics for visualisation in week 1 and week 12

Variable: Visualisation							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	204	38.45	17.63	1.23	35.13	12.69	133.00
Week 12	200	38.81	18.05	1.28	37.52	7.00	105.34

4.2.3.7 Vergence.

Table 4.12

Descriptive statistics for vergence in week 1 and week 12

Variable: Vergence							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	203	2.08	2.86	0.20	1.00	0.00	17.00
Week 12	200	2.47	3.23	0.23	1.00	0.00	16.00

4.2.3.8 Sequencing.

Table 4.13

Descriptive statistics for sequencing in week 1 and week 12

Variable: Sequencing							
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum
Week 1	202	1.94	0.99	0.07	2.00	0.00	7.00
Week 12	200	2.03	0.93	0.07	2.00	0.00	5.00

The sample sizes differ between week 1 and week 12 as some of the respondents were not available at the time of testing at week 12. In addition, the week 12 sample sizes differ across some of the variables as a few respondents did not complete all the tests, and thus information was missing for those particular variables.

Hypotheses testing will now be discussed.

4.3 Results of Left-Sided/Lower Tailed T-tests

A paired-samples left-sided/lower tailed t-test was used to determine whether sports vision exercises improve the visual skills of second-year physiology students at the tertiary institution. A paired-samples t-test is used when a comparison of the mean scores for the same group of respondents on two different occasions is required. Paired-samples t-tests are frequently used in pre-test/post-test experimental designs. Each respondent is assessed on a continuous measure both at Time 1 and then again at Time 2, after having been exposed to some experimental intervention or manipulation (Pallant, 2010). A left-sided/lower tailed t-test was used because the researcher was specifically testing to see whether the values in week 12 (Time 2) were greater than the values in week 1 (Time 1).

As mentioned in section 3.9, the data have not been tested to determine the shape of the distribution because the data set was large enough to assume an approximately normal distribution (Whitley, 2002). An approximately normal distribution can be assumed because of the number of observations per week in the data (Whitley, 2002). To determine whether sports vision exercises improve the visual skills of second-year physiology students at the tertiary institution, the following hypotheses were tested using left-sided/lower tailed t-tests:

H_0 : There is no relationship between sports vision exercises and the improvement of visual skills among second-year physiology students at the tertiary institution.

H_1 : There is a statistically significant relationship between sports vision exercises and the improvement of visual skills among second-year physiology students at the tertiary institution.

The results of the t-tests indicated that there were significant changes in only two of the visual skills, namely focusing and tracking.

The following results were obtained when the paired t-test was conducted between week 1 and week 12 for focusing and tracking:

Table 4.14

Results from t-tests on paired variables: Focusing (week 1) & focusing (week 12) and tracking (week 1) & tracking (week 12)

Paired variables: Focusing (week 1) & focusing (week 12)										
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum	t	df	Sig. (1-tailed)
Week 1	204	45.84	21.98	1.54	49.00	3.00	88.00	-3.90	195	.000
Week 12	200	52.91	20.06	1.42	57.50	5.00	92.00			
Paired variables: Tracking (week 1) & tracking (week 12)										
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum	t	df	Sig. (1-tailed)
Week 1	204	46.32	22.58	1.58	45.50	4.00	100.00	-2.86	195	0.002
Week 12	200	51.26	22.19	1.57	51.00	7.00	97.00			

From table 4.14, it is evident that there were statistically significant differences in focusing from week 1 (M=45.84, SD=21.98) to week 12 (M=52.01, SD=20.06), $p = .000$ (lower tail). The mean decrease in focusing scores was -7.07, with a 95% confidence level ranging from $-\infty$ to 22.45. For this sample of participants, the intervention had a significant effect on the focusing of these participants ($p = .000$).

Significant differences were also observed for tracking from week 1 (M=46.32, SD=22.58) to week 12 (M=51.26, SD=22.19), $p = .002$ (lower tail). The mean decrease in tracking scores was -4.94, with a 95% confidence level ranging from $-\infty$ to 23.23. For this sample of participants, the intervention had a significant effect on the tracking of these participants ($p = .002$).

Although not significant, a result that one needs to take note of is the difference in vergence between week 1 and week 12. The results are displayed in Table 4.15.

Table 4.15

Results from t-test on paired variables: Vergence (week 1) & vergence (week 12)

Paired variables: Vergence (week 1) & vergence (week 12)										
2012	N	Mean	Standard deviation	Standard error	Median	Minimum	Maximum	t	df	Sig. (1-tailed)
Week 1	203	2.08	2.86	0.20	1.00	0.00	17.00	-1.52	194	0.065
Week 12	200	2.47	3.23	0.23	1.00	0.00	16.00			

As a result of the findings of the t-test, the research hypothesis which states that there is a statistically significant relationship between sports vision exercises and the improvement of visual skills can be partially accepted.

4.4 Results of Correlation Analysis

Correlation analysis was conducted on all the variables under investigation to determine the relationships between anxiety, curiosity and visual skills. Correlation analysis examines the difference in correlations uncovered in two groups and the correlation between two variables. Correlation analysis is utilised to define the strength and direction of the linear relationship that exists between two variables (Whitley, 2002).

A Pearson Product-Moment Correlation Coefficient (r) is designed for interval level (continuous) variables. Pearson Correlation Coefficients are only able to take on values from -1 to +1. The sign in front of the number indicates whether there is a negative correlation (as one of the

variables increases, the other variable decreases), or a positive correlation (as one of the variables increases, so does the other variable). The magnitude or size of the absolute value (disregarding the sign) stipulates the strength of the relationship. A correlation of -1 or +1 indicates that the value of one of the variables can be established by knowing the value of the other variable. A correlation of 0 indicates that there is no relationship between the two variables (Pallant, 2010). To determine whether anxiety influences the learning of visual skills after receiving sports vision exercises, the following hypotheses were tested using correlation analysis:

H₀: There is no relationship between anxiety and the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: There is a statistically significant relationship between anxiety and the learning of visual skills among second-year physiology students at the tertiary institution.

To determine whether curiosity influences the learning of visual skills after receiving sports vision exercises, the following hypotheses were tested using correlation analysis:

H₀: There is no relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: There is a statistically significant relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution.

The results of the correlation analysis that was conducted showed only two significant correlations. These correlations were between anxiety and focusing, and anxiety and tracking. No significant correlations were observed between any of the visual skills and curiosity.

Table 4.16

Anxiety and focusing, and anxiety and tracking

		Total Anxiety	Total Focusing	Total Tracking
Total Anxiety	Pearson Correlation	1.000	-0.14007	-0.15231
	Sig. (2-tailed)		0.0436	0.0281
	N	204	204	204
Total Focusing	Pearson Correlation	-0.14007	1.000	
	Sig. (2-tailed)	0.0436		
	N	204	204	
Total Tracking	Pearson Correlation	-0.15231		1.000
	Sig. (2-tailed)	0.0281		
	N	204		204

p<0.05

From Table 4.16, it is evident that there was a small, inverse significant correlation between anxiety and focusing, $r = -.14007$, $n = 204$, $p = .044$, with low levels of focusing associated with high levels of anxiety.

A small, inverse significant correlation was also observed between anxiety and tracking, $r = -.15231$, $n = 204$, $p = .028$, with low levels of tracking associated with high levels of anxiety.

Once again, it is important to note that the correlation between anxiety and vergence was of interest, despite the fact that it was not significant.

Table 4.17

Anxiety and vergence

		Total Vergence	Total Anxiety
Total Vergence	Pearson Correlation	1.000	0.12414
	Sig. (2-tailed)		0.0740
	N	204	204
Total Anxiety	Pearson Correlation	0.12414	1.000
	Sig. (2-tailed)	0.0740	
	N	204	204

As a result of the above findings, the research hypothesis which states that there is a statistically significant relationship between anxiety and the learning of visual skills is partially accepted.

4.5 Results of Stepwise Regression Analysis

As discussed in 4.4, correlation analysis was first performed on the anxiety, curiosity and visual skills variables under investigation in order to determine the relationships between anxiety, curiosity and visual skills. Following this, the focus shifted to stepwise regression analysis. Various stepwise regressions were done; only the ones of interest in which significant differences were found will be reported on and discussed.

Stepwise regression analysis was conducted on all the variables under investigation to determine the influence of anxiety and curiosity on visual skills. Stepwise regression can be utilised to answer a variety of research questions, such as how well a particular variable is able to predict a certain outcome (Pallant, 2010). Stepwise regression analysis is a statistical method used to investigate the relationships between variables. The researcher seeks to determine the causal effect of one of the variables on another variable. To determine this, the researcher compiles data on the variables of interest and utilises stepwise regression analysis to assess the quantitative effect of the

independent variable on the variables that they influence. Statistical significance refers to the degree of confidence that the true relationship is close to the estimated relationship (Sykes, 1993).

In order to determine whether anxiety influences the learning of visual skills after receiving sports vision exercises, the following hypotheses were tested using stepwise regression analysis:

H₀: Anxiety is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: Anxiety is a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

In order to determine whether curiosity influences the learning of visual skills after receiving sports vision exercises, the following hypotheses were tested using stepwise regression analysis:

H₀: Curiosity is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

H₁: Curiosity is a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution.

Preliminary analyses were performed to ensure that there was no violation of the assumptions of normality, linearity and homoscedasticity. The stepwise regression analysis related to anxiety yielded a model where only two visual skills were significantly impacted upon by anxiety. The results of this model are displayed in Table 4.18.

Table 4.18

Tracking and vergence

Variable Vergence Entered: R-Square = 0.0429 and C(p) = -0.5493					
Analysis of variance					
Source	DF	Sum of squares	Mean square	F Value	Pr > F
Model	2	1.89018	0.94509	4.6	0.0112
Error	205	42.15983	0.20566		
Corrected total	207	44.05002			
Variable	Parameter estimate	Standard error	Type II SS	F Value	Pr > F
Intercept	2.17488	0.09067	118.33523	575.4	<.0001
Tracking	-0.00415	0.00171	1.21138	5.89	0.0161
Vergence	0.02380	0.01158	0.86826	4.22	0.0412

According to Table 4.18, anxiety is a statistically significant predictor of tracking and vergence ($p < .05$). It seems that the results of the stepwise regression analysis coincide to some extent with the findings of the t-test and the correlation analysis. It should be noted, however, that the model only explained 4.29% of the variance that occurred. The results therefore need to be treated with caution. Based on the results, the research hypothesis which states that anxiety is a significant predictor of the learning of visual skills is partially accepted.

Since the results did not yield a significant model with regard to curiosity, it is concluded that curiosity is not a significant predictor of the learning of visual skills among second-year physiology students at the tertiary institution. The null hypothesis is thus accepted in this instance.

4.6 Conclusion

This chapter dealt with the results of the statistical analyses that were conducted in order to confirm/disconfirm the hypotheses set for the study. Significant differences were found between focusing week 1 and focusing week 12, and tracking week 1 and tracking week 12. Significant correlations were reported between anxiety and focusing, and anxiety and tracking. The results of a stepwise regression analysis only identified tracking and vergence as being significantly impacted upon by anxiety. No significant results were displayed with regard to curiosity. The next chapter will focus on the interpretation and discussion of these results.

Chapter 5

Discussion of Results

5.1 Introduction

This chapter discusses the confirmation or rejection of the hypotheses set for the study, as confirmed/disconfirmed by the variety of statistical techniques used to conduct the analysis. Current literature will be used to confirm or refute the results. Limitations of the research, recommendations for future research and a conclusion on the study are explored in this chapter.

5.2 Results of the T-tests

In this section, the results of the t-tests will be discussed. The t-tests were conducted to determine whether sports vision exercises improve the visual skills of second-year physiology students at the tertiary institution. The t-tests conducted revealed that there were significant differences in focusing between week 1 and week 12, and tracking between week 1 and week 12. These differences could be ascribed to the administration of the sports vision exercises.

5.2.1 Focusing.

After the participants had received sports vision exercises, significant differences for the visual skill of focusing were observed between week 1 and week 12, (see Table 4.14). Focusing could therefore be improved by the administration of sports vision exercises. The results are consistent with the findings of Paul, Biswas and Sandhu (2011). These researchers assessed the effects of eye-hand coordination and sports vision training on the motor and sensory performance of table tennis players (Paul et al., 2011). Their sample consisted of 45 university-level table tennis players who were randomly assigned to three equal groups of 15 each. The experimental group received eight weeks of eye-hand coordination and sports vision training. The placebo group read articles relating to sports performance, in addition to watching televised table tennis matches. The control group underwent their routine practice session for eight weeks. Measures of motor

performance and visual function were obtained from the participants before as well as immediately after the eight weeks of training (Paul et al., 2011). The findings of the study indicated that focusing, accommodation and saccadic motility, which play an important role during visual challenges in table tennis, improved significantly in the experimental group following the eight-week training session. According to Zupan, Arata, Wile and Parker (2006), such improvements are the result of the frequent training of the visual system that gives rise to more efficient neural responses and stronger muscle fibres in the eye. Neural responses refer to responses related to the nervous system or a nerve (Weng et al., 2013).

Another study that yielded similar findings is the one conducted in Spain by Quevedo, Solé, Palmi, Planas and Saona (1999). This study aimed to determine the influence of visual training programmes in shooting initiation performance. Seventy-one (71) university students in their first year were randomly assigned to an experimental group and a control group. In addition to a nine-session shooting training programme that included psychological, physical and technical components, the experimental group received visual exercises. The control group, on the other hand, received theoretical lectures on psychological training techniques instead of doing the visual training. Pre- and post-test scores were obtained for visual acuity, saccades, concentration and shooting. The findings showed that the experimental group had significantly improved distance-near saccadic fixations and visual acuity. Saccades and focusing are related in that a certain number of saccades need to be performed per second in order to bring the whole visual field into focus (Dyckman & McDowell, 2005).

The results from the present study are consistent with the findings of Rezaee, Ghasemi and Momeni (2012). These researchers assessed the efficacy of sports training, visual training and sports-visual training programmes for table tennis and basketball players (Rezaee et al., 2012). The participants in this study had no prior table tennis or basketball training, and were screened for any eye disorders. Any subjects showing eye disorders were excluded from the study. In the end, 90 university students were randomly assigned to five experimental groups and one control group of equal size ($n=15$). The visual training programme comprised the sports visual training designed for athletes by the optometrist Dr Leon Revien and author Mark Gabor (Revien & Gabor, 1981). The sports training and visual training programmes were divided into two equal sessions consisting of 15 minutes each. The sports training programme consisted of table tennis and basketball training. The visual training comprised various visual exercises, such as “chord ball training” and “marbles in carton exercise”, intended to improve sports vision. With “chord ball training”, an athlete is

instructed to shift his/her gaze rapidly between different balls hanging from various strings. In the “marbles in carton exercise”, a cardboard box containing marbles with a black spot in the centre of the box is used. The athlete is requested to keep his/her eyes fixed on the black spot while the marbles move around in the cardboard box (Revien & Gabor, 1981). Pre-test and post-test scores were obtained before and after the completion of the eight-week visual and sports training programmes. The results showed a significant improvement in accommodative facility which is related to focusing. Accommodative facility is the term used to describe the ability of the eyes to **focus** on objects in different sequences and at various distances in a certain period of time (Pandian et al., 2006).

5.2.2 Tracking.

According to Table 4.14, significant differences occurred between week 1 and week 12 with regard to tracking. The results suggest that tracking could be improved as a result of receiving sports vision exercises.

These findings support the results obtained by Wimshurst, Sowden and Cardinale (2012). They conducted a study to determine whether the visual skills of Olympic hockey players improve after receiving sports vision training (Wimshurst et al., 2012). Twenty-one (21) players underwent a pre- and post-test on visual skills tasks (e.g. dynamic shape recognition, rotational acuity, saccadic eye movements, peripheral awareness, focus acuity, dynamic visual acuity). The intervention administered by Wimshurst et al. (2012) comprised six computer-based exercises which the participants completed three times a week, as well as four practical exercises which were practised once a week. This lasted for 11 weeks. Wimshurst et al. (2012) discovered that the visual skills related to tracking significantly improved from the pre-test to the post-test.

In another study, Balasaheb, Maman and Sandhu (2008) noted that tracking and depth perception significantly improved in cricket players who received visual training. The study was conducted on three groups of college cricket players who were assigned to either a control condition, a visual training condition or a cricket training condition. The study was conducted over six weeks. As was previously stated, the group that received visual training performed significantly better when compared to their pre-test results and the results of the control group (Balasaheb et al. 2008).

The results from the present study are consistent with the findings of Rezaee et al. (2012), whose research was discussed in 5.2.1. In addition to their findings related to focusing, Rezaee et al. (2012) noted a significant improvement in the eye movements involved in tracking.

As a result of the findings discussed in 5.2.1 and 5.2.2., the research hypothesis is partially accepted. It is thus suggested that visual skills training would lead to an improvement in an individual's focusing and tracking ability.

5.3 Results of the Correlation Analysis

The correlation matrix obtained revealed significant but weak inverse correlations between focusing and anxiety ($r = -.14007$, $n = 204$, $p = .044$), and tracking and anxiety ($r = -.15231$, $n = 204$, $p = .028$) (see Table 4.16). No significant relationships were obtained when curiosity was correlated with the visual skills previously discussed.

5.3.1 Focusing and anxiety.

As previously stated, a significant but weak inverse correlation was observed between focusing and anxiety ($r = -.14007$, $n = 204$, $p = .044$) (see Table 4.16). This result is consistent with the findings of a study conducted by Janelle et al. (1999). The aim of their research was to explore how shifts in attentional parameters might be influenced by changes in arousal (as induced through competition) and anxiety. This involved measuring drivers' ability to identify the onset of irrelevant and relevant cues in their peripheral visual field while experiencing arousal and anxiety. Drivers were exposed to an auto racing simulation. It was found that the response time required to identify relevant cues decreased when arousal and anxiety increased. A decrease in the ability to discriminate between irrelevant and relevant cues also occurred when the drivers' anxiety levels were increased (Janelle et al., 1999). Janelle et al. (1999) concluded that in high anxiety conditions, gaze behaviours became more eccentric. The result of this is increased fixations directed towards peripheral locations, and a decreased focusing ability. The researchers furthermore uncovered tendencies to be distracted by irrelevant peripheral cues, as a result of a narrowing of the attentional field. The result of a narrowing of the visual field is a greater need to direct foveal vision (sharp central vision) to peripheral cues in order to identify them. Therefore, fixations to the central

driving area were decreased when drivers looked at the peripheral cues. The narrowing of the attentional field brought about in conditions that made the drivers anxious may have heightened the likelihood of focusing on distracting or irrelevant cues (Janelle et al., 1999). The efficiency of visual search characteristics (especially search rate) and visual orientation (as measured by the quiet eye period) is reduced when people are anxious, probably as a result of attentional narrowing (Janelle et al., 1999). Attentional narrowing refers to a narrowing of the attentional field which occurs when an individual experiences higher anxiety. Consequently, during moderate levels of anxiety, performance on primary or central tasks takes place at the expense of a person's performance on peripheral or secondary tasks. However, deterioration of primary or central task performance will occur when an individual becomes highly anxious (Janelle, 2002).

In another study conducted by Murray and Janelle (2003), the researchers discovered that the efficiency of visual search characteristics and visual orientation is lowered when one is anxious. Visual search characteristics are required to enable one to focus on an object. Good visual search characteristics are a vital component of focusing, as they entail focusing visual attention on important cues, while limiting gaze tendencies towards irrelevant cues (Knudson & Kluka, 1997). Visual orientation is also central in everyday seeing and focusing (Palomares, Englund & Ahlers, 2011). It is an essential ability associated with object identification. This ability is necessary to successfully identify and focus on an object. Visual orientation represents an awareness of an object's position in an individual's environment, as well as of the relationship between the object and individual (Palomares et al., 2011).

5.3.2 Tracking and anxiety.

As was the case with focusing, tracking also showed a significant but weak inverse correlation with anxiety ($r = -.15231$, $n = 204$, $p = .028$) (see Table 4.16). This result concurs with the findings of Behan and Wilson (2008). One of the matters they investigated was whether the functional relationship between action and perception was disrupted as a result of increased anxiety. Participants ($n=20$) were monitored during performance on a simulated archery task while being exposed to various levels of anxiety. Behan and Wilson (2008) found that higher levels of anxiety resulted in decreases in the duration of the quiet eye period. The quiet eye refers to the tracking gaze that is directed to a single object or location in the visuomotor workspace (see 2.4.1.3). It is thus concluded that higher levels of anxiety would result in decreasing tracking ability.

Further confirmation for the results of the present study comes from the study conducted by Janelle (2002), in which anxiety was shown to decrease the efficiency of gaze behaviour in motor tasks which require visual detection and search, as well as tasks which require aiming. These findings have revealed that increases in anxiety result in less efficient gaze behaviour and visual search strategies (Janelle, 2002). In tasks which require the detection of peripherally presented targets, participants display higher search rates, which are depicted by increased foveal fixations. These foveal fixations to the target locations are of shorter duration when the participants are anxious compared to the duration under control conditions. These findings point to a reduction in efficiency, as a larger number of fixations are required to collect the same information that is obtained through fewer fixations in a condition of low anxiety (Janelle, 2002). It may be concluded from this that as anxiety increases, gaze behaviour becomes less efficient. Gaze behaviour involves a detection phase when tracking an object, and is one of the processes involved when an object is tracked in the visual field (Vickers & Adolphe, 1997). Thus we can conclude that increased anxiety results in less efficient gaze behaviour, which in turn results in decreased tracking ability.

As a result of the findings discussed in 5.3.1 and 5.3.2, the research hypothesis is partially accepted. It is thus suggested that there is a statistically significant relationship between anxiety and focusing and anxiety and tracking. Anxiety will thus impact on the learning of these particular visual skills among second-year physiology students at the tertiary institution.

5.3.3 Curiosity and the learning of visual skills.

The correlation analyses conducted revealed that there were no significant differences between any of the visual skills and curiosity. As a result, the researcher failed to reject the null hypothesis, which states that there is no relationship between curiosity and the learning of visual skills among second-year physiology students at the tertiary institution. At present there are no studies on this topic which have recorded similar findings. More research is needed on this matter.

5.4 Results from Stepwise Regression

The stepwise regression analysis that was performed indicated that anxiety is a significant predictor of tracking and vergence (see Table 4.18).

5.4.1 Tracking and anxiety.

According to Table 4.18 ($F = 5.89$, $p = 0.02$), anxiety is a statistically significant predictor of tracking, $p < .05$. This result confirms the findings of Wilson, Vine and Wood (2009). These researchers conducted a study to determine the influence that anxiety has on the accuracy and quiet eye period of basketball players performing free throws. In this study, 10 basketball players took free throws in two experimental conditions which were designed to influence the level of anxiety experienced. A mobile eye tracker was used to measure point of gaze, and fixations including the quiet eye were established using frame-by-frame analysis. It was found that the manipulation of anxiety caused significant decreases in the free throw success rate and the duration of the quiet eye period. The participants used a less effective and efficient attentional control strategy when anxious. These participants initiated an optimal quiet eye fixation, although they failed to maintain it (Wilson et al., 2009). The quiet eye is the **tracking** gaze directed to a single object, and is susceptible to increases in anxiety (Vickers, 1996). As anxiety increases, there is a decrease in the duration of the quiet eye period. The quiet eye period is essential for efficient visual search characteristics and visual orientation, and decreases in the quiet eye period result in a decrease in **tracking** ability (Wilson et al., 2009).

5.4.2 Vergence and anxiety.

Table 4.18 indicates that anxiety is a significant predictor of vergence ($F = 4.22$, $p = 0.04$). Anderson, Siegel and Barrett (2011) established that anxiety influences individuals' conscious experience during binocular rivalry. Binocular rivalry is realised when diverse stimuli are presented to each eye, causing perceptual switches between the two stimuli, regardless of unchanging retinal input. Both sets of stimuli compete for perceptual dominance. In binocular rivalry, perceptual dominance is influenced by stimulus salience, which includes low-level visual properties (such as colour, motion and contrast) (Alais & Blake, 2005). Binocular rivalry and vergence are related in that they are both elements of binocular vision. It is therefore concluded that because it has an impact on binocular rivalry, anxiety would impact on vergence as well.

In a similar study, Nagamine et al. (2007) explored the relationship between anxiety and the switching rate of binocular rivalry, to test the hypothesis that the switching rate varied among individuals according to the degree of anxiety. Switching rate in the dominance of binocular rivalry

was compared in 48 healthy volunteers with low and high general anxiety. Nagamine et al. (2007) found that the switching rate in binocular rivalry was faster for anxious subjects. We can conclude from this that increased anxiety results in an increased switching rate of binocular rivalry. If binocular vision is negatively affected by increasing anxiety, then vergence in turn is negatively influenced by an increase in anxiety. In addition, emotional state influences a person's conscious experience during binocular rivalry, and hence one can conclude that vergence is influenced in turn by emotional state. These results of the research conducted by Nagamine et al. (2007) confirm that binocular rivalry, and thus vergence, is impacted upon by levels of anxiety.

The above findings are further supported by the research of Anderson et al. (2013). These researchers compared the visual experiences of individuals with generalised social anxiety disorder (GSAD) with those of individuals who suffer from generalised anxiety disorder (GAD). A control group was also introduced into the study. Binocular rivalry was used to assess visual saliency in GSAD. GSAD is a social phobia in which anxiety centres on social situations. GAD on the other hand is a generalised worry and anxiety based disorder. There were 165 participants in this study who were presented with different images to each eye which competed for dominance. Results indicated that, when compared to participants with GAD and participants from the control group, smiling faces were more dominant for substantially shorter durations in participants suffering from GSAD. Anderson et al. (2013) noted that their findings are consistent with the broader view that a perceiver's emotional state directly effects visual saliency (Anderson et al., 2013). If visual saliency is affected, then binocular rivalry is also affected, which in turn influences vergence. As was demonstrated by the research conducted by Nagamine et al. (2007), binocular rivalry, and thus vergence, is impacted upon by levels of anxiety.

As a result of the findings discussed in 5.4.1 and 5.4.2, the research hypothesis is partially accepted. It is thus suggested that anxiety is a significant predictor of the ability to enhance vergence and tracking. One can therefore predict that anxiety will impair a student's ability to display vergence or track objects.

5.4.3 Curiosity.

No significant results were obtained when a stepwise regression was performed to determine whether curiosity is a significant predictor of visual skills. Because of this, the researcher failed to reject the null hypothesis which states that curiosity is not a significant predictor of the

learning of visual skills among second-year physiology students at the tertiary institution. Little is known as yet about this relationship and further research is needed on the matter.

5.5 Limitations of the Research

The first limitation of the study has to do with the sample. The sample used in the present study was not representative of the broader population of the tertiary institution. The sample was furthermore dominated by white females. Only one tertiary institution was used. As a result of this, the research findings should be interpreted with caution and cannot be generalised to the broader population of the tertiary institution.

The second limitation relates to the scope of the present study. This limited the investigation of the effects of sports vision exercises on visual skills to a relatively short period of time. The administration of the STPI and visual skills tests only took place at one time of the day. This helped to avoid respondent fatigue, however, as well as to include a broader range of results and provide a more accurate reflection of the tests administered.

The third limitation has to do with the use of a quasi-experimental design. The possibility that there may be alternative explanations for the results must be taken into consideration even though measurements were taken under standardised conditions. The nature of quasi-experiments is that this design cannot establish causality with certainty (Whitley, 2002). In addition, the lack of a control group made it difficult to establish a baseline in order to assess the effects of the treatment (Whitley, 2002).

5.6 Recommendations for Future Research

To address the first limitation, a sample from a different population, other than students, could be used to expand upon these results. The present study was an exploratory study. Future studies of this nature should use a more representative sample of the South African population, which would include a proportional distribution across age, race, gender and educational background, among others.

Regarding the second limitation, the scope of future studies of this nature could be broadened to incorporate a longer timeline into the testing period, in order to judge whether there are any lasting effects of the sports vision exercises.

With reference to the third limitation, a more stringent experimental design could be used to collect the data. This would ensure that causality can be established with certainty. The addition of a control group for future studies could also help to establish a baseline in order to assess the effects of the treatment (Whitley, 2002).

The scope of the present study is valuable in building interdisciplinary research alliances, and promotes knowledge sharing between the disciplines of Psychology and Physiology. Future studies of this nature should aim for an inter-disciplinary approach, meaning that different disciplines should collaborate in doing the research. The disciplines of Psychology and Physiology each has a unique contribution to make, and each discipline offers a different point of departure, and a different angle from which to approach the research problem. By combining both of these disciplines with their accompanying areas of expertise, a more robust solution can be provided to the research questions posed.

More research on the effects of anxiety and curiosity on the learning of visual skills is needed. Little is known about the relationship between anxiety, curiosity and the learning of visual skills, and further research in this area will contribute greatly to the existing knowledge base. The knowledge gap is particularly evident with regard to curiosity and the effect this may have on the learning of visual skills.

5.7 Conclusion on the Study

In summary, sports vision exercises can improve some visual skills. It should, however, be noted that anxiety levels must be controlled for when administering this training. The findings of the present study suggest that anxiety, to some extent, influences the learning of focusing, tracking and vergence. Curiosity on the other hand does not influence the learning of any of the visual skills under investigation in the present study.

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Appendix A: Participant Information Form

PARTICIPANT INFORMATION FORM

Investigator

Dr PJ du Toit

Department of Physiology

University of Pretoria

Tel: (012) 420 2536

Email: peet.dutoit@up.ac.za

TITLE

Determining lifestyle, heart health, body composition, fitness, anxiety and curiosity levels and visual skill index of students (between the ages of 18-22) from a traditional tertiary institution focusing on lectures over a period of 12 weeks.

INTRODUCTION

You are invited to volunteer for a research study. This information leaflet will help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved.

WHAT IS THE PURPOSE OF THIS STUDY

The aim of the study is to determine lifestyle, heart health, body composition, fitness and visual skill index of students (between the ages of 18-22) from a traditional tertiary institution focusing on lectures over a period of 12 weeks.

WHAT IS THE DURATION OF THIS STUDY

If you decide to take part you will be one of 204 participating students. The testing will last 12 weeks, where your body composition, fitness levels, heart health, anxiety and curiosity levels and visual skills will be tested on week 1 and week 12.

EXPLANATION OF PROCEDURES TO BE FOLLOWED

This study involves completing several tests including the following:

- Completing questionnaires
- Completing heart health, body composition, fitness and visual skill tests

It is important that you let the investigator know of any medicines (either prescriptions or over-the-counter medicines), alcohol or other substances that you are currently taking.

HAS THE STUDY RECEIVED ETHICAL APPROVAL

This research study protocol will be submitted to the faculty of Health Science research Ethics Committee, University of Pretoria. If it is detected that you did not give an accurate history you may be withdrawn from the study at any time.

MAY ANY OF THESE STUDY PROCEDURES RESULT IN DISCOMFORT OR INVOLVE ANY SORT OF RISKS

The only discomfort may be the fitness tests. No blood will be drawn.

CONFIDENTIALITY

All information obtained during the course of this study is strictly confidential. Data that may be reported will not include any information which identifies you as a participant. Any information uncovered regarding your test result or state of health as a result of your participation in this research study will be held in strict confidence. You will be informed of any finding of importance to your health or continued participation in this study, but this information will not be disclosed to any third party in addition to the ones mentioned above without your written permission.

Appendix B: Consent Form

INFORMED CONSENT

I hereby confirm that I have been informed by the investigator, Dr PJ du Toit about the nature, conduct, benefits and risks of the research study. I have also received, read and understood the above written information (Participant Information Leaflet and Informed Consent) regarding the research study.

I am aware that the results of this study, including personal details regarding my sex, age, date of birth, initials, health and performance will be anonymously processed into a study report.

I may, at any stage, without prejudice, withdraw my consent and participation in the study. I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in this study.

Participant's name

.....

(Please print)

Participant's signature.....

Date.....

I, PJ du Toit herewith confirm that the above participant has been informed fully about the nature, conduct and risks of the above study.

Investigator's name: Dr PJ du Toit

Investigator's signature.....

Date.....

Witness' name.....

Witness' signature.....Date.....