THE EFFECT OF A FOUR-WEEK, WEB-BASED VISUAL SKILLS TRAINING PROGRAM ON ATTENTION, TIMING AND EYE-HAND COORDINATION IN 13 To 15-YEAR-OLD ADOLESCENTS

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Keywords

Visual skills training; Eye-hand coordination; Motor skills development; Attention; Concentration; Academic performance; Reaction.

DECLARATION

I declare that the effect of a four-week, web-based visual skills programme on attention, timing and eye-hand coordination in 13 to 15- year-old adolescents, is my own work, that it has not been submitted before for any degree of examination in any other university and that all sources I have used or quoted have been indicated and acknowledged as complete references.

Anélma Janse van Rensburg

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Signature:_______________________

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ABSTRACT

There is a rising concern that more and more children struggle to pay attention and to concentrate in school. The ability to concentrate on a task, switching attention between different tasks and inhibiting impulsive responses is very important in developing cognitive control. This lack of attention can negatively influence school performance, motor skills development, the acquisition of sport skills and eventually sport performance. Visual skills are needed for daily activities such as reading and writing and this assists in the ability to attend to these tasks. This study aims to determine whether a web-based, computerized visual skills training program has an influence on cognitive skills such as continuous attention, timing, as well as proactive and reactive eye-hand coordination skills. Forty-two adolescents (aged 13 – 15 years) participated in this study. The adolescents were divided into an experimental group ($n = 23$) and a controlled group ($n = 19$). Pre- and post-cognitive sustained attention and timing tests, as well as eye-hand including proactive and reactive coordination tests were conducted. The intervention program, Eyegym®, was implemented in the school three times a week, over a four-week period which included 10 to 15 minutes per day. In both groups, there was no significant improvement in sustained attention or timing ($p > 0.05$). The intervention had a positive effect on proactive hand-eye coordination. Although neither the experimental group, nor the controlled group showed a significant increase in scores in the post- intervention period ($p = 0.11$ and $p = 0.12$ respectively), post-hoc analysis suggests that should the intervention have continued, both groups would most likely have presented a significant change. The experimental group continued to improve even after the intervention was discontinued ($p = 0.01$). When the results from the experiemental group were

pooled with the results from the controlled group, which thereby increased the sample size (n = 42), the difference from pre- to post-intervention was significant with p = 0.01. The intervention also had a positive effect on reactive hand-eye coordination in both groups. Both the experimental group and the controlled group showed a significant increase percentage-wise after the intervention period (p = 0.02 and p = 0.01 respectively). The experimental group showed further improvement in the reactive hand-eye coordination test after the intervention was discontinued (p = 0.05). As a group, they also displayed a significant improvement in this variable ($p < 0.01$).

Based on the above mentioned results, it indicates that a four-week, web-based computerised visual skills training program does have a positive effect on certain hand-eye coordination skills, such as the proactive and reactive eye-hand coordination skills, but it has no influence on cognitive attention and timing skills.

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CHAPTER ONE

1.1 INTRODUCTION

The ability to concentrate on a task, switching attention between tasks and preventing impulsive responses, is very important in developing cognitive control (Steele, Scerif, Cornish & Karmiloff-Smith, 2013; Weinberg & Gould, 2011). These skills typically improve as children get older and as their ability to concentrate and focus on tasks improve, so does their cognitive functioning (Carriere, Cheyne, Solman & Smilek, 2010). Improved cognitive functioning leads to a better performance in both academic and motor/sport skills development overall (Steele, Scerif, Cornish & Karmiloff-Smith, 2013). There is however, a rising concern that more and more children struggle to pay attention and to concentrate in school. In South Africa, the prevalence of disorders associated with concentration and attention, such as Attention Deficit (ADD); Attention Deficit and Hyperactivity (ADHD) and Developmental Coordination Disorder (DCD), are on the increase (Walker, Venter & Van der Walt, 2011). Studies have shown that these children struggle at school both academically and in sport or physical activity (Daley & Birchwood, 2010).

Processing information is essential for optimal motor and/or academic performance and to process information, one needs to have a good attention span (Forster & Lavie, 2016). The attention process consists of many parts which includes reaction time (the time needed to react or detect when a stimulus appears); immediate attention span (the amount of information that can be taken in at a given time); selective attention (the ability to focus on relevant stimuli, excluding irrelevant distractors); divided attention (the ability to respond to more than one task at a time); sustained attention (the ability to maintain attention over time) and alternating attention (the capacity to shift focus on tasks) (Commodari, 2012). Sustained *attentional focus* is essential for the development of reading, writing, spelling and mathematical skills (Green & Bavelier, 2012). Lack of attention can negatively influence school performance and has been shown to increase the risk of learning disabilities (Commodari, 2012). A deficit in attention is especially associated with reading and mathematical underachievement (Merrell, 2001). The acquisition of complex motor skills can also be negatively affected when *attention* is lacking, which may eventually impair sport participation and performance as well (Green & Bavelier, 2012).

The visual system plays a critical role in all perceptual-motor skills (Gentile, 1997). Forrester et al. (2008) explains how vision can be divided into two processes. The first physiological process involves the actual light entering the eye and the second neural process involves how the brain creates an image through this light. Light enters the eyes and goes through a refraction correction process to focus an image on the retina. The second neural process is where the brain makes sense of the visual stimuli that enters through the eye (Forrester et al., 2008), the visual input is transmitted, processed and interpreted by the visual cortex (Lombard, 2007). This elicits the appropriate efferent responses in order to ensure motor performance is maintained and/or improved. As seen in the muscular system, eye fitness is crucial to ensure sustained attention, concentration and the ability to prolong task performance (Green and Bavelier, 2012).

To improve *concentration* attentional skills such as sustained attention, divided attention, selective attention, immediate attention and the shifting of attention, they need to be practiced (Commodari, 2012). It has been shown that with repeated practice within a specific cognitive domain (where attention is one of those domains) cognitive competence can improve (Kirk, Gray, Riby & Cornish, 2015). In their study, Green and Bavelier (2012) proposed that improving eye control is one method to improve attentional focus and therefore concentration. Extensive research has been done where the aid of a sports vision training programme or visual skills training, showed improvement in certain visual abilities (Wimshurst, Sowden & Cardinale 2012; Schwab & Memmert, 2012; Calder, 2005, Calder & Kluka, 2009).

Skilled movement is not a spontaneous muscular response, but a sequence of complicated processes within the central nervous system (Griffiths, 2015). According to the authors, training the visual system, which includes training the muscles of the eye for movement and eye-hand reflexes, can enhance sports performance. Visual skills training, including computerised visual skills training programs, have already shown to improve concentration, attention and sporting skills in young adults and it is postulated that it may play a significant role in expert motor skill learning (Beilock et al., 2002; Wulf, 2013; Wulf, Shea & Lewthwaite, 2010). Kerns et al. (2010) proposed that improved attention resulting from participating in computerized visual training programs, may lead to improved academic performance in children. Van der Molen et al. (2010) also postulated that improved cognitive functions such as working memory following participation in a computerized eye training program, may improve academic performance.

1.2 STATEMENT OF THE PROBLEM

The prevalence of attention disorders in children, which continues into adolescence, is increasing. Development and/or investigation into existing interventions to improve attention and more specifically sustained attention, is needed. There is some evidence that visual skills training can enhance concentration and attention, which may influence academic and sport achievements at school. Given that Generation Z (Biber, Czech, Harris & Melton, 2013) prefer electronic games over playing outdoors and participating in physical activity, it is hypothesised that a web-based, visual training programme, such as EyeGym® can improve cognitive skills, for example sustained attention. It is also hypothesised that improved sustained attention following participation in a web-based, visual training programme, will result in improvement in selected sport skills, such as eye-hand coordination, reaction speed and visual tracking, which may eventually enhance sport performance.

1.3 AIM

The purpose of this study was to determine the effect of a four-week, web-based visual skills training program on proactive and reactive eye-hand coordination skills, sustained attention and timing or response of 13 to 15-year-old adolescents.

1.4 OBJECTIVES

The specific objectives of this study are to investigate the effect of a web-based, visual skills training programme on:

1. Sustained attention of 13 to 15- year-old adolescents.
2. Timing or response of tasks of 13 to 15 -year-old adolescents.

3. Proactive and reactive eye-hand coordination skills of 13 to 15 -year-old adolescents.

1.5 Hypothesis

H_0 A four-week, web-based visual skills training program has no effect on 13 to 15 -year-old adolescents on pro-active and reactive eye-hand coordination skills as well as sustained attention and timing or response skills.

H_1 A four-week, web-based visual skills training program has a significant effect on sustained attention in 13 to 15 -year-old adolescents.

H_2 A four-week, web-based visual skills training program has a significant effect on timing in 13 to 15 -year-old adolescents.

H_3 A four-week, web-based visual skills training program has a significant effect on proactive and reactive eye-hand coordination skills in 13 to 15-year-old adolescents.

1.6 Significance of study

In today's world, there is a lot of pressure on adolescents to improve and constantly achieve better results on the sports field and at school. Methods to enhance sporting and cognitive skills have therefore become a huge focus. The improvement in visual skills leads to the improvement in hand-eye coordination and more specifically proactive and reactive eye-hand coordination, and this can be done through a web-based computerised training program (Calder, 2005; Calder & Kluka, 2009). The area of scope can further be broadened by investigating, over a longer period of time how visual skills (by means of a web-based training program) can possibly enhance sustained attention, which might lead to the improvement in scholastic performance.

1.7 LIMITATIONS

The study is limited to adolescents attending a public mainstream school, which has adequate resources to support a web-based intervention programme.

1.8 DEFINITION OF TERMS

Visual skills training: Visual skills training is specific eye exercises that are conducted over a period of time. It eventually influences the reconstruction of the cortex and the brainstem pathways, which leads to an increase in the efficiency of performing visual perceptual tasks, which may further enhance visual motor skills (Elmur, 2015).

Attention: Attention is the ability to focus, to sustain focus, to avoid distractors and impulsive errors (Furley & Memmert, 2012) and becomes a habit over time, which can be improved through training (Dogru, 2014).

Motor development: The continuous process through which a child acquires skills and movement is called motor learning and development (Malina, Robert, & Bouchard, 1991).

Motor learning: is "the process of acquiring a skill by which the learner, through practice and assimilation, refines and makes automatic the desired movement." (thefreedictionary.com, 2016)

Hand-eye coordination: Is the coordinated control of eye movements with hand movement, and the processing of visual input to guide reaching and grasping along with the use of proprioception of the hands (Liesker, Brenner & Smeets, 2009).

Proactive hand-eye coordination skill: This skill mimics a closed motor skill environment, where the self-paced movement is initiated based on visual information regarding a target (Elmur, 2010).

Reactive hand-eye coordination skill: This skill mimics an open motor skill environment, where the reaction only takes place after a stimulus is presented; therefore this movement is externally paced (Elmur, 2010).

1.9 LIST OF ABBREVIATIONS

ADHD: Attention-deficit hyperactivity disorder

CG: Controlled Group

CPT: Continuous Performance Test

EG: Experimental Group

EF: Executive Functioning

SVT: Sports Vision Trainer

WM: Working Memory

CHAPTER TWO

REVIEW OF RELATED LITERATURE

"It's not what you look at that matters, it's what you see." — **Alphonso Dunn**

2.1 THE PROCESS OF SENSATION – HOW THE EYE WORKS

To fully comprehend visual processing, there needs to be an elaboration on vision, which entails the eye. The Eye, a book by Forrester et al. (2008) explains how vision can be divided into two processes. The first physiological process involves the actual light entering the eye and the second neural process entails how the brain creates an image through this light. Before considering training or stimulating the eye for more effective functioning, there needs to be a better understanding of how the eye actually works. Vision is the ability to see or to conceive something. Qualities such as colour, shape, size and the luminosity of an object enters the eye (cornea) through light rays. The cornea bends the light rays (refraction) and it passes through the pupil of the eye. The coloured section of the eye surrounding the pupil, the iris, opens and closes, which makes the pupil larger or smaller, regulating the amount of light rays that passes through the eye. The light rays pass through the lens, which further bends the rays so that they can focus on the retina, situated at the back of the eye. The retina contains millions of light-sensing nerve cells, called cones and rods, which are photoreceptors. In the centre of the retina, the macula, there is a concentration of cones and when the light is bright, the cones provide sharp and clear central vision and detect colour and other finer details. On the outside of the macula there are rods, which extend all the way to the outer edge of the retina.

The rods provide peripheral vision, detect motion and help with night vision or when the light is dim. Rods and cones convert light into electrical signals, which then enter the brain via the optic nerve. The visual field is the part of the environment that the retina registers (Forrester et al., 2008). This is a physiological process, which involves the actual light entering the eye and then goes through a refraction correction process to focus an image on the retina.

The second process is the neural process of the brain which takes place because of the visual stimuli via the retina (Forrester et al., 2008). The moving parts of the eye, as well as prior experience, influences basic visual skills. Visual skills are dynamic in nature and develop over time. Muscle tonus imbalances from the central nervous system and the homeostatic fluctuations of the autonomic nervous system can affect motor visual skills (Gentile, 1997).

2.2 The visual sensory organ – How vision is used

Lombard (2007) stated that humans observe and access the environment through their senses and the brain receives substantial sensory information. It works hard to filter, organize and translate information so that attention can focus on the things that are important. Lombard (2007) further stated that the visual system is the most advanced sense of all the senses, and is part of the nervous system, which allows one to see and to communicate with the brain, which then interprets information from visible light to reconstruct a picture or representation of the world that man lives in. This assists humans to operate and function. When there are deficits in visual processing and learning, the interpretation of information might be compromised (Lombard, 2007). Lombard (2007) further elaborated on how the eyes play an intricate role in gathering information and learning and how the brain processes visual sensory input from the environment. Each individual process interprets information differently because of the uniqueness of the brain. According to Gentile (1997), vision plays a critical role in survival, learning, recognizing, memory and recall, adapting to our environment, anticipation and orientation and movement in space. This is especially seen in the attentive functions such as being awake, alert and attending to what is important to learn. To communicate, to interact and constantly adapting to our environment is influenced by vision as well (Gentile, 1997).

2.3 VISUAL PERCEPTION – TO MAKE SENSE

According to Forrester et al. (2008) and Gentile (1997), visual perception or processing, is the ability of the brain or cortex to interpret sensory information from the environment that is passing through the eyes, and then to make sense of it. This process takes place between the cortex and retina. There are two types of visual processing theories; bottom-up and top-down processing. The bottom-up theory is data or stimulus driven, which means that perception begins with the actual stimulus itself, processing takes place in one direction from the retina to the visual cortex, therefore it proceeds to a higher cognitive process. For example, a stimulus-driven or bottom-up experience could be a sudden round-figured object moving towards an observer that commands visual attention. This is followed by an image recognition process; it recognizes the image as a ball. The top-down theory, which is goal-driven, states that information gets processed and absorbed, a perception is then created due to past experiences. The memory recognition of the ball is already in the mind, the possibilities of how to avoid the oncoming object have been considered and an action plan has been initiated, which includes movements of the eye and the body (Forrester et al., 2008). Visual perception is not just what one sees, but also our internal reference or experience (Lombard, 2007). Being aware of all information inherent to a task or situation or all the components of a task or situation will influence perceptual processing. Adults and children experience a multitude of problems when the ability to process incoming information does not work well as it should (Lombard, 2007). The most common problems in children are difficulties in literacy and numeracy, behavioural problems, social issues, language difficulties, coordination and motor problems. The visual system is dynamic and can be trained by using certain techniques and exercises, so that it can respond faster to stimuli (Du Toit, Kruger, Joubert & Lunsky, 2007).

2.4 VISUAL COMPONENTS – HOW VISUAL SKILLS ARE USED

It makes sense that certain visual skills should be trained, in order to enhance their functions. According to the books of Forrester et al. (2008) and Gentile (1997) *the vision field* is the total area where an individual detects movements and light and this includes the central field of sight as well as top, bottom, right and left fields. Good visual skills include the ability to interact with sensory stimuli in the periphery of this visual field, while keeping the fixation central. Most visual skills take place in this field of vision. *Fixation* or the gaze control of the eyes is the ability of both eyes to work together and to aim and rapidly shift from one object to another. This involves cognitive functioning, where certain information is deemed more important for the execution of a task (Land & Tatler, 2009). *Saccadic* movement is the ability of the eyes to change the fixation point to another point. This is especially used during reading. The ability of the eyes to fixate on a moving object is called *tracking or pursuit.* This involves movements from left to right, up and down, diagonally and in rotation (Land & Tatler, 2009). The change in the eye's focal distance takes place via the intraocular muscle of the eye, which causes an alteration of the eye's lens, the term that is used here is *accommodation.* This assists the eye to focus from far to near and vice versa. *Binocular vision* is the ability of each eye to combine the information both eyes receive via the visual pathway to achieve one single mental picture. *Convergence* is the dynamic process where the eyes turn inwards as an object moves towards the observer. The skills of determining the depth of an object within an individual's visual space is called *Stereopsis. Form perception* is one's ability to recognize and organize sensations of vision produced by different patterns of shapes, contours and lines (Gentile, 1997; Forrester et al., 2008). Everybody has their own individualized visual skills which develop as we adapt physically and cognitively to our environment. The performance of a specific task entails a basic movement or movements, which is called a movement pattern. A motor skill emphasizes how accurate, precise and how economic the performance will be. Fundamental motor skills are refined through practice and learning and therefore over time, the quality and quantity of performance improves and eventually basic movement patterns are integrated into more complex motor skills, which is necessary for sport and sport performance (Malina & Bouchard, 1991). Motor learning takes place through physical practice and is affected by age, maturation, time spend on practice and a few other factors. Well-developed motor skills are not the only pre-requisite in determining sport performance. The enhancement of performance takes place over time and includes visual training (Griffiths, 2015). Attention plays a significant role in expert motor skill learning (Wulf, 2013; Beilock et al., 2002; Wulf, 2007).

Sport vision forms part of several integrated networks of different systems; this includes the visual system, the brain, the central and somatic nervous systems and the skeletal muscle system. All of the systems work together to maintain hand-eye coordination, peripheral awareness, depth perception, visual anticipation, working memory and visual concentration (Du Toit et al., 2006). Sport vision and sport performance will be influenced if any of these systems do not operate properly (Du Toit et al., 2006). A fast and effective response by the visual motor system of a player to visual cues in skilled performance is one of the factors that influences sport performance (Calder, 2005; Calder, 2014). Enhancing eye-hand coordination is just one of many sport skills that was focused on during this research on visual skills training. Eye-hand coordination is a very important aspect of sport performance, because most of the time decisions and reactions must be made very quickly based on a huge range of visual stimuli. Sustained attention should be paid to environmental stimuli in order to make the correct decisions. When fatigue sets in, reactions slow down and errors occur. Therefore, training attention might slow down fatigue and improving eye control and movements may influence this process. The next section will delve further into how concentration and attention is maintained.

2.5 Concentration and attention

Concentration is the ability to maintain focus and attention on relevant environmental cues. When the environment changes rapidly, attentional focus must change rapidly as well (Weinberg & Gould, 2011). Maintaining attentional focus for a certain duration, is part of concentration. Concentration has several parts: (a) Selective attention, which is the focusing on relevant environmental cues, (b) Sustained attention, the ability to maintain attentional focus over time (Dye & Bavelier, 2004; Commodari, 2012), (c) Situational awareness, the ability to understand what is going on in the environment and (d) Divided attention, to be able to respond to multiple different tasks at a given time (Commodari, 2012). Attention is the ability to focus, to sustain focus, to avoid distractors and impulsive errors (Furley & Memmert, 2012) and becomes a habit over time, which can be improved through training (Dogru, 2014). Attention requires the executing of simple cognitive operations and involves a conscious effort by an individual (Lewin, 2014; Raffone, Tagini & Srinivasan, 2010). The key to all information processing is attention (Forster & Lavie, 2016), but it is limited as individuals can only pay attention to one cognitive task at a time. Over time, one develops procedures to accomplish a variety of skilled and complex tasks (Gentile, 1997). Visual attention is the ability to use visual information and to make sense of it (Forrester et al., 2008).

2.6 VISUAL ATTENTION – HOW ATTENTION IS MAINTAINED

Proper attentional focus is important in achieving high levels of performance (Daley & Birchwood, 2010). There are several factors that influence concentration and attention. Here we need to distinguish between internal and external distractors. Internal distractors are any factors that can interfere with basic cognitive functions, or that disrupt concentration, for example thoughts, worries and concerns. Emotion is the one key factor that can influence attention and eventually performance (Vast, Young & Thomas, 2010; McCarthy, Allen & Jones, 2013). Negative emotions such as anxiety (McCarthy, Allen & Jones, 2013; Vast, Young & Thomas, 2010), unhappiness and anger consume attention and therefore negatively correlates with concentration. Positive emotions such as excitement and contentment have a positive influence on concentration and automaticity of movement, which leads to better performance (Vast, Young & Thomas, 2010). Students experience poor achievement performance if they are distracted by anxious thoughts, which also interfere with their ability to pay attention (Grills-Taquechel et al., 2013). Other key factors that influence focused attention are visual and auditory distractors in the environment, which are external distractors. The enhancement of concentration can only take place when attention improves and therefore by improving eye control or movement, attention will be promoted (Weinberg & Gould, 2011). Dogru (2014) stated that attention training programs aim to develop visual perception and has an important place in learning with children. Another method to increase attention is mindfulness; this is where there is a conscious decision made to concentrate or to pay attention. (Lewin, 2014; Raffone, Tagini & Srinivasan, 2010). Attention or focused awareness is a set of neural functions that emphasizes perception through selected sensory information (Kohonen, 2002). A lack of attention or inattention has a direct correlation in the inhibition of response time. Inconsistent response time can be used as a marker for inattention (Adams, Roberts, Milich & Fillmore, 2011). This research focuses on training visual skills for four weeks to increase certain response or reaction time and it is postulated to have an influence on sustained attention. Sustained attention fulfils a huge roll in learning to memorize and keeping information for later use. Working memory influences academic achievement.

2.7 VISUAL WORKING MEMORY – HOW TO REMEMBER WHAT WAS SEEN

Memory can be defined as the storage of experiences and information, to retrieve later. Working memory is the ability to store and process information for a short period of time (Alloway, Banner & Smith, 2010). Working memory (WM) is the process by which individuals maintain information that is no longer present in the immediate environment, but is needed for future behaviours and their adaptations (Ikkai & Curtis, 2011). WM is not only memory itself, but also the cognitive processing of information and the executive control skills that manage this information (Cowan et al., 2010). Alloway et al (2010) have found that working memory is a predictor in the outcomes of English, Science and Maths. It was stated that students with a low working memory had a correlation with lower scores in their academic subjects. Working memory and attention increases with age. Attention processes in younger children is as efficient as in older children and young adults, however younger children have a smaller working memory capacity. When the work load increases, it compromises the efficiency in younger children (Cowan et al., 2010). Commodari (2012) found that children struggling with attention have an increased risk of developing learning difficulties in school. The behaviour of inattention was found to be the most important factor associated with underachievement in reading and mathematics (Merrell, 2001). It was stated through some research that early intervention of childhood inattention may slow down dysfunction at school in late childhood and adolescents (Wu & Gau, 2013). Titz and Karbach's (2014) review confirmed that working memory and executive functioning training (attention is one executive function), plays a huge role in academic achievement. Englund et al. (2014) also confirmed with their studies that cognitive impairments in working memory in children with ADHD and autism and typically developing children are different. The controlled attention of the working memory capacity has a direct relation in staying attentive and avoiding distractors and impulsive errors (Furley & Memmert, 2012). Therefore, training attention is important for learning and academic performance and should be promoted.

2.8 LEARNING AND ACADEMIC PERFORMANCE

Academic performance, professional functioning and social competence are influenced by deficits in sustained attention (Merrell, 2001). A fundamental skill for learning is the ability to control and prioritize an individual's attention. Attention plays a significant role in selectively attending to important stimuli and ignoring the irrelevant ones (Kannass, Oakes & Shaddy, 2006). Learning is only possible if there is a state of attention (Lewin, 2014). The executive function of attention is also influenced by postural control. Postural control requires attentional resources. Younger children struggle with postural control if given a cognitive task; they also struggle with a cognitive task when performing a motor task. As children get older, they improve in both these tasks. It is therefore important to create a conducive environment for children to learn and pay attention (Reilly et al., 2008). One of the key questions that arises is; "How do we learn attention?" Some research has indicated that play and timing; especially predictive timing, assists in learning attention. Predictive timing is a cognitive process which includes selective attention and predicts when sensory information arrives, in essence, what do we do, when (Hedges et al., 2013). Goldstand, Koslowe and Parush (2005) stated in their research that there are differences in the visual functions between children with and without mild academic problems as well as their visual-perception scores. Kulp (1999) concluded that academic performance is directly related to the performance of visual analysis and visual motor integration tasks. Her research indicated that writing and maths performance has a significant relationship with visual analysis/visual fine motor/visual integration skills. Posner, Rothbart & Tang (2015) also confirmed that attention can be trained and improved through network training. Several studies indicate that visual attention may be improved by computerized games and programmes (Belchior et al., 2013; Dye & Bavelier, 2004). Therefore, further exploration should be done on how to train attention with existing web-based computerised programs, to slow down cognitive exhaustion and to enhance the ability for sustained attention.

2.9 TRAINING ATTENTION – TO KEEP FOCUSING AND ATTENDING

There are several ways to train attention and concentration. Lewin (2014) has a philosophical approach to training attention. He distinguishes attention from concentration, mental focus and mindfulness. He states attention is capable of voluntary control and involuntary wandering and believes that training attention through mindfulness techniques will improve focus and concentration. McCarthy, Allen and Jones (2013) suggested interventions that targeted cognitive focus disruptions (inattention is one of them) and interferences should focus on reducing emotions such as anxiety and unhappiness. Vast, Young & Thomas (2010) also confirmed with their research that emotions in sport, such as negative emotions, have a huge impact on attention and sport performance. Anxiety and inattention was also proved to be predictors in poor scholastic achievements such as in maths and reading (Grills-Taquechel et al., 2013). The question arises then how to address all these aspects so as to improve and train attention. Certain computerized training showed improvement in attention and working memory, which may lead to an improvement in the academic environment (Kerns et al., 2010; Van der Molen et al., 2010). Research on some attention training programs proved an increase in attention and visual perception. These programs were suggested as a supportive medium for children with learning and attention deficits (Dogru, 2014). Training attention networks through computer exercises or video games may improve aspects of attention (Posner, Rothbart & Tang, 2015; Tang & Posner, 2009). Achtman, Green & Bavelier (2008) researched the effect of video games on different visual skills and attention. It was found that playing action video games improves dynamic attention, visual spatial attention and attentional tracking. Dynamic attention is the ability to process or track dynamic information and stimuli over time and space, and improved dynamic attention leads to faster reactions. Enhancing visual spatial attention (the efficiency which attention is distributed across the visual field) will increase the attention to search visually. Improvement on attentional tracking by playing video games enhances the ability to track several objects at once.

Research done by (Land, Tenenbaum, Ward & Marquardt, 2013) on golf putting, has found that participants that were not given attentional focus instructions, used internal focus to execute the movement. It was also found that individuals that were given an external focus outperformed the control group without external focus. However, the group that received attention instructions' performance did not significantly decline when their vision was removed. Therefore, skilled performers may not require visual information once the movement has been prepared and planned. It was concluded that external focus effects are independent of online visual information and that it is largely mediated cognitively. Perkins-Ceccato, Passmore & Lee (2003), confirmed with their research on golfers, that low skilled golfers improved their performance more through the internal focus of attention instruction, rather than under external focus of attention instruction. Highly skilled golfers improved their performance through external focus of attention instructions rather than internal focus of attention instruction. They also explain the findings of their research, once the fundamentals of the swing or motor skill has been learned well, the performance will be enhanced based on where to hit the ball (external focus) rather than how to hit the ball (internal focus).

The important variable in question for this research is sustained attention. Training the visual skills regularly might slow down fatigue of the visual system, which effectively delays the process of losing attention. Finding a creative visual training programme, stimulating visual skills to become fit and more alert might eventually have a positive influence on sustained attention.

2.10 VISUAL INTERVENTION PROGRAMMES – HOW TO DEVELOP VISUAL SKILLS

The integration between the visual system and the musculoskeletal system is important so as to function effectively as humans in the environment; this is known as visual-motor integration. Successful, rapid and appropriate motor movements (which include eye-hand movements) are determined by how efficiently visual information is processed (Liesker, Brenner & Smeets, 2009). This visual processing involves the integration of the visual system, central nervous system and the skeletal-muscular system (Silverthorn, 2007). Training the different visual components leads to better visual-motor integration and positively influences motor skills. Extensive research has been done on how sports vision training programs or visual skills training can help visual abilities and has shown improvement in certain visual abilities in adults (Schwab & Memmert, 2012; Wimshurst, Sowden & Cardinale, 2012; Calder 2005; Campher, 2008). Calder (2005) and Calder and Kluka (2009) showed that participation in a visual awareness and skills program of four weeks, of one hour per week, significantly improved the visual skills in elite female field hockey players. Another study, over ten weeks, on 21 Olympic Field Hockey players conducting a visual skills training programme, positively influenced the visual skills of these players (Wimshurst, Sowden & Cardinale, 2012). This statement was further supported by Campher's (2008) research on the visual skills training of cricket players over eight weeks of one hour per week, results showed improvement in half of the vision skills, especially in eye-hand coordination. This was further confirmed by Maman et al. (2011) a vision intervention program of eight-weeks, increased visual skills, specifically eye-hand coordination. Du Toit et al. (2007) also proved with their research on 20 female rugby players, that there was an increase in reactive and proactive skills, by using the Accuvision test battery. Schwab and Memmert (2012) conducted a six-week visual skills intervention program for 20 minutes, three times per week, on young hockey players and showed that specific choice reaction time (similarly to proactive and reactive coordination in this study) improved significantly. Another study that utilised a frequency of tests three times a week, that yielded a similar effect, was done by Balasaheb, Maman and Sandhu (2008) who executed computerised visual skills training on 30 club-level male cricketers (16 to 25-year-olds). Their sample however was exposed to a duration of six weeks, and positively influenced eye-hand coordination skills. According to Calder (2005) and Kruger, Campher and Smit (2009) visual skills related to physical skills that affect sports and academic performance, can be developed and teach children how to absorb, perceive and process information and improve their visual perception enabling them to make better decisions. Visual skills training not only improves the visual abilities of athletes, but also has a positive result in the non-athlete population. Du Toit et al. (2011) conducted visual skills training on 129 physiology university students, results displayed a positive influence in some visual skills (eye-hand coordination was one of them), but not in all. Research by Wilson (2011) stated that the improvements from the visual skills training exercises in eye movement skills, focusing skills, peripheral visual awareness, and visual perceptual skills will carry over to the field of play. Mashige (2014) further concluded that visual functions contribute to success and that poor visual performance could be a barrier to higher achievement. Vision in sport provides individuals with information regarding when, where and what to do. Visual training programs, varying from four to ten weeks, not only improve visual skills but also visual perceptual skills, which enhance motor and cognitive performance and therefore leads to better sport performance (Du Toit, Kruger, Joubert & Lunsky, 2007; Du Toit et al., 2010; Du Toit et al., 2006; Kruger, Campher & Smit, 2009; Ahmed & Shosha, 2010). Motor and physical abilities as well as cognitive and perceptual skills are linked to sport performance (Schwab & Memmert, 2012). Schwab and Memmert's (2012) study showed significant improvement in choice reaction time, after conducting a six-week visual intervention programme on male youth hockey players (12 to 16-year-olds), more significantly was the positive influence on choice reaction time after a six-week retention test was performed. Ahmed and Shosha (2016) supported the above statement of enhancing visual skills and cognitive skills through a six-week visual skills training programme, with their research of under 15 year-old synchronized swimmers. It has been shown that visual control training may facilitate perceptual-motor learning in sport and also improves performance in certain sports (Oudejans, 2012). Beilock et al. (2002) also confirmed that experienced or highly skilled golf and soccer players achieved lower performances when attention was prompted by step-by-step execution. It may be more beneficial for highly skilled individuals to allocate their attention to the performance itself and not on the execution of the skill. Peh, Chow and Davids (2011) critically evaluated research on attentional focus, especially the influence thereof during the learning of a skill. They elaborated on the need of attention to execute a motor skill or a sport skill. In some instances, external focus will contribute more to a better performance outcome, while in other cases internal focus is more important. For this research, the focus will be improving eye-hand coordination. Eye-hand coordination is the ability to produce a planned hand action, conducted via visual information from the eyes.

Computerized visual perception training proved to be more effective than visual perception training, which was conducted with paper and a pen (Atasavun, Songèul & Dèuger, 2012). Therefore, the use of a web-based computerized program was implemented to enhance certain visual skills (pro-active and reactive eye-hand coordination) and would eventually have a positive influence on sustained attention.

2.11 TESTING FOR SUSTAINED ATTENTION

There is a rising concern that more and more children struggle to pay attention and to concentrate in school (Berger & Cassuto, 2014). Their ability to concentrate on a task, switching attention between the tasks, excluding distractors and inhibiting impulsive responses, is very important in developing cognitive control.

Several tests have been developed to test attention, but more specifically designed to assess Attention-deficit hyperactivity disorder (ADHD). Continuous performance tests (CPT) assesses one's ability to keep attention over time and discarding unnecessary distractors, and is therefore widely used as a preferred tool to assess cognitive function such as sustained attention (Kanaka et al., 2008; Hsieh et al., 2005). Research was done on computerized continuous performance tests (CPT), including visual and auditory distractors, which works on a go and no-go method, and it has been found that these tests were more accurate in their measurements of inattention or attention deficits (Berger & Cassuto, 2014; Berger et al., 2013; Slobodin, Cassuto & Berger, 2015; Berger & Goldzweig, 2010).

For this specific study the MOXO d-CPT was used to assess attention deficits or sustained attention (Berger et al., 2013). The MOXO d-CPT includes auditory and visual distractors within various levels, and functions on a go and no-go method (Berger et al., 2013).

2.12 TESTING FOR PROACTIVE AND REACTIVE EYE-HAND COORDINATION

Several manual and computerized eye-hand coordination tests exist. For the purpose of this study, the computerized Sports Vision Trainer (SVT™) was used to test eye-hand coordination and decision making skills (Ellison et al., 2014). Ellison et al. (2004) found that the Sports Vision Trainer (SVT™) was valid and reliable.

Based on the above research on literature, a comprehensive web-based visual skills training program was implemented to investigate the improvements in some cognitive abilities, such as sustained attention, as well as sport skills, such as proactive and reactive eye-hand coordination, of learners.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 RESEARCH DESIGN

A pre-post, cross-over experimental design was used to investigate the effect of a four-week, web-based Eyegym® intervention program on learners aged 13 to 15 years-old. A cross-over experimental design is a repeated measurement design (three tests were conducted in different stages on each group). This design allows for comparisons to be made between two groups; Experimental group and Control group, by implementing an intervention. A comparison was made between the Experimental Group (EG) of 23 learners and a Control Group (CG) of 19 learners in the change of attention, timing/response, proactive and reactive eye-hand coordination skills and self-perceptions of attention. With this design a relatively small sample group can be used and be pooled together to increase the sample size. Both groups can also receive the intervention and retention can be measured. Both the EG and CG were tested (pre-test) before the intervention. The EG first received the intervention (Eyegym®) and after four-weeks both the EG and CG were re-tested (post-test 1). After post-test 1, the CG received the intervention (Eyegym®) and both groups (EG and CG) were tested again (retention / post-test 2). The intervention (Eyegym®) includes its own built-in tests (pre- and post-intervention) to monitor progress of the different skills trained (eye skipping, click sequencing, perception endurance, visual recognition and visual attention).

3.2 POPULATION SELECTION AND SAMPLE

Research was conducted in a government subsidised school, situated in the Northern suburbs of Cape Town with 210 pupils, both boys and girls, in Grade 9, aged between 13 and 15 years. A purposive sample of convenience was used in the selection criteria. Forty-two adolescents (aged 13 to 15 years) participated in this study. The adolescents were divided into an experimental group (n = 23, mean age = 14.28) and a control group (n = 19, mean age = 14.18). Two admin classes from the Grade 9 group were selected. One admin class was based in the school's computer room and the other in the same school block. This approach was adopted because all the learners were together in one class when the intervention started and they were available during the admin time early in the morning. After four-weeks, EG stopped with the intervention and CG started the same intervention (Eyegym® drills).

Additional inclusion criteria:

- male and female learners
- their age was between 13 and 15 years

This study made use of quantitative methods to generate data.

Exclusion criteria:

- learners that were sick and missed four intervention sessions or more
- learners that did not receive consent from their parents
- learners that did not give their assent

3.3 RESEARCH PROCESS

The following process was followed with EG and CG. Both groups were tested at baseline (test 1). Three tests were administered in the EG and CG groups (baseline). The computer based MOXO d-CPT Adult's ADHD test was used to assess attention and timing. The computerized Sports Vision Trainer (SVT™) assessed proactive and reactive eye-hand coordination. The EG conducted a third test, the EyeGym® pre-test program (pre-intervention, test 1). The web-based EyeGym® program includes a test (test 1) before one can commence with the drills of the program. This provides a base line to monitor progress over time with EyeGym® drills. At the end of the four-week intervention period, test 2 was conducted (MOXO d-CPT Adult's ADHD and SVT™) on the EG and CG. EyeGym® tests (test 2) was performed on the EG, to assess whether changes occurred or not in the drills that were performed during the intervention. The CG conducted the EyeGym® test (test 2) before exposure to the intervention, after the EG discontinued the intervention (EyeGym®), and was tested again after the intervention (test 3). Both EG and CG were tested (MOXO d-CPT Adult's ADHD, SVT™ and EyeGym®) for the third time (retention for EG/ test 3 for CG) after the CG was exposed to the intervention (EyeGym®) (see Table 1). The EG and CG completed a self-perception questionnaire before commencing with the intervention programme. Computers used for training were connected to the internet and data during testing and training was sent automatically to Neurotech (Company that developed the MOXO d-CPT Adult's ADHD test) and stakeholders of EyeGym®.

According to current literature, various intervention periods are indicated for training visual skills. Several studies used a four-week intervention period (Abernethy & Wood, 2001; Calder, 2005; Calder & Kluka, 2009) others used a six-week intervention period (Ahmed & Shosha, 2010; Schwab & Memmert, 2012; Balasaheb, Mamon & Sandhu, 2008) and Wimshurst, Sowden and Cardinale

(2012) used ten weeks. For this research, a four-week period was implemented in the second term of the school's academic year. Both groups (EG and CG) therefore could be tested, intervention implemented and re-tested before the June school holiday.

Table 1: Research process

Group	Test 1	Intervention (Eyegym®) for 4 weeks	Test 2 (After 4 weeks)	Intervention (Eyegym®) for 4 weeks	Retention / Test 3
EG	1) MOXO d-CPT test (Attention & Timing) 2) SVT test (Proactive & reactive eye-hand coordination test) 3) Eyegym®	Eyegym®	1) MOXO d-CPT test (Attention & Timing) 2) SVT test (Proactive & reactive eye-hand coordination test) 3) Eyegym®	No Eyegym®	1) MOXO d-CPT test (Attention & Timing) 2) SVT test (Proactive & reactive eye-hand coordination test) 3) Eyegym®
CG	1) MOXO d-CPT test (Attention & Timing) 2) SVT test (Proactive & reactive eye-hand coordination test)	No Eyegym®	1) MOXO d-CPT test (Attention & Timing) 2) SVT test (Proactive & reactive eye-hand coordination test) 3) Eyegym®	Eyegym®	1) MOXO d-CPT test (Attention & Timing) 2) SVT test (Proactive & reactive eye-hand coordination test) 3) Eyegym®

3.3.1 Tests

3.3.1.1 The MOXO d-Continuous Performance Test (MOXO d-CPT)

The current study employed the MOXO d-CPT Adult's ADHD test. The MOXO d-CPT (Neuro Tech Solutions Ltd.) is a standardized computerized continuous performance test, serving as an objective tool to evaluate the learner's attentiveness profile (Berger & Cassuto, 2014). Research conducted by Berger and Cassuto (2014), confirmed the validity of the MOXO d-CPT Adult's ADHD test after they tested it on participants aged 13 to 18 years. The MOXO d-CPT task requires participants to sustain attention over a continuous period, responding to pre-specified targets, while being distracted by visual and auditory stimuli. The four attentiveness indices measured by the MOXO d-CPT Adult's ADHD test are attention, hyperactivity, impulsivity and timing. Each index is measured quantitatively and relative to the norm (age and gender). The MOXO d-CPT Adult's ADHD test contains a series of distractors (visual and auditory) that aims to simulate real-life environment and thus improves the validity of the assessment in relation to everyday life.

The MOXO d-CPT Adult's ADHD distractors are short animated videos that are irrelevant to the task being performed. The test is divided into eight levels, with various types of distractors, which appears during the eight levels. The duration of the test is 18.2 minutes. In each trial a stimulus (target and non-target) is presented in the middle of the computer screen for a duration of 0.5, 1, or 3 seconds and is followed by a "void" or a "blank screen" of the same duration. Each stimulus remains on the screen for the full duration of the designated presentation time, regardless whether a response was given or not. This allows the measuring of timing of the response as well as its accuracy.

The MOXO d-CPT test consists of a go and a no-go system. Participants are instructed to respond to target stimuli on a computer screen as quickly as possible by pressing the spacebar (this is a go), only once. The participants are also instructed not to respond to any other stimuli but the target, and not to press any other key but the space bar (this is a no-go). During the test, participants were subjected to different test stimuli, with and without distractors and needed to correspond accurately, timely and correctly. Here follows more detail about the test stimuli:

- **Test Stimuli:** Consists of target and non-target stimuli. The target stimulus is indicated as a playing card with three hearts. Non-target stimuli incl udes different images such as diamonds, three leafed clovers, or anything else but the three hearts. Some non-target stimuli only have one or two hearts on the card.
- **Distracting stimuli:** To simulate the everyday environment the MOXO d-CPT included visual and auditory distracting stimuli. These distractors were short animated video clips containing auditory and visual features, which can appear simultaneously or separately.
- **Test levels:** The test comprised of eight levels. The stimuli and their presentation time are identical across all levels. The different levels of the MOXO d-CPT were characterized by different sets of distractors. Levels one and eight, only includes target and non-target stimuli and did not include any visual or auditory distractors. Levels two and three contained only visual stimuli, levels four and five contained just auditory stimuli and levels six and seven included visual and auditory stimuli. The load of stimuli distractors increased in the uneven numbered levels. During the 3^{rd}, 5^{th} and 7^{th} levels, two distracters were presented simultaneously.

The Performance Indices.

The MOXO d-CPT includes the following two performance indices.

i. ***Attention*** – Attention reflects the ability of an individual to locate, evaluate and respond correctly to a stimulus, while busy with a task. By pressing the spacebar on the computer keyboard in response to a target stimulus (a card with three hearts), this parameter included the number of correct and incorrect responses during the test. The difference between the total number of the target stimuli and the number of correct responses produced the number of omission errors. This is a pure measurement of sustained attention because it measures responses independently of the response time. Thus it is possible to evaluate whether the participant responded correctly to the target, therefore being attentive to the target. An increase in result leads to an increase in attention performance.

ii. ***Timing –*** Timing reflects the ability to respond correctly within a specific time during a task. Pressing the spacebar on the computer keyboard in response to a target stimulus (a card with three hearts), when the target stimulus is still present on the screen or after the stimulus disappeared (void period) will distinguish if the accurate response was performed in "slow response" or "good timing". Individuals who struggle with attention will not respond to the stimuli at all because they are not alert to the target. Individuals responding correctly, but slower to stimuli, might not be inattentive, but just take longer to respond. An increase in result will lead to a better timing performance.

3.3.1.2 Sport Vision Trainer (SVT™)

The computerized Sports Vision Trainer (SVT™) tests eye-hand coordination and decision making skills (Ellison et al., 2014). It can also be used for the following:

- Replicating and testing stressful demands of sport.
- Assessing and training for specific body movements.
- Testing both central and peripheral vision and enhancing the athlete's awareness of external stimuli.

- Identifying weakness in vision and motor movements.
- Assessing improvements in general or specific training periods and drills.
- Providing an alternative to physical activities during rehabilitation from injury.

Eye-hand coordination as tested and trained on the SVT™ for this research was divided into 2 components:

a) **Proactive mode** - mimics a closed motor skill environment. It is a movement that is initiated by the individual. When a light is illuminated on the SVT™, the subject hits the light, the quicker it is hit, the quicker the next light appears. The SVT™ program waits until it has measured the response before producing the next light. A pre-set drill of 30 lights was used for this research. The response time was measured in seconds. A decrease in results (time) leads to an increase in proactive eye-hand coordination ability of a person. The response time reacting on the lights was measured in seconds.

b) **Re-active mode** - mimics an open motor skill environment and is a movement that occurs in response to another action being initiated. In this testing mode, the reaction time was set for 0.50 seconds. If a person is able to hit 80% of the lights at this speed, the reaction time is decreased by 200 milliseconds. The correct reaction time was measured as a percentage. An increase in percentage leads to an increase in the ability to react faster.

   Participants stood 30 cm away, directly in front of the SVT board that is a 1.2 x 1 m panel of 30 lights that was placed on a wall. The board consists of a grid of lights which is programmed to flash in a pre-designed sequence. The SVT™ program randomized the target order and location for every participant.

3.3.2 Self-perception questionnaire

A paper-based, quantitative, self-perception questionnaire was developed and included to determine the participant's own perceptions before and after the intervention process (Appendices H). The questionnaire was self-designed, based on literature and was divided into two sections (A similar self-perception questionnaire which tries to include validity and reliability of these). Questions one to twelve, relate to attention problems and questions thirteen to twenty, focused on hyperactivity and impulsiveness. The self-perception questionnaire was used as a pilot on four learners before the commencement of the study.

3.3.3 Pre-intervention Testing Protocol

Participants were divided into two groups, EG and CG. EG and CG were tested on the MOXO d-CPT Adult's ADHD test first. Before running the actual test, all participants did a practice test to familiarize themselves with the task and its different stimuli and to assure that the participants understood the test instructions and performance correctly. The instructions of the practice test were similar to the actual clinical test. In the clinical test computers had speakers, the school's computers did not have any and therefore learners used earphones. During clinical tests, individuals were tested one on one. Participants were spread out in the computer classroom with dividers separating them. Eight MOXO d-CPT were administered simultaneously. This testing procedure was repeated three times. All instructions were given in English and Afrikaans. Three first-year students from the ETA College in Stellenbosch assisted with the testing. Students were trained in how to conduct the tests. The MOXO d-CPT Adult's ADHD test took place over two days for both groups. After the completion of the MOXO d-CPT Adult's ADHD test, group EG and CG were tested on the SVT™ test. The SVT™ test was explained and demonstrated to all participants before doing the actual test. The SVT™ test was conducted over two days. The same three first-year ETA College students assisted with this testing. The EG was enrolled in a four-week, web-based Eyegym® intervention program consisting of three, 10 to 15 minute sessions per week. The EG did not receive any intervention during the first four weeks of the research. After the four weeks, CG and EG were tested with the same two tests (MOXO d-CPT and SVT™) and completed a second self-perception questionnaire. CG was exposed to the same four-week, web-based Eyegym® intervention program after the second test took place. EG and CG were tested for the third time after CG's intervention was completed. In this case, EG served to determine the long-term outcome of the intervention program. The web-based, computerized training program also has built-in tests, which were conducted pre- and post- intervention. EG and CG were tested before EyeGym® drills were implemented and again four weeks later, after the intervention was completed. EG was tested again for a third time after CG received their intervention, to gain knowledge about the long term influence of the EyeGym® intervention after the intervention was stopped. The testing and intervention process took place before and during the admin period of the school in the morning, in the computer classroom. The Sports Vision Trainer (SVT™) tests took place in the school's media centre.

3.4 INTERVENTION PROGRAMME OR DRILLS

A web-based, computerized training program was used over a period of four weeks, participants trained on it for 10 to 15 minutes a day, three days per week, for a maximum of 12 sessions. A username and password was created for each participant. After logging in, the session started with a brief explanation of how to do each drill. Here follows an explanation of all drills that were used over the four-week period:

Eye skipping exercises: This drill trains the ability to rapidly respond to information. It enhances the ability to react to specific visual information as well as enhances eye-hand coordination. At each level, there is a ball with an arrow on it. The learner needs to indicate the direction of the arrow with the keyboard cursors. Each level has a different ball, and the direction of the cursors are at random. The background colours change during the exercise as well. The learner needs to achieve a minimum of 70% to proceed to the next level.

Click sequence exercises: This drill trains the ability to scan and correctly respond to information. Eye-hand coordination is also practiced. When a specific object appears, in this case a ball appears on the screen, the learner needs to tap the space bar on the keyboard as quickly as possible. The background colours also change randomly during the exercise. As the learner progresses to the next level, the exercises add extra elements that act as distractors. The learner needs to achieve 85% to proceed to the next level.

Perception endurance exercisers: The ability to quickly assess and judge distance/direction is crucial in any sport. This drill trains the ability to make judgment within a longer time frame.

Visual recognition exercises: This drill improves your ability to remember and quickly recall that which you see. It trains the processing of visual information, response time and recognition speed. Numbers appear on the screen for a very limited time. The learner needs to recall the number displayed and enter it into a space on the computer screen as fast as possible. This focuses on short-term memory. During this exercise the background colour changes constantly. The target percentage to achieve is 100%.

Keep eye on exercise: This drill trains the ability to follow and focus on a moving object or concentrating while tracking an object. Rather than moving the head to track an object, it is important to follow with your eyes. This drill improves the ability to focus on an object and its changes, and enhances visual concentration as well. Fine coordination skills are also being trained by keeping the mouse cursor on the object. This skill is necessary and important in many activities. During this drill a certain type of ball was followed and it changed several times. An increase in achievement levels leads to an increase in more distractors and speed of movements of the objects. To advance to the next level a 100% achievement performance had to be reached.

3.5 DATA PROCESSING

3.5.1 Attention and Time data processing (MOXO d-CPT)

The dependent variables; attention and timing, were populated on an excel spreadsheet, consisting of eight levels each, with 35 possible omissions per level. The total of these eight levels per variable, equalled to a maximum total of 280. The mean of each group was used for statistical analysis. This test was repeated three times during the research period.

3.5.2 Eye-hand coordination data processing (SVT board)

Proactive results: Results were generated via a computer and the time per learner was written down manually and documented onto an excel spreadsheet.

Reactive results: These results were also generated via a computer and the percentage per learner was written down manually and documented on an excel spreadsheet

Both these results were repeated three times.

3.6 Data Analysis

Attention, timing and eye-hand coordination for each group (EG and CG) was compared using a mixed model, ANOVA, for repeated measures, in order to identify any improvements ($p > 0.05$). Descriptive stats are presented in tables and graphs. Pearson's correlation coefficients were used to correlate selected demographic variables (boys vs girls) to determine the relationship among the attention and timing/response.

3.7 Ethics

- The study was approved by the Senate Research Ethics Committee at the University of the Western Cape, as well as the Western Cape Department of Education.
- Information letters and informed consent forms were sent to the parents of the two admin classes and those whose parents had given written consent and who themselves have agreed to participate voluntarily, were recruited to be part of the research.

- Permission to conduct the study was approved from the Faculty of Community and Health Sciences' Ethics Committee at the University of the Western Cape.
- Approval to conduct the research at Stellenberg High School was granted by the Western Cape Department of Education.
- Only learners with written, informed parental consent and who themselves have given assent to taking part were included in this study.
- Autonomy and confidentiality were respected for those learners who chose to withdraw during the research, without consequence.
- All aspects of the research project were explained to all those involved with the research, in order for them to fully understand the concepts and purpose of the research project.
- Participants were not charged nor incurred any expenses.
- The reporting of results is anonymous and all participant information was dealt with confidentially.
- The intervention posed minimal risk and no injuries took place.

CHAPTER FOUR

RESULTS

In this chapter, the results pertaining to the variables of interest namely; attention, timing and eye-hand coordination results are reported. Data generated by the Eyegym® also allowed for comparison between different measures of the intervention program for certain eye-hand coordination skills, which were correlated with the SVT Proactive and reactive eye-hand coordination skills.

4.1 SAMPLE DEMOGRAPHICS

A total of 42 learners (out of 54 in total) were selected for participation in the current study. Nine learners chose not to participate as either their parent(s) or they themselves did not sign the informed consent or assent forms. Three learners could not attend the minimum required 10 training sessions because of other school commitments and was excluded from the study. In order to align the research programme in the school timetable the final sample size was EG (n=23) and the CG (n=19). Two admin classes from the Grade 9 group were selected. One admin class was based in the school's computer room and the other in the same school block. This approach was adopted because all the learners were together in one class when the intervention started and they were available during the admin time early in the morning.

Table 2: Sample demographics

	Experimental Group (23)	Control Group (19)
Male	8	10
Female	15	9
Mean age	14.25	14.18

4.2 ATTENTION AS MEASURED BY THE MOXO D-CPT

The intervention had no effect on attention in this cohort (Figure 1). Neither the Experimental Group (EG, test 1 to test 2)) nor the Control Group (CG, test 2 to test 3) showed a significant improvement in attention.

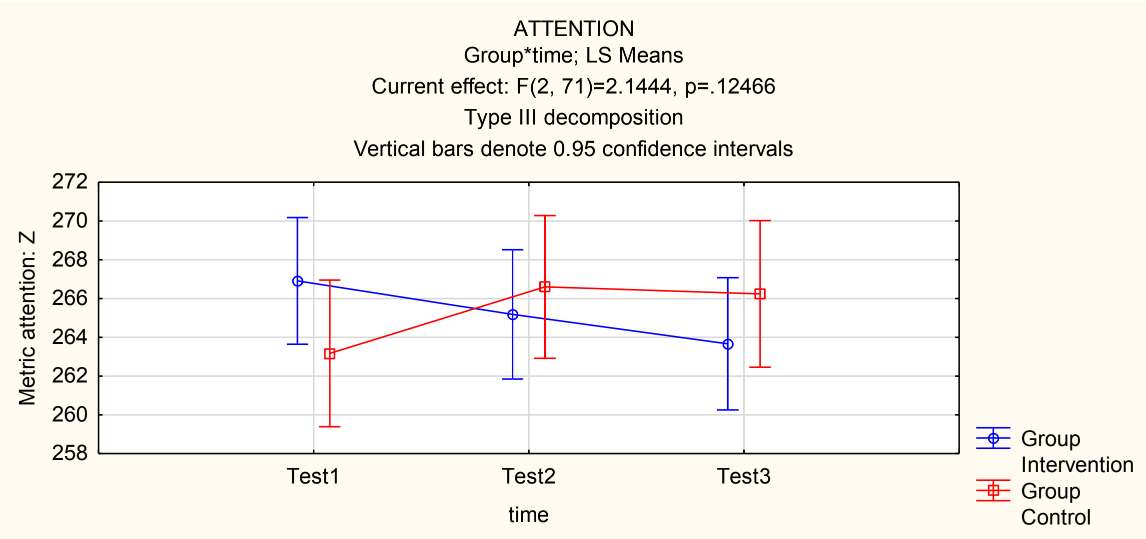

Figure 1: Effect of intervention on attention

Table 3 displays the descriptive statistics (total learners (N), the mean (M), standard deviation (SD), the mean difference (MD) and the statistical significance (p) for all the attention tests.

Neither the Experimental Group (EG) (Test 1 to Test 2) nor the Control Group (CG) (Test 2 to Test 3) showed a significant increase in scores post intervention period (p = 0.42 and p=0.88 respectively) (Table 3). Even when the data from EG (Test 1 to Test 2) is pooled with the data from CG (Test 2 to Test 3), thereby increasing the sample size (n=42), the effect remained unchanged with p > 0.05. However the EG showed a slight decrease in scores (Test 1 to Test 2) (after intervention) and a further decrease in scores after Test 2 to Test 3 (intervention discontinoued). The CG showed a slight increase in scores from Test 1 to Test 2 (no intervention) and the same score from Test 2 to Test 3 was noted. These results suggest that the intervention has no significant effect on attention. A large standard deviation was noted in EG and CG. This might be because of some outliers in the sample population of the EG and CG. An increase in sample size might negate this and have a different effect.

Table 3: Descriptive statistics for attention

LSD Test: ATTENTION														
TESTS	**T1**			**T2**			**T3 - T1 MD**	**Within group effect**	**T3**			**T3 - T2 MD**	**Within group effect**
Within group	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**MD**	**p**	**N**	**Mean**	**SD**	**MD**	**p**
Intervention	23	266.91	3.88	23	265.22	10.01	1.73	0.42	21	263.95	11.80	1.51	0.49
Control	17	263.00	7.73	18	266.55	4.00	-3.43	0.16	17	266.55	5.29	5.29	0.88
					Between group effect p			0.05					

T1 T2 T3: Test 1, Test 2, Test 3;
SD: standard deviation
MD: mean difference

4.3 TIMING AS MEASURED BY THE MOXO D-CPT

Neither the EG (Test 1 to Test 2) nor the CG (Test 2 to Test 3) showed a significant increase in scores post intervention period ($p = 0.14$ and $p = 0.22$ respectively) (Figure 2 and Table 4). However when the data from EG (Test 1 to Test 2) were pooled with the data from CG (Test 2 to Test 3), thereby increasing the sample size (n=42), the effect changed with $p < 0.05$. These results suggest that the intervention has a positive effect on timing as a whole. The EG improved in scores (Test 1 to Test 2) after the intervention and so did the CG (Test 1 to Test 2), without intervention.The EG experienced a decrease in scores (Test 2 to Test

3) after the intervention was discontunued, where the CG showed an increase in scores (Test 2 to Test 3) after the intervention. A large standard deviation was noted in the EG and CG. This occurrence might be because of the spread of the data and the outliers in the sample population of the EG and CG. Again an increase in sample size might negate this and have a different effect.

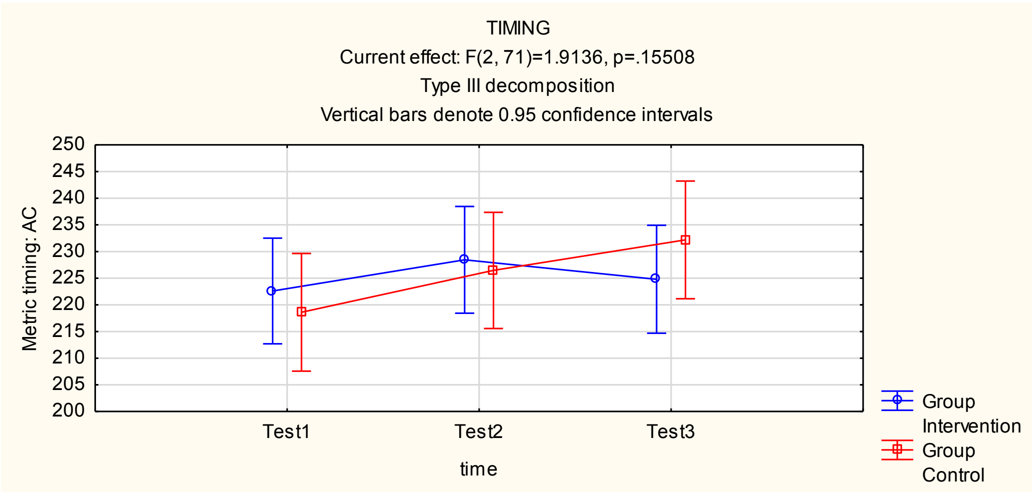

Figure 2: Effect of intervention on timing

Table 4 displays the descriptive statistics for all the timing measurements.

Table 4: Descriptive statistics for timing

LSD Test: TIMING														
TESTS		**T1**			**T2**		**T2 - T1 MD**	**Within group effect**		**T3**		**T3 - T2 MD**	**Within group effect**
Within group	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**MD**	**p**	**N**	**Mean**	**SD**	**MD**	**p**
Intervention	23	222.62	24.66	22	229.36	23.93	-5.83	0.14	21	225.81	29.63	6.63	0.37
Control	17	216.59	20.13	18	226.61	23.47	-7.85	0.09	17	233.82	16.28	-5.72	0.22
									Between group effect p				**0.05**

T1 T2 T3: Test 1, Test 2, Test 3;
SD: standard deviation
MD: mean difference

4.4 EYE-HAND COORDINATION

Eye-hand coordination was tested using the SVT™ board, in its proactive and reactive mode. Pro-active eye-hand coordination was recorded in seconds and reactive eye-hand coordination as a percentage (refer to Chapter 3, point 3.3.1.2 on pg. 34 for a full explanation of these terms).

4.4.1 Proactive eye-hand coordination

The intervention had a positive effect on proactive eye-hand coordination in this cohort. Table 5 displays the total number learners (N), the mean (M), standard deviation (SD), the mean difference (MD) and the statistical significance (p) for all the proactive eye-hand coordination tests.

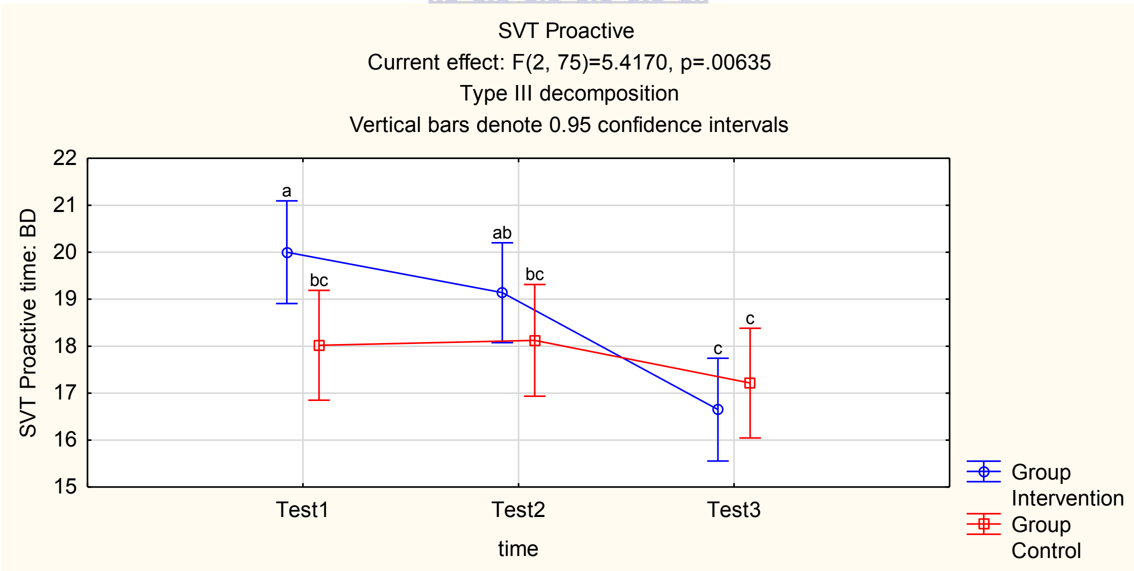

Figure 3: Effect of intervention on Proactive eye-hand coordination

Although neither the EG (Test 1 to Test 2) nor the CG (Test 2 to Test 3) showed a significant increase in scores post intervention period (p = 0.11 and p= 0.12 respectively) (Figure 3 and Table 4), post-hoc analysis suggests that should the intervention have continued, as the trend suggests that both groups would most likely have shown a significant change. This can be seen in the postive trend demonstrated in the figure above (Figure 3).

The EG also seemed to continue to improve, even after the intervention was discontinued (Test 2 to Test 3) (p = 0.01) (Table 5).

When the data from EG (Test 1 to Test 2) was pooled with the data from CG (Test 2 to Test 3), thereby increasing the sample size (n=42), the difference from pre- to post- intervention was significant with p = 0.01 (Table 5). These results suggest that the intervention did have a positive effect on proactive eye-hand coordination.

Table 5: Descriptive statistics for proactive eye-hand coordination

PROACTIVE EYE-HAND COORDINATION														
TESTS	**T1**			**T2**			**T2 - T1 MD**	**Within group effect**	**T3**			**T3 - T2 MD**	**Within group effect**
Within group	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**MD**	**p**	**N**	**Mean**	**SD**	**MD**	**p**
Intervention	21	20.04	3.18	23	19.14	2.89	0.86	0.11	21	**16.33**	**1.72**	**1.92**	**0.01**
Control	19	18.02	2.28	18	18.27	2.31	-0.11	0.85	19	17.21	3.35	0.91	0.12
									Between group effect p				**0.01**

T1 T2 T3: Test 1, Test 2, Test 3;
SD: standard deviation
MD: mean difference

4.4.2 Reactive eye-hand coordination

The intervention also had a positive effect on reactive eye-hand coordination in this cohort. Table 6 displays the total learners (N), the mean (M), standard deviation (SD), the mean difference (MD) and the statistical significance (p) for all the reactive eye-hand coordination tests.

The EG (Test 1 to Test 2) and the CG (Test 2 to Test 3) showed both groups had a significant increase in percentage post intervention period (p = 0.02 and p = 0.01 respectively) (Table 6). The EG (Test 2 to Test 3) showed a further improvement in the reactive eye-hand coordination test after the intervention was discontinued (p = 0.05) (Table 6).

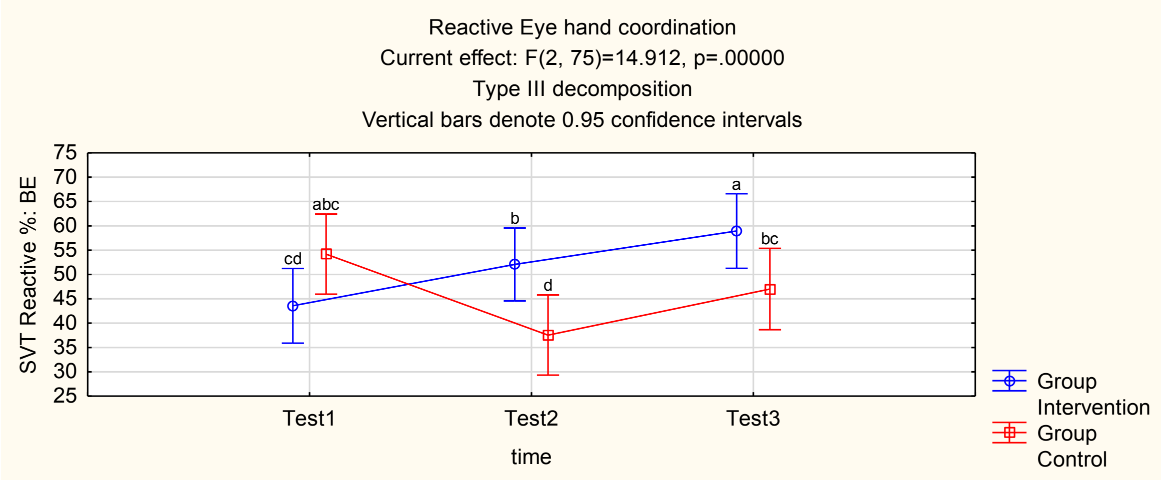

Figure 4: Effect of intervention on Reactive eye-hand coordination

When the data from EG (Test 1 to Test 2) was pooled with the data from CG (Test 2 to Test 3), thereby increasing the sample size (n=42), the effect improved significantly with p < 0.01 (Figure 4).

These results suggest that the intervention had a positive effect on reactive eye-hand coordination. However, a very large standard deviation was noted with the EG and CG. This occurrence was due to the spread of the data and some outliers in the sample population of the EG and CG. An increase in sample size should negate this and might provide a different effect in future studies.

Table 6: Descriptive statistics for Experimental and Control Group

REACTIVE EYE-HAND COORDINATION													
TESTS	**T1**			**T2**			**T2 - T1 MD**	**Within group effect**	**T3**			**T3 - T2 MD**	**Within group effect**
Within group	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**MD**	**p**	**N**	**Mean**	**SD**	**MD**	**p**
Intervention	21	44.44	18.27	23	52.07	18.34	**-8.50**	**0.02**	21	**59.92**	**18.86**	**-6.87**	**0.05**
Control	19	54.19	15.67	19	37.54	20.45	**16.65**	**0.01**	18	**45.93**	**17.97**	**-9.47**	**0.01**
									Between group effect p				**0.01**

T1 T2 T3: Test 1, Test 2, Test 3;
SD: standard deviation
MD: mean difference

4.5 SELF-PERCEPTION QUESTIONNAIRE

Part of this study was to investigate whether the learners perceived themselves to have better attention or focus after the four weeks of the intervention was completed (See Annexure for Self-Perceived Questionnaire and Summary). Neither group showed a significant increase in perception post- intervention. The EG however showed an improvement in their perception in two questions post-intervention. These included; Question 5: “I sometimes cannot choose which tasks or homework I need to do first and Question 10: “I sometimes listen to the teacher for the first half of the class, and then loose concentration for the second half”.

CHAPTER FIVE

DISCUSSION

Attending to tasks, maintaining attention and inattention, especially with learners at school, has become a topic of concern (Dayley & Birchwood, 2009; Walker et al., 2011). Visual skills training has been proven to influence certain sport skills, but the question arose as to whether it can improve certain cognitive skills, such as attention (Dogru, 2014). Dogru (2014) also stated that in the academic context, sometimes a high degree of cognitive performance is required, which also requires attention. Various factors influence attention and for this purpose the current study's focus was on examining the effect of a computer-based, visual skills training program on attention, timing and eye-hand coordination. The results of the current study showed that 10 to 15 minutes, on a computerised visual skills training programme, three times per week, for a period of four weeks, was effective for improving reactive eye-hand coordination in adolescents only. With longer exposure to the programme suggesting it may be effective for pro-active eye-hand coordination as well. The current study, however, did not show any significant effect on attention and timing. This is possibly due to the small sample size used for this study or can be attributed to gender differences.

The current chapter begins with a discussion of the effect of the selected intervention on the sample and how it compares with other studies reported in the literature.

5.1 ATTENTION

The current study found that attention did not improve post- intervention for either the EG or the CG. Neither the EG nor the CG from pre- to post- test showed a significant increase in scores (p=0.42 and p=0.88 respectively). There are however several possible factors that could have influenced the learners' attention during these tests.

Firstly, as stated by Lewin (2014) attention requires a conscious decision to pay attention. It can be assumed that some learners may not have taken that conscious decision to attend to the task at hand. The test was also done first thing in the morning before school, and some might have felt pressured for time to get it done before the school day started. Furthermore, the environment could have distracted the learners during these tests. In the current study, six to eight learners were tested simultaneously in a large venue while other reported studies, the test is performed in a clinical environment with one learner in a quiet room. Furthermore, the testing protocol was adapted due to a limited amount of time available to evaluate learners and to implement the intervention in one school term for the EG and CG. Other factors that may have contributed to the lack of attention was noise outside the classroom when the tests were performed, which could have distracted the learners' attention during the tests. Additional factors that could have also affected the results are emotions, such as anxiety. Learners sometimes feel anxious when they know they have to do a test and this emotion could have influenced their attention and maybe the results (McCarthy, Allen & Jones, 2013). Test three was done on the first day of the school's June exam and some learners seemed anxious and distracted during the test. The school's internet service was also found to be extremely slow at times, especially when test two was done with the EG. The test could not be continued and had to be re-started again, for several learners; thus challenging the learners' ability to concentrate or to focus their attention again and for extended periods.

The effect on attention was disappointing. For this outcome there was no significant change across the three tests for either group. It should however be noted that the test was postponed twice because of internet connectivity issues at the school. This caused a delay and subsequently the test had to be done on the first day of the June exam, when the 13 to 15 -year-old adolescents had to write a Maths exam. It was observed that the learners were extremely tense and stressed due to this exam and this could have influenced the attention test result. The stress therefore, could have led to more omission faults or learners' minds to wonder off. Future research should ensure a more conducive testing and training environment to accurately determine the influence of the intervention program on attention.

5.2 TIMING

Timing for both EG (Test 1 to test 2) and the CG (Test 2 to Test 3) increased post intervention, but again not significantly ($p = 0.14$ and $p = 0.22$ respectively).

Visual skills training is known to improve eye-hand coordination and reaction and it was hypothesised that the intervention would also improve timing scores with less omissions. The intervention program made use of eye-hand coordination exercises, which were done three times a week (10 to 15 minutes per training session) and could have positively influenced the learner's timing when performing this test. For both groups, following their intervention period, there were no significant findings, however, when the data from EG (T1 to T2) was pooled with the, data from CG (T2 to T3), the significant effects changed with $p < 0.05$. These results suggest that the intervention has a significant effect on timing and it is assumed that if the groups have been exposed to the intervention over a longer period, for example an eight to twelve-week period, the effect size would have been greater.

5.3 EYE-HAND COORDINATION

Several studies indicate that visual intervention programmes enhance certain visual skills, specifically eye-hand coordination (Calder & Kluka, 2009; Du Toit et. al, 2011; Schwab & Memmert, 2012; Mashige, 2014; Ahmed & Shosha, 2010; Wimshurts; Sowden & Cardinale, 2012). In the current study, proactive eye-hand coordination was not found to be as significant as previous research had suggested, however reactive eye-hand coordination improved significantly. This is discussed in more detail below.

5.3.1 PROACTIVE COORDINATION

The intervention had a positive effect on proactive eye-hand coordination in this cohort, the EG and CG responded faster after an intervention of four-weeks, three times per week for 10 to 15 minutes. Although neither the EG (Test 1 to Test 2) nor the CG (Test 2 to Test 3) showed a significant increase in scores post intervention period ($p = 0.11$ and $p= 0.12$ respectively) (Table 4), post-hoc analysis suggests that should the intervention had continued, both groups would most likely have shown a significant change. A supporting reason might be that the learners became familiar with the SVT test and therefore an increase in reaction could not be directly linked to the intervention. However, as a combined group the intervention showed a positive improvement on proactive coordination ($p = 0.01$).

The current study also showed that the effect was maintained after the Intervention was discontinued (p = 0.01). This study relates well with other studies in the same field, using similar equipment and finding similar results (Du Toit et al., 2007; Du Toit et al., 2011; Schwab & Memmert, 2012; Manan et al., 2011; Abernethy & Wood, 2011).

Therefore, the current study's results indicate that visual skills training might improve proactive eye-hand coordination, but a longer and more frequent exposure to the intervention might have a more positive effect on the outcome.

The testing environment and the timing of tests should be carefully considered. Testing for proactive coordination should be done when students are relaxed and are not pushed for time. All students were exposed to one test to prepare themselves, but a few more tests before the start of the actual test should be considered so that the students are fully prepared for how difficult it is and how the SVT board works. The researcher observed that some of the learners did not push hard enough on the lights of the SVT board, which resulted in a slower reaction time.

5.3.2 Reactive percentage coordination

The intervention showed to have the most positive effect on reactive eye-hand coordination. The EG (Test 1 to Test 2) and the CG (Test 2 to Test 3) showed both a significant increase in percentage post intervention period (p = 0.02 and p = 0.01 respectively) (Table 6). The EG (Test 2 to Test 3) showed a further improvement in the reactive eye-hand coordination test after the intervention was discontinued (p = 0.05) (Table 6). A further interesting phenomenon was the increase in the percentage of the reactive eye-hand coordination in the EG, after the intervention was discontinued (T2 to T3) ($p=0.05$). This study compares well to other studies done in this field (Calder & Kluka, 2009; Balasaheb, Mamon & Sandhu, 2008; Wilmshursts, Sowden & Cardinale, 2012).

In summary, the current study could not show that it had a positive influence on cognitive attention and this might be because of other factors that influenced executive functioning, such as attention. Results indicated a positive influence on timing as measured with the d-MOXO CPT, but it was not a significant change.

Lastly, this study's web-based, visual skills training programme for four weeks and for three ten minute sessions per week, influenced proactive eye-hand coordination skills of the EG and CG, but not significantly. However, there was a significant improvement after the intervention was discontinued with the EG. A significant improvement in reactive eye-hand coordination was indicated which supported some of the other studies' outcomes as indicated in previous discussions.

In the case of the current study, a web-based, visual skills training programme was shown to have the best effect on certain eye-hand coordination skills, especially for reactive eye-hand coordination.

CHAPTER SIX

6.1 CONCLUSION

This study was done to determine the effect a web-based, visual skills training program had on cognitive abilities such as attention, timing and eye-hand coordination skills, such as proactive and reactive eye-hand skills. The implementation of a web-based, visual skills training program in a government-funded school environment had several challenges. Internet connectivity played a crucial part in the implementation of the intervention of a visual skills training program. The internet speed tended to be slow when the usage on the computers was increased. This was especially evident when the whole class was doing the web-based, visual skills exercises, which then caused a delay in going from one exercise to the next. This delay created tension and frustration among the learners. Some of the learners did not want to re-start the exercises or felt it to be a drag. Learners also started talking to each other during these delays and ended up not completing all the eye exercises. Furthermore, it needs to be noted that in this particular school, they have more than one computer room, which means different learners have access to these classrooms at the same time, which further influenced the speed of the internet.

As per observations, it was not always a conducive environment for training visual skills for the following reasons; 19 to 23 learners sitting side by side in one classroom could potentially influence one another while doing the training. Furthermore, the environment should be quiet and the learners need to be seated away from each other so that they cannot have conversations with each other while doing the training. It was observed that within the sample, the boys tended to influence one another, both positively and negatively. Positively, it was noted that there were in some instances, where the boys were constantly in competition with one another, an improvement on the different visual skills training levels and this lead to an increase in attention during the training. Negatively, for some (boys and girls) learners had soft conversations which influenced their attention while they were partaking in the training. In addition, there was also a limited time in which the learners could do the visual skills training, as the sessions took place just before school and during the admin period of the class. Due to this, some learners felt pressurised to complete the visual skills training in time. Another observation that was made was that some learners really enjoyed the visual skills training program, while others became bored with it after week three.

Therefore, from this study, it can be concluded that a visual skill training programme is not an effective training programme for all individuals. Some learners also kept training those visual skills exercises which they liked more than exercises they disliked or found difficult, which lead to increase in levels of those exercises at the expense of others. The visual skills training program did not have a built-in mechanism, where it would force the learners to rotate through all the different levels of all the different visual drills after they improved in a level. Some drills were therefore practiced more than others. On several occasions the researcher had to fetch learners from their class to train with the intervention program. The researcher also had to ask learners on several occasions to complete the all drills of the intervention program and not only certain ones that they had enjoyed more.

A small sample size with a large deviation as in this study deems problematic and in-depth analysis should be done on those outliers influencing the large deviation.

Proper calculation of sample size should be considered. The results have indicated that the web-based, visual intervention programme only had a significant effect on reactive eye-hand coordination skills and an effect, however not significant, on proactive eye-hand coordination skills, which suggests a possible significant effect should the time or programme be extended. Furthermore, it is uncertain if this web-based, visual intervention programme has an influence on cognitive abilities such as attention and timing, because there was no improvement in the attention scores of the learners and no significant improvement on the timing scores. Considering all of this and with the aforementioned problems experienced in the testing, the effect of a four-week, web-based, visual skills training program on 13 to 15-year-old adolescents appears to be very limited.

From the current research it is concluded that a four-week, web-based, visual skills training program is not an effective tool to have significant effects on 13 to 15-year-old adolescent's sustained attention and timing/response. However, it does improve visual skills, such as proactive and reactive eye-hand coordination skills.

6.2 RECOMMENDATIONS

For future research the following recommendations should be followed when investigating the effect of a web-based, visual skills training program:

- Schools should have proper resources to provide the opportunity to implement a web-based, visual skills training program, for example fast internet connectivity and sufficient computers.

- The training environment should be quiet without any distractions. Testing protocol for attention should not be adapted; each learner should be tested individually for 20 minutes in a quiet environment. This begs the question whether this is possible in a school context.

- A smaller group of learners (a maximum of six to eight) should be trained at the same time, while being closely observed.

- The visual skills training program should be implemented over a longer period of time (a minimum of eight weeks) to investigate the influence on cognitive abilities such as attention and timing and to further investigate the improvement on eye-hand coordination.

- The current intervention program (Eyegym®) should incorporate a function in the program where learners are encouraged to train all the exercises equally and learners should not be able to choose a certain preferred eye exercise.

- Most importantly, a larger sample size is suggested, which will decrease the sample error or large standard deviation. Proper analysis should be done in determining what the proper sample size should be for an intervention of this nature. Comparing gender difference according to attention, timing and proactive and reactive eye-hand coordination skills should be considered for future research.

REFERENCES

Abernethy, B. & Wood, J. (2001). Do generalized visual training programmes for sport really work? An experimental investigation. *Journal of Sports Sciences, 19*(3), 203-222.

Achtman, R. L., Green, C. S., & Bavelier, D. (2008). Video games as a tool to train visual skills. *Restorative Neurology and Neuroscience*, *26*(4-5), 435–446.

Atasavun, U., Songèul, D.T. (2012). Visual perception training on social skills and activity performance in low-vision children. *Scandinavian Journal of Occupational Therapy, 19*(1), 33-41.

Balasaheb, T., Maman, P., & Sandhu, J. (2008). The impact of visual skills training programme on batting performance in cricketers. *Serbian Journal of Sport Science, 2*(1), 17-23.

Beilock, S. L., Carr, T. H., MacMahon, C., & Starkes, J. L. (2002). When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied, 8*(1), 6-16.

Belchior, P., Marsiske, M., Sisco, S.M., Yam, A., Bavelier, D., Ball, K., Mann, W.C. (2013). Video game training to improve selective visual attention in older adults. *Computers in Human Behaviour, 29*(4), 1318-1324.

Berger, I., & Cassuto, H. (2014). The effect of environmental distractors incorporation into a CPT on sustained attention and ADHD diagnosis among adolescents. *Journal of Neuroscience Methods, 222*, 62-68.

Berger, I., & Goldzweig, G. (2010). Objective measures of Attention-Deficit/Hyperactivity disorder: A pilot study. *Imaj, 12*, 531-535.

Berger, I., Slobodin, O., Aboud, M., Melamed, & Cassuto, H. (2013). Maturational delay in ADHD: Evidence from CPT. *Frontiers in Human Neuroscience, 7*(69)

Biber, D. D., Czech, D. R., Harris, B. S., & Melton, B. F. (2013). Attraction to physical activity of generation Z: A mixed methodological approach. *Open Journal of Preventive Medicine, 3*(3), 310.

Calder, S. (2005). *Enhanced skill performance of field hockey players following of visual awareness training.* Unpublished Doctoral thesis, Sport Science Institute of South Africa, Cape Town.

Calder, S. (2014). *Looks good for hockey: A new visual training program improves game skills in elite players.* Retrieved May, 2015, from sportsci.org/news/news9705/hockeyvison.html

Calder, S., & Kluka, D. (2009). The efficacy of eyethinksport training software programme on South African high school cricketers. *African Journal for Physical, Health Education, Recreation & Dance, 15*(1), 44-61.

Carriere J.S., Cheyne J.A., Solman, G.J., & Smilek, D. (2010). Age trends for failures of sustained attention. *Psychology and Aging, 25*(3), 569-74.

Commodari, E. (2012). Attention skills and risk of developing learning difficulties. *Current Psychology, 31*(1), 17-34.

Cowan, N., Morey, C.C., AuBuchon, A.M., Zwilling, C.E., & Gilchrist, A.L. (2010). Seven-year-olds allocate attention like adults unless working memory is overloaded. *Developmental Science, 13*(1), 120-33.

Daley, D., & Birchwood, J. (2010). ADHD and academic performance: Why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom? *Child: Care, Health & Development, 36*(4), 455-464.

Dogru, S. S. (2014). The efficacy of attention training on upskilling the children's ability to notice details and attention focusing skills. *International Journal of Academic Research, 6*(1), 143-149.

Du Toit, P.J., Kruger, P.E., De Wet, K.B., Van Vuuren, B., Joubert, A., Lottering, M.L. & Van Wyk, G.J. (2006). Transfer effects of eye-hand co-ordination skills from the right to the left cerebral hemispheres in South African schoolboy rugby players: Sport. *Ajpherd African Journal for Physical Health Education, Recreation and Dance, 12*(1), 41-49.

Du Toit, P.J., Kruger, P.E., Fowler, K.F., Govender, C. & Clark, J. (2010). Influence of sports vision techniques on adult male rugby players: Sports vision. *Ajpherd African Journal for Physical Health Education, Recreation and Dance, 16*(3), 487-494.

Du Toit, P.J., Kruger, P.E., Joubert, A & Lunsky, J. (2007). Effects of exercise on the visual performance of female rugby players: Sport science. *Ajpherd African Journal for Physical Health Education, Recreation and Dance, 13*(3), 267-273.

Du Toit, P. J., Krüger, P. E., Mahomed, A. F., Kleynhans, M., Jay-Du Preez, T., Govender, C., et al. (2011). The effect of sports vision exercises on the visual skills of university students. *African Journal for Physical, Health Education, Recreation & Dance, 17*(3), 429-440.

Dye, M. W. G. & Bavelier, D. (2004). Playing video games enhances visual attention in children. *Journal of Vision Journal of Vision, 4*(11), 40.

Ellison, P. H., Sparks, S. A., Murphy, P. N., Carnegie, E., & Marchant, D. C. (2014). Determining eye–hand coordination using the sport vision trainer: An evaluation of test–retest reliability. *Research in Sports Medicine, 22*(1), 36-48.

Elmurr, P. (2010). Classical Vision Training: An Introduction to Vision and Sports Performance. Presentation at the Boston Sports Vision meeting, Boston, USA. Available online at: www.sportsvision.com.au. Retrieved, November, 2010.

Elmur, P. (2015). *Training eyehand coordination on the SVT TM.* Retrieved May, 2015, from sportsvision.com.au.

Englund, J.A., Decker, S.L., Allen, R.A. & Roberts, A.M. (2014). Common cognitive deficits in children with Attention-Deficit/Hyperactivity disorder and autism: Working memory and visual-motor integration. *Journal of Psychoeducational Assessment, 32*(2), 95-106.

Forrester, J. V., Dick, A. D., McMenamin, P. G., & Roberts, F. (Eds.). (2008). *The eye - basic sciences in practice* (3rd ed.). Philedelphia, US: Elsevier Limited.

Furley, P. A., & Memmert, D. (2012). Working memory capacity as controlled attention in tactical decision making. *Journal of Sport & Exercise Psychology, 34*(3), 322-344.

Gentile, M. (Ed.). (1997). *Functional visual behaviour - A therapist's guide to evaluation and treatment options* (1st Ed.). United States of America: The American Occupational Therapy Association, Inc.

Goldstand, S., Koslowe, K. & Parush, S. (2005). Visual perception and visual factors - vision, visual information processing, and academic performance among seventh-grade schoolchildren: A more significant relationship than we thought? *The American Journal of Occupational Therapy: Official Publication of the American Occupational Therapy Association., 59*(4), 377.

Green, C. S., & Bavelier, D. (2012). Learning, attentional control, and action video games. *Current Biology, 22*(6), R197-R206.

Griffiths, G. (2015). *A strategy for sports vision assessment.* Retrieved May, 2015, from www.sportsvision.co.uk/pdf/articlestrategy.pfd

Grills-Taquechel, A., Fletcher, J. M., Vaughn, S. R., Denton, C. A., & Taylor, P. (2013). Anxiety and inattention as predictors of achievement in early elementary school children. *Anxiety, Stress & Coping, 26*(4), 391-410.

Hedges, J. H., Adolph, K. E., Amso, D., Bavelier, D., Fiez, J. A., Krubitzer, L., et al. (2013). Play, attention, and learning: How do play and timing shape the development of attention and influence classroom learning? *Annals of the New York Academy of Sciences, 1292*(1), 1-20.

Hsie, P., Chu, C. L., YANG, Y. K, YANG, Y. C., YEH, T. L., LEE, I. H., CHEN, P. S. (2005). Regular article: Norms of performance of sustained attention among a community sample: Continuous performance test study. *Psychiatry and Clinical Neurosciences, 59*(2), 170-176.

Ikkai, A., & Curtis, C. E. (2011). Common neural mechanisms supporting spatial working memory, attention and motor intention. *Neuropsychologia, 49*(6), 1428-1434.

Kanaka, N., Matsuda, T., Tomimoto, Y., Noda, Y., Matsushima, E., Matsuura, M., Kojima, T. (2008). Measurement of development of cognitive and attention functions in children using continuous performance test. *Psychiatry and Clinical Neurosciences, 62*(2), 135-41

Kannass, K. N., Oakes, L. M., & Shaddy, D. J. (2006). A longitudinal investigation of the development of attention and distractibility. *Journal of Cognition & Development, 7*(3), 381-409.

Kerns, K. A., MacSween, J., Vander Wekken, S., & Gruppuso, V. (2010). Investigating the efficacy of an attention training programme in children with foetal alcohol spectrum disorder. *Developmental Neurorehabilitation, 13*(6), 413-422.

Kirk, H. E., Gray, K., Riby, D. M., & Cornish, K. M. (2015). Cognitive training as a resolution for early executive function difficulties in children with intellectual disabilities. *Research in Developmental Disabilities, 38*(0), 145-160.

Kohonen, T. (2002). Modeling of automatic capture and focusing of visual attention. *Proceedings of the National Academy of Sciences of the United States of America, 99*(15), 9813-8.

Kruger, P.E., Campher, J. & Smit, C.E. (2009). The role of visual skills and its impact on skill performance of cricket players: Physical education and sport science. *Ajpherd African Journal for Physical Health Education, Recreation and Dance, 15*(4), 605-623.

Kulp, M. T. (1999). ARTICLES - relationship between visual motor integration skill and academic performance in kindergarten through third grade. *Optometry and Vision Science: Official Publication of the American Academy of Optometry., 76*(3), 159.

Land, W.M., Tenenbaum, G., Ward, P. & Marquardt, C. (2013). Examination of visual information as a mediator of external focus benefits. *Journal of Sport & Exercise Psychology, 35*(3), 250-9.

Land, M. F & Tatler, B. W (Ed.). (2009). *Looking and acting* (2010th Ed.). Great Clarendon Street, Oxford, OX2 6DP: Oxford University Press.

Lewin, D. (2014). Behold: Silence and attention in education. *Journal of Philosophy of Education, 48*(3), 355-369.

Liesker, H., Brenner, Eli., Smeets, J.B.J. (2009). Combining eye and hand in search is suboptimal. *Experimental Brain Research. Experimentelle Hirnforschung. Experimentation Cerebrale, 197*(4), 395-401.

Lombard, A. (2007). In Metz W. (Ed.), *Sensory intelligence, why it matters more than IQ and EQ* (1st Ed.). 1 Cameronians Avenue, Welgemoed, 7560, South Africa: Metz Press.

Mashige, K. P. (2014). A review of assessment and skill training methods used in sports vision. *Ajpherd African Journal for Physical Health Education, Recreation and Dance, 20*(1), 204-213.

McCarthy, P.J., Allen, M.S. & Jones M.V. (2013). Emotions, cognitive interference, and concentration disruption in youth sport. *J.Sports Sci.Journal of Sports Sciences, 31*(5), 505-515.

Merrell, T. (2001). Inattention, hyperactivity and impulsiveness: Their impact on academic achievement and progress. *British Journal of Educational Psychology, 71*(1/1), 43-56.

Motor learning. (n.d.) medical dictionary for the health professions and nursing. (2012). (2016). Retrieved November 9, 2016, from http://medical-dictionary.thefreedictionary.com/motor+learning

Oudejans R.R.D. (2012). Effects of visual control training on the shooting performance of elite female basketball players. *Coaching International Journal of Sports Science and Coaching, 7*(3), 469-480.

Packiam, A.T., Banner, G.E., & Smith, P. (2010). Working memory and cognitive styles in adolescents' attainment. *The British Journal of Educational Psychology, 80*, 567-81.

Peh, S.Y.C., Chow, J.Y., & Davids, K. (2011). Focus of attention and its impact on movement behaviour. *Journal of Science and Medicine in Sport, 14*(1), 70-78.

Perkins-Ceccato, N., Passmore, S., & Lee, T. (2003). Effects of focus of attention depend on golfers' skill. *Journal of Sports Sciences, 21*(8), 593-600.

Posner, M. I., Rothbart, M. K., & Tang, Y. (2015). Enhancing attention through training. *Current Opinion in Behavioral Sciences, 4*(0), 1-5.

Raffone, A., Tagini, A., & Srinivasan, N. (2010). Mindfulness and the cognitive neuroscience of attention and awareness. *Zygon: Journal of Religion & Science, 45*(3), 627-646.

Reilly, D. S., van Donkelaar, P., Saavedra, S., & Woollacott, M. H. (2008). Interaction between the development of postural control and the executive function of attention. *Journal of Motor Behavior, 40*(2), 90-102.

Schwab, S.& Memmert, D. (2012). The impact of a sports vision training program in youth field hockey players. *Journal of Sports Science & Medicine, 11*(4), 624-31.

Silverthorn, D.U. (2007). *Human Physiology: An Integrated Approach*. San Francisco: Pearson Benjamin Cummings.

Steele, A., Scerif, G., Cornish, K., & Karmiloff-Smith, A. (2013). Learning to read in Williams syndrome and Down syndrome: Syndrome-specific precursors and developmental trajectories. *JCPP Journal of Child Psychology and Psychiatry, 54*(7), 754-762.

Tang, Y., & Posner, M. I. (2009). Attention training and attention state training. *Trends in Cognitive Sciences, 13*(5), 222-227.

Titz, C & Karbach, J. (2014). Working memory and executive functions: Effects of training on academic achievement. *Psychological Research Psychological Research: An International Journal of Perception, Attention, Memory, and Action, 78*(6), 852-868.

Van der Molen, M. J., Van Luit, J. E. H., Van der Molen, M. W., Klugkist, I., & Jongmans, M. J. (2010). Effectiveness of a computerised working memory training in adolescents with mild to borderline intellectual disabilities. *Journal of Intellectual Disability Research, 54*(5), 433-447 15p.

Vast, R. L., Young, R. L., & Thomas, P. R. (2010). Emotions in sport: Perceived effects on attention, concentration, and performance. *Australian Psychologist, 45*(2), 132-140.

Walker, S., Venter, A., & van der Walt, A. (2011). Prevalence of Attention-Deficit/Hyperactivity disorder (ADHD) symptomatology and psychiatric comorbidity among adolescents diagnosed with ADHD in childhood. *South African Journal of Psychiatry, 17*(1), 261.

Weinberg, R.S & Gould, D. (2011). *Foundations of sport and exercise psychology*. Champaign, IL: Human Kinetics.

Wilson, M. (2011). Quiet-eye training for soccer penalty kicks. *Cognitive Processing, 12*(3), 257-266.

Wimshurst, Z., L., Sowden, P. T., & Cardinale, E. M. (2012). Visual skills and playing positions of Olympic field hockey players. *Perceptual & Motor Skills, 114*(1), 204-216.

Wu, S., & Gau, S. S. (2013). Correlates for academic performance and school functioning among youths with and without persistent attention-deficit/hyperactivity disorder. *Research in Developmental Disabilities, 34*(1), 505-515.

Wulf, G., Jiang, S. (2007). An external focus of attention enhances golf shot accuracy in beginners and experts. *Research Quarterly for Exercise & Sport, 78*(4)

Wulf, G., Shea, C., & Lewthwaite, R. (2010). Motor skill learning and performance: A review of influential factors. *Medical Education, 44*(1), 75-84.

APPENDICES

APPENDIX A: ETHICAL CLEARANCE

UNIVERSITY *of the* WESTERN CAPE

DEPARTMENT OF RESEARCH DEVELOPMENT

UWC RESEARCH PROJECT REGISTRATION AND ETHICS CLEARANCE

APPLICATION FORM

This application will be considered by CHS Faculty Higher Degrees Committee [CHSHD] (student projects)/CHS Faculty Research Committee [CHR] (staff projects), then by the UWC Senate Research Committee [SR]. SR may also consult outsiders on ethics questions, or consult the UWC ethics subcommittees, before registration of the project and clearance of the ethics. No project should proceed before project registration and ethics clearance has been granted.

A. PARTICULARS OF INDIVIDUAL APPLICANT	
NAME: Anélma Janse van Rensburg	TITLE: Mrs.
DEPARTMENT: Sport, Recreation and Exercise Science	FACULTY: Community & Health Sciences
FIELD OF STUDY: Masters Sport & Exercise Science	

ARE YOU:	
A member of UWC academic staff?	Yes ☐ No ☒
A member of UWC support staff?	Yes ☐ No ☒
A registered UWC student?	Yes ☒ No ☐
From outside UWC, wishing to research at or with UWC?	Yes ☐ No ☒

PARTICULARS OF PROJECT
PROJECT NUMBER: TO BE ALLOCATED BY SENATE RESEARCH COMMITTEE:
EXPECTED COMPLETION DATE: November 2017
PROJECT TITLE: The effect of a four-week web-based visual skills training program (EyeGym®) on attention, timing and eye-hand coordination in Grade 9 learners.
THREE KEY WORDS DESCRIBING PROJECT: Attention, Visual skills, Sport skills
PURPOSE OF THE PROJECT: To investigate the effects of vision training (Eyegym) on attention and timing as well on sport skills. M-DEGREE: MA Sport Science D-DEGREE: POST GRADUATE RESEARCH:

C. PARTICULARS REGARDING PARTICULAR RESEARCHERS

	FAMILY NAME:	INITIALS:	TITLE:
PRINCIPAL RESEARCHER:	Andrews	BS	DR
OTHER RESEARCH PROJECT LEADERS: n/a			
OTHER CO-RESEARCHERS: n/a			
THESIS: STUDENT RESEARCHER:	Janse van Rensburg	A	Mrs.
THESIS: SUPERVISOR:	Andrews	BS	Dry

GENERAL INFORMATION

STUDY LEAVE TO BE TAKEN DURING PROJECT (days): 14

IS IT INTENDED THAT THE OUTCOME WILL BE SUBMITTED FOR PEER REVIEWED PUBLICATION?

YES ☒ NO ☐

COMMENTS: DEPARTMENTAL CHAIRPERSON:

SIGNATURE OF THESIS STUDENT RESEARCHER – WHERE APPROPRIATE: Mrs. A Janse van Rensburg

DATE: 07/08/2015

SIGNATURE OF THESIS SUPERVISOR – WHERE APPROPRIATE: Dr. BS Andrews

DATE 07/08/2015

SIGNATURE OF PRINCIPAL RESEARCHER – WHERE APROPRIATE:

DATE:

SIGNATURE OF DEPARTMENTAL CHAIRPERSON: Prof A. Travill

DATE 07/08/2015

NOTE: THESE SIGNATURES IMPLY AN UNDERTAKING *BY THE RESEARCHERS*, TO CONDUCT THE RESEARCH ETHICALLY, AND AN UNDERTAKING BY THE THESIS SUPERVISOR (WHERE APPROPRIATE), AND THE DEPARTMENTAL CHAIRPERSON, TO MAINTAIN A RESPONSIBLE OVERSIGHT OVER THE ETHICAL CONDUCT OF THE RESEARCH.

APPENDIX B: LETTER FROM WCED

UNIVERSITY *of the* WESTERN CAPE

DEPARTMENT OF RESEARCH DEVELOPMENT

15 January 2016

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape approved the methodology and ethics of the following research project by:
Mrs A Janse van Rensburg (SRES)

Research Project:	The effect of a four-week web-based visual skills training program (EyeGym®) on attention, timing and eye-hand coordination in Grade 9 learners.
Registration no:	15/7/84

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Private Bag X17, Bellville 7535, South Africa
T: +27 21 959 2988/2948 . F: +27 21 959 3170
E: pjosias@uwc.ac.za
www.uwc.ac.za

A place of quality,
a place to grow, from hope
to action through knowledge

APPENDIX C: LETTER FROM STELLENBERG HIGH

HOËRSKOOL STELLENBERG HIGH SCHOOL

Vivat Scientia

Laat Kennis Leef
Let Knowledge Live

VIR WIE DIT MAG AANGAAN

Hiermee word bevestig dat **Anelma Janse van Rensburg** haar meestersgraad se intervensieprogram by Hoërskool Stellenberg kan doen.

Vriendelike groete

YHavinga

Y. HAVINGA
DEPUTY PRINCIPAL: ACADEMICS
1-Dec-16

HOËRSKOOL STELLENBERG
PRIVAATSAK X2 TYGERPARK
PRIVATE BAG X2 TYGER PARK
7536
STELLENBERG HIGH SCHOOL

PRIVAATSAK/PRIVATE BAG X2 · TYGERPARK · 7536 · TEL 919 1029 · FAKS/FAX 919 3420
e-pos/e-mail: info@stellenberg.org.za

GELOOF INTEGRITY UITNEMENDHEID RESPONSIBILITY

APPENDIX D: INFORMATION SHEET TO PARENTS AND LEARNERS

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959-3688, Fax: 27 21-959-3137

E-mail: bandrews@uwc.ac.za

INFORMATION SHEET

Project Title: The effect of a web-based comprehensive cognitive and sport related visual training program specifically designed to enhance sporting productivity, attention and timing on 13 - 15-year-old adolescents.

What is this study about?

This is a research project being conducted by Anélma Janse van Rensburg from the University of the Western Cape. We are inviting your child to participate in this research project because he or she is in Grade 9 at Stellenberg High and is also participating in sport. The purpose of this research project is to test whether a computer based program (Eyegym), a visual skills training program, has an influence on concentration, timing and sport skills.

What will I be asked to do if I agree to participate?

Your child will be asked to be part of either a group that will receive the above intervention (Eyegym) (visual skills training) or be part of a control group that does not receive the intervention. The visual skills training will take place over 6 weeks, three times per week, at Stellenberg High's computer centre. Your child will undergo computer based testing where I assess his/her concentration and timing as well as an eye-hand coordination test. He/she will be re-tested after six weeks for the same tests. Testing will be 20 minutes per learner. The actual visual skills training will be 10 to 20 minutes per session.

Would my participation in this study be kept confidential?

The researchers undertake to protect your identity and the nature of your child's contribution. To ensure their anonymity, their name will not be included on the surveys and other collected data; a code will have used. Only the researcher will have access to the identification key linked to the code. All collected data will be stored in a safe place. Only the researchers will have access to this. If we write a report or article about this research project, your identity will remain protected.

What are the risks of this research?

There may be some risks from participating in this research study. All human interactions and talking about self or others carry some amount of risks. We will nevertheless minimize such risks and act promptly to assist your child if they should experience any discomfort, psychological or otherwise during the process of their participation in this study. Some children might find the testing and intervention mentally exhausting, it will be tough for some children, they must just try as hard as they can and will not be forced to complete the test if it is too difficult. Refreshments will be provided after the test before the children return to their classes. Any child that appears stressed will be offered a debriefing by the tester and he/she will inform the class teacher. Where necessary, an appropriate referral will be made to a suitable professional for further assistance or intervention.

What are the benefits of this research?

This research is not designed to help your child personally, but the results may help the investigator learn more about the influence of visual skills training (Eyegym) on concentration and timing and eye-hand coordination. We hope that, in the future, other people might benefit from this study through improved understanding of how visual skills training can enhance concentration or attention, which can influence academic performance as well as sport sports performance.

Do I have to be in this research and may I stop participating at any time?

Your child's participation in this research is completely voluntary. Your child may choose not to take part at all. If your child decides to participate in this research, your child may stop participating at any time. If your child decide not to participate in this study or if your child stop participating at any time, your child will not be penalized or lose any benefits to which your child otherwise qualify.

What if I have questions?

This research is being conducted by *Anélma Janse van Rensburg from the Department of Sport, Recreation and Exercise* at the University of the Western Cape. If you have any questions about the research study itself, please contact *Anélma Janse van Rensburg* at: 082 852 4453, anelma@etasa.co.za.

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Head of Department:

Prof A. Travill

University of the Western Cape

Private Bag X17

Bellville 7535

Tel: 021 959 3934

Email: atravill@uwc.ac.za

Dean of the Faculty of Community and Health Sciences:

Prof José Frantz

University of the Western Cape

Private Bag X17

Bellville 7535

chs-deansoffice@uwc.ac.za

This research has been approved by the University of the Western Cape's Senate Research Committee and Ethics Committee.

APPENDIX E: PARENTAL PERMISSION FORM

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959 3137, Fax: 27 21-959 3137

E-mail: bandrews@uwc.ac

PARENTAL PERMISSION FORM

Title of Research Project: The effect of a four-week web-based visual skills training program on attention, timing and eye-hand coordination in 13 - 15 year old adolescents.

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my child's participation will involve and I agree to allow them to participate of my own choice and free will. I understand that their identity will not be disclosed to anyone. I understand that I may withdraw them or them may withdraw themselves from the study at any time without giving a reason and without fear of negative consequences or loss of benefits.

Parent's name……………………….

Parent's signature……………………………….

Participant's name………………………..

Date………………………

APPENDIX F: LEARNER ASSENT FORM

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21-959 3137, Fax: 27 21-959 3688

E-mail: bandrews@uwc.ac.za

ASSENT FORM

Title of Research Project: The effect of a four-week web-based visual skills training program on attention, timing and eye-hand coordination in 13 - 15-year-old adolescents.

The study has been described to me in language that I understand. My questions about the study have been answered. I understand what my participation will involve and I agree to participate of my own choice and free will. I understand that my identity will not be told to anyone. I understand that I may withdraw from the study at any time without giving a reason and without fear of anything bad happening to me or me losing anything.

Participant's name………………………..

Participant's signature……………………………….

Date………………………

APPENDIX G: LEARNER DEMOGRAPHIC FORM

VISION INTERVENTION QUESTIONNAIRE

Please read and complete all sections of this questionnaire.

Name of learner ☐

Surname of learner ☐

Current Age ☐ years ☐ months

Birthdate ☐ Year ☐ Month ☐ Day

Gender

Male ☐
Female ☐

Ethnicity

White ☐
Black ☐
Coloured ☐
Other ☐

Do you take part in sport?

Yes ☐
No ☐

In what sport do you take part currently?

Hockey ☐
Rugby ☐
Netball ☐
Tennis ☐
Cricket ☐
Cycling / MTB ☐
Athletics ☐
Running ☐
Dance ☐
Shooting ☐
Swimming ☐
Other ☐
If other, please specify ☐

Level of participation

National ☐
Provincial ☐
Regional ☐
First team ☐
Second team ☐
Third team and lower ☐

Cellphone use
How many hours per day are you on your phone/ facebook / social media?

Less than 1 hour / day ☐
Between 1 - 2 hrs / day ☐
Between 3 - 4 hrs / day ☐
Between 4 - 5 hrs / day ☐
More than 6 hrs / day ☐

Do you wear glasses?

Yes ☐
No ☐

Did you ever do any eye exercises in the past for sport or school?

Yes ☐
No ☐

How many hours per week to you spend on participating in sport?

Less than 1 hour / week ☐
Between 1 - 2 hrs / week ☐
Between 3 - 4 hrs / week ☐
Between 4 - 5 hrs / week ☐
More than 6 hrs / week ☐

Computer use
How many hours per day are you on your computer or game station, playing games?

Less than 1 hour / day ☐
Between 1 - 2 hrs / day ☐
Between 3 - 4 hrs / day ☐
Between 4 - 5 hrs / day ☐

Do you play action games on your computer or game station?

Yes ☐
No ☐

How many hours per week do you participate in sport

Less than 1 hour / week ☐
Between 1 - 2 hrs / week ☐
Between 3 - 4 hrs / week ☐

Recreational Club		Between 4 - 5 hrs / week More than 6 hours per week	

APPENDIX H: SELF-PERCEPTION FORM

SELF – PERCEPTION QUESTIONNAIRE Participant name:

Sometimes we do things unintentionally or without thinking about it and some we do it more often than others. Read the following statements and think about how these apply to yourself in the last 6 months. Please place a cross in the appropriate block.	**Most of the time** **4**	**Hardly ever** **3**	**Almost never** **2**	**Never** **1**
1. Sometimes when I read, and realise after a while that I cannot remember what I have read.				
2. Sometimes when I sit in class, I listen for a while to the teacher and then I start thinking about other stuff.				
3. When I am busy with a class tasks, I tend to lose interest sometimes because a friend or class mates talks too loud.				
4. I sometimes start a task and then start with a new one before the first one was completed.				
5. I sometimes cannot choose which tasks or homework I need to do first.				
6. I sometimes listen to a friend or a teacher and then start thinking about other stuff.				
7. I sometimes will see the teachers or a friend speaking to me, but cannot remember what they said because I was busy with another task.				
8. Sometimes I struggle with homework or a class task because I cannot remember what the teachers said I must do.				
9. I sometimes struggle to memorize my work for a test?				
10. I sometimes listen to the teacher for the first half of the class, and then loose concentration for the second half.				
11. I sometimes struggle to complete class tasks in the allocated time.				
12. I sometimes ask the teachers to explain a task again because I struggled to understand what was explained.				
13. I sometimes lose my temper because of feeling frustrated.				
14. I sometimes struggle to sit still in class.				
15. I sometimes get up in class and start walking around.				
16. I sometimes do not feel motivated to complete a task.				
17. I sometime rush my tasks and schoolwork because I want to get it done as fast as possible.				
18. I sometimes struggle to wait in a line for something.				
19. I sometimes struggle to read on my own because I would rather move around?				

APPENDIX I: TABLE OF RESULTS - SELF PERCEPTION

LSD test: Self Perception Question 1 (Attention)						
1st Mean	2nd Mean	Mean Differ.	Standard Error	p	-95.00% Cnf.Lmt	+95.00% Cnf.Lmt
Intervention*Test1	Intervention*Test2	0,367350	0,191551	0,065393	-0,02502	0,759724
Control*Test1	Control*Test2	0,511125	0,207498	0,020177	0,08608	0,936166
LSD test: Self Perception Question 2 (Attention)						
Intervention*Test1	Intervention*Test2	0,490701	0,249091	0,058806	-0,01954	1,000940
Control*Test1	Control*Test2	0,518487	0,273604	0,068457	-0,04197	1,078939
LSD test: Self Perception Question 3 (Attention)						
Intervention*Test1	Intervention*Test2	0,142398	0,218998	0,520847	-0,30620	0,590996
Control*Test1	Control*Test2	0,815823	0,237647	0,001876	0,32902	1,302621
LSD test: Self Perception Question 4 (Attention)						
Intervention*Test1	Intervention*Test2	0,405332	0,249905	0,116023	-0,10658	0,917240
Control*Test1	Control*Test2	0,433461	0,272779	0,123277	-0,12530	0,992223
LSD test: Self Perception Question 5 (Attention)						
Intervention*Test1	Intervention*Test2	0,662123	0,218594	0,005228	0,21435	1,109893
Control*Test1	Control*Test2	-0,086105	0,237120	0,719237	-0,57182	0,399614
LSD test: Self Perception Question 6 (Attention)						
Intervention*Test1	Intervention*Test2	0,298505	0,254120	0,250025	-0,22204	0,819046
Control*Test1	Control*Test2	-0,114596	0,277875	0,683184	-0,68380	0,454604
LSD test: Self Perception Question 7 (Attention)						
Intervention*Test1	Intervention*Test2	0,404957	0,226039	0,084023	-0,058063	0,867976
Control*Test1	Control*Test2	-0,377326	0,247823	0,139083	-0,884968	0,130316
LSD test: Self Perception Question 8 (Attention)						
Intervention*Test1	Intervention*Test2	0,045018	0,253847	0,860517	-0,47497	0,565001
Control*Test1	Control*Test2	0,519031	0,277412	0,071833	-0,04922	1,087285
LSD test: Self Perception Question 9 (Attention)						
Intervention*Test1	Intervention*Test2	0,287740	0,226028	0,213477	-0,17526	0,750739
Control*Test1	Control*Test2	0,408695	0,245483	0,107093	-0,09415	0,911544
LSD test: Self Perception Question 10 (Attention)						
Intervention*Test1	Intervention*Test2	0,526530	0,249650	0,044010	0,01515	1,037914
Control*Test1	Control*Test2	-0,114865	0,273194	0,677365	-0,67448	0,444747
LSD test: Self Perception Question 11 (Attention)						
Intervention*Test1	Intervention*Test2	0,407634	0,205699	0,057408	-0,01372	0,828989
Control*Test1	Control*Test2	0,248149	0,222836	0,274921	-0,20831	0,704608
LSD test: Self Perception Question 12 (Attention)						
Intervention*Test1	Intervention*Test2	0,211739	0,233661	0,372574	-0,26689	0,690372
Control*Test1	Control*Test2	0,005073	0,256672	0,984370	-0,52070	0,530843

LSD test: Self Perception Question 13 (Hyperactivity & Impulsiveness)						
1st Mean	2nd Mean	Mean Differ.	Standard Error	p	-95.00% Cnf.Lmt	+95.00% Cnf.Lmt
Intervention*Test1	Intervention*Test2	0,546907	0,248926	0,036456	0,03701	1,056808
Control*Test1	Control*Test2	0,542640	0,271575	0,055500	-0,01366	1,098935
LSD test: Self Perception Question 14 (Hyperactivity & Impulsiveness)						
Intervention*Test1	Intervention*Test2	0,127131	0,241223	0,602326	-0,36699	0,621254
Control*Test1	Control*Test2	0,309237	0,262342	0,248415	-0,22815	0,846621
LSD test: Self Perception Question 15 (Hyperactivity & Impulsiveness)						
Intervention*Test1	Intervention*Test2	-0,171650	0,240292	0,480931	-	0,320566

					0,663866	
Control*Test1	Control*Test2	-0,076673	0,262604	0,772459	-0,614593	0,461246
LSD test: Self Perception Question 16 (Hyperactivity & Impulsiveness)						
Intervention*Test1	Intervention*Test2	0,144385	0,293199	0,626243	-0,456207	0,744977
Control*Test1	Control*Test2	-0,119048	0,323550	0,715683	-0,781809	0,543714
LSD test: Self Perception Question 17 (Hyperactivity & Impulsiveness)						
Intervention*Test1	Intervention*Test2	0,202951	0,212633	0,348015	-0,23261	0,638509
Control*Test1	Control*Test2	0,017539	0,230482	0,939882	-0,45458	0,489660
LSD test: Self Perception Question 18 (Hyperactivity & Impulsiveness)						
Intervention*Test1	Intervention*Test2	-0,042565	0,234550	0,857303	-0,52302	0,437890
Control*Test1	Control*Test2	0,304406	0,255150	0,242863	-0,21825	0,827058
LSD test: Self Perception Question 19 (Hyperactivity & Impulsiveness)						
Intervention*Test1	Intervention*Test2	0,318965	0,226801	0,170617	-0,14562	0,783546
Control*Test1	Control*Test2	0,287401	0,247972	0,256243	-0,22055	0,795350

APPENDIX J: TABLE OF RESULTS - EYEGYM® (INTERVENTION PROGRAM)

Peripheral Response and Reaction %						
Test groups		**Mean Differ.**	**Standard Error**	**p**	**-95.00% Cnf.Lmt**	**+95.00% Cnf.Lmt**
Intervention*Test1	Intervention*Test2	0.14	0.29	0.61	-0,44	0.74
Control*Test1	Control*Test2	0.21	0.31	0.50	-0,43	0.84
Visual Concentration and Tracking %						
Intervention*Test1	Intervention*Test2	**-2.57**	**1.14**	**0.03**	**-4.88**	**-0.25**
Control*Test1	Control*Test2	-2.06	1.7	0.11	-4.64	0.52
Visual Recognition %						
Intervention*Test1	Intervention*Test2	-9.11	4.57	0.05	-18.35	0.13
Control*Test1	Control*Test2	-7.57	4.95	0.13	-17.60	2.44
Detailed eye tracking %						
Intervention*Test1	Intervention*Test2	**-18.35**	**6.36**	**0.01**	**-31.20**	**-5.47**
Control*Test1	Control*Test2	-7.36	7.00	0.29	-21.51	6.78
Eye Jump & Coordination %						
Intervention*Test1	Intervention*Test2	**-33.00**	**4,83**	**0.01**	**-42.77**	**-23.23**
Control*Test1	Control*Test2	**-24.54**	**5.43**	**0.01**	**-35.53**	**-13.56**
Eye hand reaction standard %						
Intervention*Test1	Intervention*Test2	**-8.17**	**2.89**	**0.01**	**-14.01**	**-2.34**
Control*Test1	Control*Test2	**-7.89**	**3.18**	**0.02**	**-14.31**	**-1.47**
Perception Speed & Coordination %						
Intervention*Test1	Intervention*Test2	-2.05	1.46	0.17	-5.01	0,91
Control*Test1	Control*Test2	-2.16	1.58	0.18	-5.37	1,05

APPENDIX K: TABLE OF RESULTS - EYEGYM® CORRELATION

WITH EYE-HAND COORDINATION VARIABLES

Eyegym™ correlation with SVT Proactive and Reactive Eye-hand Coordination					
Variable 1	**Variable 2**	**Test 1**		**Test 2**	
		Pearson	**Pearson p**	**Pearson**	**Pearson p**
Detailed eye tracking %	SVT Proactive time	0,12	0,48	-0,07	0,66
Detailed eye tracking %	SVT Reactive %	-0,20	0,22	0,22	0,16
Eye jumps & co-ordination %	SVT Proactive time	-0,09	0,57	-0,21	0,20
Eye jumps & co-ordination %	SVT Reactive %	0,03	0,86	0,30	0,06
Eye-hand reaction standard %	SVT Proactive time	0,06	0,71	0,07	0,66
Eye-hand reaction standard %	SVT Reactive %	-0,07	0,68	0,02	0,89
Visual Concentration and Tracking %	SVT Proactive time	0,13	0,42	-0,02	0,92
Visual Concentration and Tracking %	SVT Reactive %	-0,03	0,84	-0,11	0,51

APPENDIX L: TABLE OF RESULTS – GENDER COMPARISON PER VARIABLE

LSD test: ATTENTION (Gender)				
Test groups		**Mean**	**Standard**	**p**
Intervention*Test1*Female	Intervention*Test2*Female	1,21	2,71	0,66
Intervention*Test1*Male	Intervention*Test2*Male	2,54	3,50	0,47
Control*Test2*Female	Control*Test3*Female	0,54	4,44	0,90
Control*Test2*Male	Control*Test3*Male	0,14	2,95	0,96
LSD test: TIMING (Gender)				
Intervention*Test1*Female	Intervention*Test2*Female	-7,79	5,09	0,13
Intervention*Test1*Male	Intervention*Test2*Male	-2,41	6,62	0,72
Control*Test2*Female	Control*Test3*Female	-9,58	8,65	0,27
Control*Test2*Male	Control*Test3*Male	-4,13	5,59	0,46
LSD test: PROACTIVE EYE-HAND COORDINATION (Gender)				
Intervention*Test1*Female	Intervention*Test2*Female	0,61	0,68	0,37
Intervention*Test1*Male	Intervention*Test2*Male	1,24	0,87	0,16
Control*Test2*Female	Control*Test3*Female	0,83	0,99	0,40
Control*Test2*Male	Control*Test3*Male	1,01	0,72	0,17
LSD test: REACTIVE EYE-HAND COORDINATION (Gender)				
Intervention*Test1*Female	Intervention*Test2*Female	-8,50	4,40	0,06
Intervention*Test1*Male	Intervention*Test2*Male	-8,52	5,57	0,13
Control*Test2*Female	Control*Test3*Female	13,28	6,40	0,04
Control*Test2*Male	Control*Test3*Male	7,23	4,63	0,12