DESIGN, RELIABILITY AND VALIDITY OF A PAEDIATRIC RATE OF READING CHART.

By

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2012

DESIGN, RELIABILITY AND VALIDITY OF A PAEDIATRIC RATE OF READING (PRR) CHART

By

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Submitted in part fulfillment of the requirements for the degree of

MASTERS OF OPTOMETRY

in the Discipline of Optometry

School of Health Sciences (Westville campus)

at the **University of KwaZulu-Natal**

SUPERVISOR: Professor O. A. Oduntan

DATE: November 2012

DECLARATION

I, Urvashni Nirghin, hereby declare that the dissertation submitted for the degree Master in Optometry to the University of KwaZulu-Natal has not been submitted before for consideration of a degree at this University or any other University previously.

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ABSTRACT

Background: Reading rate is a measure of fluency, reflecting the level of reading performance especially in children, which is not typically measured during routine eye examinations. Optometric clinical tests such as Snellen visual acuity are often poor predictors of everyday reading performance, as they test the smallest print a person is able to read rather than fluency. Conventional reading rate tests for educational purposes presents with many limitations; they concentrate on linguistic skills, increase in complexity as the reading progresses, limited by the readers vocabulary but more importantly, they do not take the level of the child's vision into consideration. There is currently no reading rate chart that is designed with optometric notations specifically for children with normal vision and low vision. It is therefore necessary to design a reading rate chart that takes the above limitations into consideration.

Aim: This study aimed to design a chart that can be used to measure reading rates in normal sighted and low vision primary school children.

Methods: The aim of the study was achieved in four parts; the design, reliability, validity of a reading rate chart and finally the testing of the chart on low vision participants. In the design of the chart, ten frequently used words in grade one English reading books were randomly selected from five primary schools in KwaZulu-Natal province, South Africa. The reliability and validity of the chart were established on normal sighted children, aged nine to twelve years from two primary schools in the Durban area chosen by convenience sampling method, with sample size of 100 for reliability and 100 for validity. Reliability was established with test and retest reading rates using the new chart while validity was established by determining the reading rates using new the chart and the Wilkins reading rate chart. Data were analyzed using the Paired *t*-test, Pearson correlation, and Bland and Altman method. Finally, the testing of the new chart without and with low vision device, on fourteen low vision children, aged eight to

nineteen years, attending a school for the visually impaired in KwaZulu-Natal. Data was analyzed using Paired *t*-test and Pearson correlation.

Results: The words were arranged in random order, ten words per row and ten rows per paragraph. The chart consisted of six paragraphs (versions A, B, C, D, E and F) with six acuity levels and four optometric notations. Each version was printed on a separate sheet, in Arial and Times New Romans fonts and printed in black ink on approximately white cardboards. In reliability, the mean test and retest reading rates were 77.65 ± 25.30 and 78.23 ± 24.70 (p = 0.29, R^2 = 0.95). In Bland and Altman method, the mean difference was −0.58 with confidence limits at +10.07 and -11.23. In validity, reading rate for Wilkins chart and the new chart were 75.82 ± 23.64 and 74.92 ± 23.58 (p = 0.01, R^2 = 0.99) respectively. In Bland-Altman method, the mean difference was +0.90, upper limit at +6.33 and lower limit at –4.53. The mean reading rate, of the low vision children, without and with the low vision device were 59.32 ± 24.08 words per minute (wpm) and 67.04 ± 25.63 words per minute (wpm) respectively (p = 0.09 and r = 0.82).

Conclusions: This chart can be used for reading rate assessment for both normally sighted and low vision children and is statistically reliable and valid.

DEDICATION

This dissertation is dedicated to

My family for their continuous support and love

&

All the children with learning difficulties and visual impairment throughout the world.

ACKNOWLEDGEMENTS

This research would have not been possible without the help and support of the following people:

To my family especially my husband Rakesh and children Dheeya and Nirja for their personal support and patience.

To my supervisor, Professor O.A Oduntan, for his expert advice, guidance and invaluable knowledge, for which I am extremely grateful.

All the children that participated in the study.

Staff members at the various schools that have given support and assistance during data collection.

A very special thank you to my friends for their encouragement and unwavering support during the duration of my study.

Staff members at the discipline of Optometry at the University of KwaZulu-Natal, who have rendered their motivation and support

Finally, my intense gratitude to God, for giving me the strength to pursue and complete this study.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

School children spend more than six hours a day at school, of which four to five hours are intended to be spent on academic-related work. Approximately half of the learner‟s academic work day is spent on reading (Ritty, Solan, & Cool, 1993). The reading tasks include sustained reading at near point, from a book or worksheet, and far point from the chalkboard.

Reading is related to an individual‟s experience, ability, and neurological functioning (Committee on Children with Disabilities, 1998). Griffin *et al.* (1997) stated that reading is also affected by multiple factors which include intelligence level, educational exposure, primary emotional, mental and physical state, auditory, speech and vision, the latter being the key sensory input to reading (Ellis, 1987). As reading is performed daily by both normally sighted individuals and those with low vision, a reduction in vision may limit reading performance therefore restricting learning (Ahn & Legge, 1995; Goodrich & Kirby, 2001). Hence low vision children‟s reading performance may not be comparable to that of normally sighted children.

As a child learns to read, the words are stored in their memory banks or forms part of their vocabulary and when the words are encountered again, they are retrieved

from this memory bank (Stanovich *et al*., 1984). The process of retrieving words from the memory bank is referred to as automaticity (Howell & Lorson, 1990; Therrien, 2004; Wise *et al*., 2010). When automaticity is reached, the learner performs the reading task so rapidly that it occurs effortlessly or without paying attention (Howell & Lorson, 1990; Therrien, 2004; Wise *et al*., 2010). Automaticity in reading therefore frees the reader from basic word decoding and enables them to concentrate on higher thought processes such as the meaning of the text (Howell & Lorson, 1990; Therrien, 2004; Wise *et al*., 2010); therefore as automaticity increases, fluency develops.

Fluency is an important indicator of reading performance and is measured by reading rate (Wise *et al*., 2010). Reading rate is calculated as the number of correct words read per minute (Eperjesi, Fowler, & Evans, 2004; Espin & Deno, 1993). As the learner matures and the average reading fluency increases, the rate of correct words read per minute is regarded as a sensitive measure of overall reading progress (Hasbrouck & Tindal, 1992; Wise *et al*., 2010). Therefore when considering the design of a reading test chart, reading rate should be considered as the key factor to assess overall reading performance.

Conventional reading rate tests are tests that have been accepted but not necessarily researched. They may also have been designed for educational use, whereby the following items apply:

(1) tests assess the linguistic and semantic aspects of reading;

(2) the complexity of the words and contents increase in complexity until the reader fails;

(3) performance is usually limited by a reader"s vocabulary and knowledge, and adults therefore score at or near the ceiling; and
(4) children with poor reading ability are aware of their failures and are often embarrassed by them (Wilkins *et al*., 1996).

Even though reading rate is frequently measured in educational settings, Snellen visual acuity and other common clinical tests used by optometrists are often poor predictors of everyday reading function (Ahn & Legge, 1995). Reading rate is an example of everyday visual function that is not typically measured during routine eye examinations especially on children (Legge *et al*., 1992; Legge et al., 1985). Optometric reading tests are designed for near assessment such as near visual acuity and prescribing near additions (Mansfield, Ahn, Legge, & Leubker, 1993). These reading tests may contain single optotypes or connected texts. However, the texts used may not be suitable for young children with limited vocabulary.

Optometric charts such as the Bailey and Lovie and the MNREAD charts measure reading rate and are available in varying print sizes catering for low vision subjects, however, the words used in the charts do not take into consideration the limited vocabulary of children (Bailey & Lovie, 1980; Ahn & Legge, 1995; Elliott, Patel & Whitaker, 2001). The Wilkins Rate of Reading test is a non-optometric chart that also measures reading rate (Wilkins *et al*., 1996). However, the effect of visual factors such as coloured overlays and visual distortions on reading rate is assessed. The words used in the design of the chart are suitable for children as young as seven years. This chart is only available in two print sizes and anecdotal evidence reveals that this chart is not suitable for most low vision subjects.

1.2 SIGNIFICANCE OF THE STUDY

Reading rate is an important indication of reading fluency but there are no optometric charts which measure reading rate, specifically designed for children, that can be used on both the normally sighted and low vision children. It is therefore necessary to design a chart that measures reading rate and is appropriate for use on children with normal and low vision. Further, as reading problems and illiteracy are strongly associated with unemployment, poverty, crime *etc.* (Mecer *et al*., 2000); a possible outcome of this research is to improve the level of literacy in society through detection and early management of difficulties that may hinder learning.

1.3 AIM

The aim of this study was to design a reading rate test chart that can be used to determine reading rate in normal sighted and low vision primary school children (aged 6 to 12 years old).

1.4 OBJECTIVES

The objectives of this study were to:

1. Design a rate of reading test chart for normally sighted and low vision children.
2. Establish reliability of the new chart.
3. Establish validity of the new chart.
4. Test the new chart on a selected number of low vision patients without and with low vision device.

1.5 CONCLUSION

Many of the visual problems contributing to reading difficulties can be completely eliminated or partly addressed with direct optometric intervention. It is therefore imperative that optometric examinations should incorporate reading assessments, as well as to ensure that appropriate tests are readily available to assess children with a range of visual impairments. Kiely *et al.* (2001) also states that optometrists play a significant role in maintaining visual comfort during reading thus allowing a child to persevere with reading tasks. Even reading difficulties experienced by low vision children, can be effectively managed with the aid of appropriate low vision devices (Lueck, 2004). Any non-visual causes of reading difficulties can be identified by optometrists and referred to appropriate professionals (Griffin *et al*., 1997). These professionals may include educators, psychologists, physicians and other professionals concerned with reading difficulties.

1.6 OUTLINE OF THE PRESENT STUDY

Following the introduction of this study in chapter one, this study is further addressed in subsequent chapters. Chapter two reviews the reading process, factors affecting the reading process, the various reading assessments available in both educational and optometric fields, as well as the limitations of these tests. Chapter three explains the entire methodology adopted in this study which follows four parts; the design of the new reading rate chart, the reliability and validity testing of the new chart on normally sighted children, and finally the trial use of the new chart on low vision children. The results of this study are subdivided into four parts (as in chapter three) and are presented in chapter four. The discussion and conclusion drawn from the results are presented in chapter five. Finally in chapter six, the recommendations and limitations of the study are addressed.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Reading is a complex process involving a series of intricate neurological processes that range from basic word recognition to higher order processes such as comprehension. As it is necessary to assess reading performance in children, it is also necessary to understand what reading entails. This chapter presents an overview of reading, the processes involved in reading, the various stages of reading, importance and types of reading, factors influencing reading, reading disability, reading rate, the various reading assessments currently available and the limitations of these assessments. Reading is performed by both normal sighted and low vision children and the processes involved in reading are similar. It is therefore necessary to have some knowledge regarding low vision and reading in low vision children. These aspects are also addressed in this chapter.

2.2 READING

Reading may be defined as "*the mapping of meaningful language onto symbols"*; or, "*the reconstituting of language from its symbolic form into its original state"* (Rosner, 1990a, 1990b). This definition applies not only to "visual" reading but also to a blind person. Hence reading is not exclusively a "visual" or "auditory" behavior but, rather, a blending of the two in a way that enables a person to convert a

visual, a tactile, or an acoustical code into meaningful information (Garzia, 1996). For the purpose of this study, only the visual aspects of reading will be discussed.

2.2.1 Reading Processes

Reading is a complex multilevel learning process involving cognitive and linguistic functioning (Kamhi & Catts, 1989). If there is a disruption in any of these processes, then reading is affected. The cognitive level starts from the initial sensory input stage, and goes to perceptual analysis (visual analysis), word recognition, visualization, and finally, a higher order processing stage, resulting in comprehension (Griffin *et al.,* 1997). This means that in order to read, a person has to see the word, analyse and understand what is seen (Ellis, 1987).

2.2.1.1 Visual Input to the brain

Griffin *et al.* (1997) explained that the reflected light from the printed page is directed by the optical components of the eye and focused onto the retina. By a process of photo-transduction, the optical energy is then converted into electrochemical signals. The neural processes in the retina consist of four areas;

(1) the outer nuclear, which contains the cell bodies of the rod and cone photoreceptors;

(2) the outer plexiform layer, which contains the synaptic connections of the bipolar, horizontal, interplexiform and photoreceptor cells;

(3) the inner nuclear layer, which contains the cell bodies of the bipolar, horizontal, amacrine and interplexiform cells; and

(4) the inner plexiform layer, which contains the synaptic connections of the ganglion, amacrine, bipolar and interplexiform cells (Griffin, Christeson, Wesson, Erickson, & Solan, 1997).

The ganglion cells is then responsible for carrying the signal from the retina to the visual cortex via two specialized pathways, the magnocellular (M) and the parvocellular (P), for further processing (Garzia, 1996).

The M pathway responds to rapid-motion, fast-flicker and low spatial frequency (gross shapes like word shape or length of information) (Corcos & Williams, 1993), even with low luminance contrast. The P pathway in contrast responds to fine details (letter shapes), edges and colour-defined targets but can only be processed in higher luminance. The M pathway helps to localize targets in the visual field and the P pathway identifies and recognizes these targets. Simply stated, the M pathway can be referred to as the "where" system and the P pathway as the "what" system (Ungerleider & Mishkin, 1982). Research studies have shown that deficit in the M pathway is associated with reading disabilities (Williams, LeCluyse & Bologna, 1990; Lovegrove 1996; Talcot *et al.,* 1998; Solan *et al.,* 2007). Rayner (2001) stated that, reading is a complicated skill, which must be learned and practiced consistently. The areas in the brain needed for reading are present in all children, but remain dormant until the child learns to read. Unlike walking or talking which becomes active spontaneously at a certain age, this skill becomes active only through exposure to reading (Mosse, 1982). Reading involves different functions and areas of the brain that have to be intact and integrated, such that fluent reading is possible. All senses, including vision and hearing, are involved either directly or through association. Visualization, motor

acts of speech and eye movements also play an important part in reading. The brain has to make these parts readily available in the reading process (Mosse, 1982).

The different functions involved in the reading process are not controlled by one specific site in the brain, rather, the peripheral input reaches different areas of the brain. Mosse (1982) broadly explained the different areas of the brain that are used in reading. On the left side of the brain, Brodman‟s area 39 of the angular gyrus is of fundamental importance for reading as it is located equidistant from three important projection fields: the visual field in the occipital cortex, the acoustic field in the Heschl‟s transverse gyrus in the temporal lobe, and the tactile field in the postcentral gyrus in the parietal lobe. These cortical areas must be intact and integrated and maintain connections with other parts of the cortex, subcortical structures, sense organs, and peripheral nerves. Efferent and afferent signals and information must be able to flow unhindered (Mosse, 1982).

Shaywitz and Shaywitz (2008) further explained in detail the neural systems involved in reading. Their studies showed that there are interrelated neural connections between the posterior and anterior brain regions. The posterior brain system involves an interaction between two neural systems. The first includes the parietotemporal system, which is involved in word analysis and phonological processing, the parts of the supramarginal gyrus in the inferior parietal lobe, posterior aspects of the superior temporal gyrus, as well as portions of the angular gyrus in the parietal lobe (Shaywitz & Shaywitz, 2008). The second neural system in the posterior brain is the occipitotemporal area, which is referred to as the visual

word-form area (VFWA) (Cohen *et al*., 2000; Dehaene, Cohen & Vinckier, 2005, Vinckier *et al*., 2007). A study by Gaillard *et al.* (2006) showed that the VWFA is critical in fluent reading. The anterior brain system involved in the reading process is the inferior frontal gyrus (Broca‟s area) which is associated with articulation and silent reading (Frackowiak *et al*., 2004). A recent study has shown that this system comprises two additional areas, the dorsal and ventral premotor cortex (Nakamura, 2007).

According to Shaywitz *et al*. (2004), good readers use areas on the left side of the brain to decode letters into sounds, combine them to make words, and process them fluently. The authors also showed that poor readers look at words as though they are pictures and use compensatory activity in the visual centers of the right hemisphere with very little activity in the phonological areas of the left hemisphere. Many studies on dyslexic children have shown that failure of the left hemisphere particularly posterior brain systems, functions properly in reading (Temple *et al*., 2000; Seki *et al*., 2001; Temple *et al*., 2001).

2.2.1.1.1 Factors affecting visual input during reading

Scheiman (2002) described vision as consisting of three components: (1) visual pathway integrity, (2) visual efficiency and (3) visual perceptual skills. Griffin *et al*. (1997) stated that dysfunctions in any one of these components can result in general reading problems and not specific reading problems. Each of these will be discussed, with specific focus on the third one; visual perceptual skills. The first component, visual pathway integrity, includes visual acuity, refractive anomalies

and ocular health. A study by Ygge *et al.* (1993) revealed that disabled readers had a lower prevalence of best corrected visual acuity at 20/20 than their control subjects. Distance, near, monocular as well as binocular visual acuity were noted. This study also showed that disabled readers display reduced contrast sensitivity levels.

Refractive error affects visual acuity and results in a defocussed image on the retina. Garzia (1996) stated that no reports had shown an association between myopia and poor reading and hyperopia with good reading. However, Eames (1955) performed a study on emmetropes, myopes and hyperopes on reading achievement and found that across the three refractive groups, good readers showed no difference in reading performance. The same study revealed that among the poor readers, the hyperopes had the lowest reading levels. Anisometropia, which is a difference in refractive error of at least 1.00D between the two eyes, was found to be more prevalent among reading disabled.

Ocular pathology may directly affect vision which in turn can affect the reading performance of an individual. A study by Stifter, Sacu, Benesch and Weghaupt (2005) revealed that visual impairment due to cataract significantly affects reading performance. Glaucoma was associated with slower reading and increased reading impairment with advanced bilateral field loss (Ramulu *et al*., 2009).

Component two (visual efficiency) which means “the effectiveness of the visual system to clearly, efficiently, and comfortably allow an individual to gather visual information at school, work, or play” (Scheiman, 2002). This component includes

accommodation, binocular vision and ocular motility. Some problems associated with accommodative dysfunction are blurring at near, difficulty in changing fixation from near to far, asthenopia and headaches. Studies have shown that accommodative dysfunction is highly prevalent among reading and learning disabled subjects (Bennett *et al*., 1982). Therefore, accommodation anomalies may affect reading.

An effective visual system maintains clear and single binocular vision. Binocular variables such as heterophoria, vergence, fixation disparity and strabismus have been associated with below average reading performance (Simon & Gassler, 1988). Evans (1994) and Griffin (1997) further explained that such binocular anomalies are not the cause of specific reading disabilities but rather affect general reading problems. In daily reading activity, text is static and people read by moving their eyes. Ocular motilities therefore, are important part of ordinary reading (Pelli *et al*., 2007). The two significant ocular motor acts involved in reading are saccades and fixation pauses (Garzia, 1996). During reading, the eyes rapidly jump along the lines of text, called saccades (Rayner *et al*., 1981; Rayner, 1998). The velocity of this movement is as high as 500 degrees per second. This saccadic activity is driven by high frequency neural activity. During saccades, antagonistic muscles are inhibited and then reactivated when the fovea reaches the next target (Griffin *et al*., 1997). As the eye makes the saccadic movement across the printed text, the retinal image created is a blur from which no information can be picked up. Some studies have found that cognitive activities are suppressed during saccades (Pavlidis, 1983; Irwin & Carlson-Radvansky, 1996).

Saccades during reading are forward or progressive from left to right (as in English and some other languages), but can also be backward or regressive, to allow the reader to reread or verify what was initially read (Rayner *et al*., 1981; Griffin *et al*., 1997), with about 10 to 15% of saccades being regressions (Rayner *et al*., 1981). Return sweep is a large regressive saccade that occurs when the eye reaches the end of the line, and then attempts to refixate at the beginning of the next line (Garzia, 1996).

A fixation pause follows each saccade when the next target of interest comes to rest on the fovea. Fixation pauses last on average about 250ms. It is during this time that information processing about the word or phrase occurs enabling the reader to recognize each character (Griffin *et al*., 1997; Rayner, 1998). Saccade on the other hand enables the reader to reach the next point of fixation. Griffin *et al.* (1997) stated that beginner readers require more time on each fixation per word compared to more experienced readers who require fewer saccades and fixations. In addition, slower readers show longer duration of fixation, shorter saccades and more regressions. The importance of the oculomotor system in the reading process can be appreciated and any disruption in this system can affect reading. However, in the reading process, oral language is matched to written language symbols, hence any difficulty in the language area can create reading problems. This could in turn be mistaken as an oculomotor problem. Researchers have also shown that an increase in text difficulty increases the duration of fixation, while saccadic length decreases and the number of regressions also increase (Elterman, Abel & Daroff, 1980; Irwin, Carlson-Radvansky, & Andrews, 1995).

This may also mimic an oculomotor problem, but is in fact due to the nature of the cognitive process involved as a result of the difficult text.

The eye movements observed in dyslexic individuals are similar to those of normal readers when attempting to read difficult texts (Elterman *et al*., 1980; Irwin *et al*., 1995). Griffin *et al*. (1997) stated that while dyslexia is not caused by poor eye movement problems, they have an adverse effect on reading efficiency, and ocular motility must therefore be evaluated.

The third component, visual perceptual skills, enables an individual "to analyze, interpret and make use of incoming visual information in order to interact with the environment" (Scheiman, 2002). In order for a print to be recognized, it must be detected and analyzed. The visual stimulus to visual perceptual analysis is the printed word (Kamhi & Catts, 1989). The visual system is used in detecting print, which is then followed by perceptual analysis. Visual perceptual analysis involves a variety of visual skills which are: form perception, visual attention, visual memory, visual spatial relationships, visual auditory integration and visual motor integration (Kavale, 1982; Garzia, 1996), each of which will be reviewed below.

The first skill, form perception, refers to the ability to discriminate, recognize and identify the form of objects. This category is subdivided into visual discrimination, visual figure ground, visual closure and visual form constancy. Visual discrimination is the awareness of the distinctive features of written language symbols, including shape, orientation, and size (Kamhi & Catts, 1989). This enables the reader to perceive visually the differences and similarities between

different stimuli which may be letters, numbers and words. Visual figure ground refers to the ability to discern objects from its background yet still being aware of the meaningful distinction between them (Kamhi & Catts, 1989). Visual closure refers to the ability to recognize or identify a complete stimulus when viewing incomplete or fragmented forms of that stimulus or when all the details of that stimulus are not present (Scheiman, 2002). Visual form constancy is the ability to distinguish between forms and symbols in one"s environment, regardless of their size or angle (Scheiman, 2002). This simply means that the form of the object remains the same even though the size or orientation has changed. The second skill, visual attention is another perceptual skill that is closely linked to form perception. This means that when the individual views an object form, the individual has to concentrate on certain important aspects of the object while ignoring others. Hence individuals with attention problems may have difficulty keeping focused on the task at hand (Kavale, 1982; Garzia, 1996).

The third skill, visual memory is the ability to recall and identify detail and specific characteristics of a previously seen visual stimulus (Kamhi & Catts, 1989). Visual memory in turn refers to both spatial and sequential memory. Visual spatial memory is the ability to recall the actual spatial location of the object specifically orientated about the y-axis (Scheiman, 2002). Visual sequential memory refers to the reader"s ability to recall the exact sequence or order of previously presented visual stimuli (Scheiman, 2002). These concepts are essential when remembering the alphabets, numbers and even words. Visual memory plays a significant role in the reading process. It is not only necessary for word recognition but is also

involved in the higher order process of reading, which is comprehension (Kavale, 1982; Garzia, 1996).

Visual spatial relationships are the ability to understand the concept of a position of an object in space (Scheiman, 2002). This makes special reference to up and down, front and back, and right and left. This system involves three concepts namely: bilateral integration, laterality and directionality. Bilateral integration refers to the ability of the individual to be aware of and use both the right and left side of the body either separately or simultaneously in a coordinated manner (Scheiman, 2002). Laterality is the internal awareness and the ability to identify right and left on the self (Kavale, 1982; Garzia, 1996). Directionality is the awareness of right and left of objects in external space. In order for directionality to develop the individual must first develop laterality (Kavale, 1982; Garzia, 1996). This implies that the individual first develops this awareness with the self, followed by objects in space and then the relationship of such objects to the self. Visual spatial relationships are essential, as they enable a person to move around in the world, to understand directions, and recognize the orientation of printed symbols, as in the case of the letter *b* versus *d*. Children with visual spatial difficulties often confuse letters that are mirror images of each other, such as *b* and *d,* resulting in reversals of such letters. Reversals are common in children entering school, however, by the age of eight years, this ceases. If reversals persist, then this can contribute to reading disability (Kavale, 1982; Garzia, 1996).

Visual auditory integration refers to the ability to match visual stimuli to previous auditory stimuli (Kavale, 1982; Garzia, 1996). This involves matching letters,

syllables and words in reading with the sounds that they represent. For example, the child‟s ability to match a word to an auditory phonetic instruction by the teacher. Thus in order for the child to replicate the sound of a seen word, the child must be able to relate this visual stimulus to a previous auditory stimulus. Visual motor integration (VMI) is a visually guided motor response due to the integration of visual perception with motor movements of the body (Frijters *et al*., 2011). It is the ability to translate abstract visual information into an equivalent fine motor activity, typically of the hand in copying and writing referred to as eye hand coordination. Garzia (1996) stated that VMI is most important for academic achievement. Although the reading process may not require a motor output, Frijters *et al.* (2011) found a consistent moderate relationship between VMI and reading. Children that have poor visual motor skills, have difficulty with writing speed and accuracy. Such children are unable to cope with the academic demands and are unable to reinforce the recognition of letters and words with writing thereby lagging behind in the classroom.

Kavale (1982) showed each visual perceptual skill and its positive effect on reading. The study showed an even stronger association between visual discrimination and visual memory. A study by Velletino (1987) found no difference in the relationship between visual perception and reading in disabled and normal readers. Garzia (1996) stated the there is an ongoing controversy between the effect of visual perception on reading. However, various researchers (Willows, Kruk, & Corcos, 1993; Frijters *et al*., 2011) have found a positive relationship between them.

2.2.1.2 Word Recognition

Word recognition refers to the ability to retrieve a previously seen word from the word memory bank (Griffin *et al.,* 1997). This bank of words represents the individual"s vocabulary. Stanovich, Cunningham, and Feeman (1984) in a longitudinal study revealed that an increase in the accuracy and speed of word recognition positively correlates to reading comprehension. Kamhi and Catts (1989) explained a positive relationship between word recognition and reading, with features that are identified in the perceptual analysis stage being used in the word recognition stage. This output information regarding the printed word follows two pathways: (1) lexical pathway and (2) phonological pathway (Kamhi & Catts, 1989; Dien, 2009).

2.2.1.2.1 Lexical Pathway

As a child is exposed to written words, these words get stored in the child"s mental lexicon/vocabulary. Information regarding each word including its phonology, visual form, meaning and how the word relates to other words also gets stored. This represents the child"s vocabulary (Kamhi & Catts, 1989). When a child sees a word, this word is then associated with the stored words. As the child encounters a word more frequently, the child looks at the overall visual impression of the word and the uses the information from the mental lexicon to identify the word. The child therefore uses a top-bottom process which becomes more advanced with mature fluent readers (Kamhi & Catts, 1989). Hence this process allows the individual more time in comprehension rather than trying to decipher the word. However, if

the child is exposed to an unfamiliar word that is not stored in the mental lexicon, then a different pathway will follow. This pathway is the phonological pathway (Kamhi & Catts, 1989; Castles *et al*., 2009).

2.2.1.2.2 Phonological pathway

Visual representation of an unfamiliar written word following perceptual analysis, is broken up into its phonetic components by a process of decoding (Kamhi & Catts, 1989). This skill involves the ability to recognize letters (graphemes) and then match sounds to each of these components (phonemes) (Castle *et al*., 2009). Each of these phonemes is then blended together to form the word. This is referred to as the bottom-up process. In order for a child to follow this pathway, the child must have awareness of phonological structure of words, which has already been stored in the mental lexicon. This concept is further explained later under linguistic functioning below. There is therefore a constant interaction between the two pathways (Dien, 2009).

2.2.1.3 Visualization

Visualization refers to the unique ability of the brain to form a mental representation or internally "visualize" objects, events and faces (Gulyas, 2001). Such visual imagery is related to reading and occurs when the brain has to perform complex tasks. When a subject is reading, the written words are extracted from memory and transformed into visual imagery. It is in this form that the letters or texts are further explored. Studies have shown that the primary visual cortex

may be involved in the visualization process (Kosslyn, Thompson, & Alpert, 1997; Kosslyn *et al*., 1999). However, the study by Gulyas (2001) indicated that other cortical structures may be used in this process.

2.2.1.4 Higher Order Processing

Reading involves low level processing, which is decoding (as discussed previously) and high order processing, which is a cognitive ability referred to as comprehension. It also involves the ability to utilize linguistic knowledge (Kamhi & Catts, 1989), which will be explained later. According to Kamhi and Catts (1989), comprehension *"is an active, constructive process, the goal of which is to determine and understand the meaning intended by the author".* This means that comprehension is the ability of the reader to understand written texts. Spiro (1980) also stated that that comprehension is an interactive product of linguistic, prior knowledge and apparent situation.

Comprehension may be affected by an individual who has difficulties in understanding the spoken language due to different cultural backgrounds or educational deprivation, and in identifying written language code due to a decoding or word recognition problem (Carlisle & Rice, 2002). Hence by understanding the reason behind comprehension problems, the actual cause can be addressed and the individual can be helped accordingly.

2.2.1.5 Linguistic Function

Linguistic functioning in reading involves processing written language and using language for coding, storing and retrieving information (Vellutino *et al*., 2004). In order to read, the individual must be able to pronounce and understand the written language (Ellis, 1987). This is directly dependent on phonology, morphology, semantics and syntax of oral language (Garzia, 1996).

Each word that is read is broken up into various components or syllables. Each of these syllables has distinctive sounds which are represented verbally by speech codes. Speech codes when combined represent information in the form of words. This representation of sound units of the spoken language is referred to as phonology (Ellis, 1987; Castle *et al*., 2009). Letters, also termed graphemes, are combined in a particular way to form words. The rules that have to be followed for word formations are referred to as morphology (Garzia, 1996). Words combined form phrases and phrases combined form sentences. Each of these words, phrases and sentences have meaning referred to as semantics. The grammatical rules on how words can be combined into organized sentences, is referred to as syntax (Kamhi & Catts, 1989; Vellutino *et al*., 2004). Studies have shown that problems in any aspect of linguistic functioning, directly affects reading performance (Kamhi & Catts, 1989; Vellutino *et al*., 2004).

2.2.2 Stages of reading

Literature by Kamhi and Catts (1989) and Garzia (1996) has been merged to explain and understand the six stages of reading which are explained below. As the child commences with a new stage, there is some overlap with the preceding one. This implies that each stage need not be mastered before the next stage begins (Kamhi & Catts, 1989; Garzia 1996).

The first stage refers to *linguistic knowledge* and by the age of five years just prior to entrance of formal schooling, the child should be familiar and have knowledge of story structure, taking into account oral letter-sound, syntactic and semantic functions. The child at this stage is not familiar with letter order and linguistic function on the page (Garzia 1996; Kamhi & Catts, 1989). The second stage refers to the *initial decoding and reading stage* of children between five and seven years. This stage reflects the ability of the child to recognize letters of the alphabet. The child must have knowledge of the spatial organization of letters, orientation of letters from left to right on the page, print organized from top to bottom of the page and spacing between letters and words. Children at this stage may acquire approximately twenty sight words which are words that are easily identified (Garzia 1996; Kamhi & Catts, 1989).

The third stage involves further *decoding skills and word recognition*. This is characteristic of children between the ages of seven to nine years. Automaticity in decoding skills starts developing allowing the child more time to focus on meaning. The reader that is able to decode rapidly and accurately is referred to as a fluent

reader. By the end of this stage, the child has developed a substantial sight vocabulary (Kamhi & Catts, 1989; Garzia 1996). Stage four is referred to as *the reading to learn stage,* and marks the ultimate goal of reading, which is comprehension. This is marked by age group nine to eighteen years. In order for this level of reading to be achieved, the reader must have passed the previous stages. This stage is also dependent on the reader‟s knowledge of the subject being read. Decoding skills are now fully developed. Children in lower primary grades are identified as learning to read whereas higher grades are reading to learn. Abstract thinking develops and at stage four (fourteen to eighteen years) these adolescents are able to understand more than one point of view referred to as *multiple viewpoints* (Kamhi & Catts, 1989; Garzia 1996).

Stages four and five represent stages of cognitive development rather than reading development. Stage five (eighteen years and over) represents *construction and reconstruction*. The reader is able to reason through a process of analysis and judgment thus constructive knowledge grows. The reader also develops the ability to consider alternative solutions to problems through hypothetical reasoning (Kamhi & Catts, 1989; Garzia 1996).

2.2.3 Importance and types of reading

The problems associated with failing to learn to read are serious. Difficulty in reading affects a child‟s educational achievement and later occupational opportunities (Cutting *et al*., 2009). Failing to cope with the demands of schooling may further result in the individual leaving school. The consequences of not having

proper education in turn inhibit these individuals from obtaining employment and they are therefore unable to sustain the daily necessities in life. Crime, poverty, lack of civic awareness and involvement are consequences of inability to read (U. S. Department of Labour, 1990; Sarkees-Wircenski & Wircenski, 1994; Juel, 1995).

According to Carver (1990) and Fraser (2007), there are five types of reading namely: scanning, skimming, rauding, learning and memorizing. Each type involves different cognitive components from basic word recognition in scanning to a more complex process of memorizing. Each in turn results in different comprehension outcomes. Scanning involves the least complex reading component which is lexical access or word recognition. Here the reader searches through words in the text in order to identify a specific word. In this process, each word is matched to the target word. This represents the fastest reading rate of about 600 words per minute (wpm) for a university student (Bell, 2001).

Skimming is the second fastest reading type with a reading rate of 450 wpm. The reader selectively sifts through the text to get an overall gist of the text or uses this type of reading when specific information is required. The reader does not carefully read through the entire text and misses out certain information. Hence the finer details are missed and comprehension is affected. This process involves word recognition, lexical access and semantic encoding. The meaning of words in sentence context is also determined (Roit, 2008) which refers to normal daily reading with comprehension being the ultimate goal. The subject is reading within his or her reading level hence the text is understood by the reader. This process

therefore is characterized by fewer regressions for rereading or rethinking. The rauding rate is 260 to 300 wpm for a university student, depending on the cognitive speed of the individual (Fraser, 2007). Learning involves semantic encoding, comprehension as well as an additional component of remembering what is being read. This is characterized by longer fixations on words and more regression to reread words and sentences. Carver (1990) further stated that difficult text that cannot be understood by rauding alone is taken over by the learning process. The reading rate in this learning process is about 200 wpm (Carver, 1990).

Memorizing is the slowest reading process with reading rate of 138 wpm for university students (Marton, Wen, & Wong 2005). This process involves word recognition, semantic encoding, remembering and the ultimate goal of recalling ideas and words as they appear in the text. In order to practice this, the reader engages in a rehearsal process with more frequent pauses at the end of sentences and regression.

2.2.4 Factors influencing reading

Several factors may influence reading, including motivation, vocabulary acquisition, home life, attention, self-esteem, background knowledge, educational opportunities, social-emotional support and physical health. Motivation plays an integral part in the reading process and therefore in learning. Guthrie and Humenick (2004) defined motivation as, "*A cognitive commitment towards reading to learn and to extend one's aesthetic experience*". The authors further explained that motivation provides both the energy and direction towards reading. Research

has shown that when individuals are deeply engaged in text interaction and are motivated to understand over prolonged periods, their achievement in reading comprehension increases (Guthrie & Wigfield, 2000). Snow, Burns and Griffin (1998) stated that the main deterrent from becoming a skilled reader is the lack of motivation.

Vocabulary acquisition also impacts on reading (Biemiller & Emeritus, 2007). By the end of grade two, an average child knows about 6000 word meanings. During grade three to six, children acquire about 1000 word meanings per year. Therefore by the end of grade six, average children understand about 10000 word meanings (Biemiller, 2005). According to Cunningham and Stanovich (1997), children with smaller vocabularies are at a higher risk of performing poorly in high school. Rowe, Raudebush, and Goldin-Meadow (2012) stated that, the cause of this is due to poor intervention earlier in life. Knight and Gregg (2001) suggested that vocabulary acquisition is not only restricted to the innate capability of the child, but that home and school life also influence vocabulary acquisition.

Research has shown that children living in advantaged homes or working class homes, hear three times as many spoken words as children in disadvantaged homes (Hart & Risely, 1995). This research also showed that children from advantaged homes understand more word meanings than children from disadvantaged homes. Garzia (1996) stated that poor attention, low self-esteem, background knowledge, educational opportunities, social-emotional support and physical health impact on the learning process hence affects reading.

2.2.5 Reading Disability

Many terms have been used to describe individuals who demonstrate reading problems. More frequently used terms are reading disability, dysfunction, disorder, impairment, dyslexia, poor reader as well as learning disability (Kamhi & Catts, 1989). Reading disability is one of the listed conditions under learning disability.

Learning disability, as explained by Carlisle and Rice (2002), refers to a learner who has significant difficulty acquiring basic academic skills. Learning disability is further classified as being specific or general. According to the Education for All Handicapped Children Act the term, "*Specific learning disability means a disorder in one or more of the basic psychological processes involved in understanding or using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations. The term includes perceptual handicaps, brain injury, dyslexia….."* (U.S. Office of Education, 1977). This act further explains that learning problems caused by visual, hearing, motor handicap, mental retardation, emotional disturbance, cultural or economic disadvantage do not fall in this term of specific learning disability but rather under a more general learning disability. Hence eliminating the cause eliminates the learning problem (Johnston, 1984). Pugh *et al.* (2000) characterized reading disability as a failure to develop reading skills at the appropriate age level despite normal intelligence and adequate instruction. Reading disability can also be categorized as specific or general.

2.2.5.1 General Reading Disability

According to Griffin *et al.* (1997), general reading disability is a decrease in reading performance associated with other factors outside the actual break down in the reading process. A general reading disability has numerous etiologies. These etiologies can exist separately or in combination. Such etiologies as listed by Griffin *et al.* (1997) may include low intelligence, educational deprivation, sociocultural differences (e.g. in the case where English is the second language), and problems relating to primary emotional and mental health, auditory, attention, speech, vision and poor motivation and nutrition. This implies that the reading problem is secondary to an underlying primary problem. Once the primary problem is eliminated, then the reading ability of the individual improves. Optometrists play a vital role in assessing and managing individuals with general reading disability especially when the primary cause is visual.

2.2.5.1.1 Reading in the visually impaired

Individuals with severe visual impairment may require special visual aids such as low vision devices for reading tasks. Magnifiers are low vision devices that are used for reading. An increase in magnification results in an increase in print size with a decrease in field of view. Magnifiers, even though useful may limit the reader"s field of view hence affect reading rate. A reading rate chart may prove useful to assess the reading rate of the visually impaired and determine which device or management strategy they would benefit from (Ahn & Legge, 1995; Goodrich & Kirby, 2001).

2.2.5.1.2 Scotopic Sensitivity Syndrome

Garzia (1996) explained that Scotopic Sensitivity Syndrome (SSS) is characterized as a reading difficulty due to sensitivity to light source, luminance, wavelength and colour contrast. However, the author stated that there is no documented scientific evidence to support this theory. Irlen & Las (1989) used coloured overlays on dyslexic individuals to investigate the effect of coloured overlays on reading. These individuals had to report which coloured overlay assisted them to read faster and reduced fatigue. Such colour overlay was then prescribed to the individual in the form of spectacles with coloured lenses. According to Garzia (1996), the downfall of Irlen‟s research was that the diagnosis of these dyslexic subjects was based on self-report through teacher or parent and not on objective standardized criteria. Furthermore, the accuracy of the individuals report to the effect of the coloured overlays was also not objectively standardized.

2.2.5.2 Specific Reading Disability

Specific reading disability also termed dyslexia is one of the manifestations of specific learning disability. This is a primary reading problem with some form of central nervous system dysfunction not attributable to environmental causes or other handicap conditions (Kamhi & Catts, 1989). Lyon (1995) defines dyslexia as: *“a specific language based disorder of constitutional origin characterized by difficulties in single word decoding, usually reflecting insufficient phonological*

processing". Griffin *et al.* (1997) stated that a combination of general and specific reading disability can also exist.

Specific reading disability (RD) may be explained as deficits in word reading accuracy and/or reading comprehension (Cutting *et al*., 2009). Tunmer and Greaney (2010) further defined dyslexics as otherwise typically developed children with persistent learning difficulty in phonological processing skills which is required to learn to read, write and spell, despite exposure to high quality literacy instruction and intervention. Such individuals have adequate vision, hearing, intelligence and general language functioning.

2.2.5.2.1 Types of Dyslexia

According to Kamhi and Catts (1989), dyslexia may be categorized as either acquired or developmental. Acquired dyslexia refers to individuals that were previously literate but due to some neurological damage, such as a stroke, now have reading deficits (Kamhi, 1989). Depending on the location of the neurological insult, these individuals are further sub-grouped as either having surface, phonological or deep dyslexia (Ellis, 1987; Kamhi & Catts, 1989).

Individuals with surface dyslexia have impaired sight vocabulary hence have difficulty identifying whole words. In order to read out the word, these individuals rely on phonetic route and therefore each word is read as if it is encountered for the first time. Such individuals also have difficulty accessing meaning of words. On the other hand, deep and phonological dyslexics have difficulty accessing the phonological route in reading. Temple and Marshal (1983) further distinguished

the difference between phonological dyslexia and deep dyslexia. They stated that phonological dyslexics have poorer non-word (a combination of letters with no meaning) reading than word reading. However, deep dyslexics find non-word reading impossible and often will not respond to non-words. They also present with poorer word reading and semantic errors compared to phonological dyslexics.

According to Temple and Marshall (1983), developmental dyslexia can be expressed as "congenital word blindness". Developmental dyslexia is a specific learning disability of neurobiological and or genetic origin in children (Lyon, Shaywitz, & Shaywitz, 2003). These dyslexic persons typically have difficulties in word recognition, poor spelling and decoding (Shaywitz & Shaywitz, 2005). Developmental dyslexia can be further sub grouped as dysphonesia, dyseidesia and dysnemkinesia (Griffin *et al*., 1997) depending on which part of the reading process is affected. In dysphonesia, the primary deficit is in phonetic skills and these children rely on whole word strategies to read. Dysphonetic persons or children either know the word, as these whole words have been stored in their sight word lexicon, or unable to recognize it. However, should the child be exposed to an unfamiliar word, the child may have great difficulty in the decoding process, resulting in a reading error. As this subgroup depends on a top-down reading strategy, a common reading error displayed is semantic substitution. Here, the actual word may be replaced by another word of similar meaning e.g. *house* for *home*. This subgroup also display spelling errors with letter transposition e.g. *solw* for *slow*.

In dyseidesia, the individuals possess good phonetic skills but have difficulty recognising whole words. When dyseidetic dyslexics encounter a word, it is as if they are seeing it for the first time and these individuals rely on the phonetic approach to decode words. Therefore, the typical spelling error made would be to spell out a word the way it actually sounds e.g*. rede* for *ready.* In dysnemkinesia, the deficit is in the motor cortex which according to Griffin *et al*. (1997) is the area where letter forms are stored and retrieved from when writing. When writing, these individuals commonly display letter reversal e.g*. b* for *d* or *doy* for *boy*. All three of these subgroups of dyslexia can exist in isolation or as a combination.

2.3 READING RATE AND READING SPEED

Studies has shown that when reference to reading performance are made, the words reading rate or reading speed are used, with some studies showing similar meaning and others different meaning (Natan & Bulat, 2006; Mansfield, & Legge, 2007; Legge; Ramulu *et al.*, 2009). Therefore, the concepts of reading speed and reading rate are discussed below.

2.3.1 Reading Speed

A study by Dyson and Haselgrove (2001) stated that reading speeds refers to how fast or how slow an individual is able to read. More specifically they refer to the time taken to read a passage, thus making reference to fast or slow readers. Individuals maybe naturally fast readers or the reading speed can be altered by

requesting the individual to read faster. The authors concluded that reading speed is a variable that can be manipulated depending on the need.

Other studies have shown that reading speed can be calculated as the number of words read accurately in one minute (Chung, Mansfield, & Legge, 1998; O"Brien, Mansfield, & Chung, 2001; Kwon *et al*., 2007; Mansfield, & Legge, 2007; Legge; Ramulu *et al*., 2009). This definition is synonymous with the reading rate discussed previously. Dyson and Haselgrove (2001) mentioned that when making reference to reading performance, the term reading rate should be used. Rasinski (2000) stated that reading rate is an important tool when assessing reading and should not be ignored. Hence the term reading rate will be used in this study.

2.3.2 Reading Rate

In order to understand what is being read, one needs to read accurately and also fluently (Camp, Wilson, & Zinna, 1981). When a reader has difficulty with word recognition, more energy is devoted to this process compared to the cognitive capacity involved in comprehension. Fluent readers are able to (1) automatically recognize words, (2) group individual words into meaningful phrases, and (3) identify unknown word by applying rapid phonetic, morphemic, and contextual analysis. Fluency may be defined as a measure of reading rate (Natan & Bulat, 2006), which represents oral reading fluency and refers to the total number of words read correctly per minute (using either passages or word lists) (Crawford, Tindai, & Stieber, 2001; Bouldoukian, Wilkins, & Evans, 2002). Oral reading fluency can be defined as translating written text into an oral output with speed

and accuracy (Speece & Ritchey, 2005). At the most basic level, fluent reading depends on automatic word recognition, which requires proficient phonological processing and the ability to identify and manipulate individual sounds within the prescribed language.

A study by Wise *et al.* (2010) indicated that word oral reading fluency was most strongly related to reading comprehension performance when compared to oral reading fluency of connected text. This result indicates that if a child performs poorly on word oral reading fluency, then his / her reading comprehension should be assessed because of the significant relationship between these two skills.

2.3.2.1 Factors influencing reading rate

Reading rate and comprehension are important factors in the reading process. Whittaker & Kitchin (1993) found that reading rate is more sensitive to changes in visual functioning and stimulus as opposed to comprehension. Reading rate is affected by several non-visual and visual factors (Whittaker & Kitchin, 1993).

2.3.2.1.1 Non visual factors

Depending on the reading goal, the reader will choose a specific type of reading that is required for that goal. Hence how carefully the reader attempts to read will thus affect reading rate. The reader may for example choose scanning that may result in an increased reading rate, as opposed to a reader requiring a reading

goal for the learning. Such a reader will use a slower type of reading and thereby decrease reading rate (Whittaker & Kitchin, 1993; Fraser, 2007).

Once the reader has engaged in a particular type of reading, the reading rate is further affected by the difficulty level of the reading material (Whittaker & Kitchin, 1993). A more difficult text will therefore result in a decreased reading rate. A study by Carver (1990) showed that the effect of text difficulty on reading rate, on easy to moderately difficult texts, can be minimized by calculating the reading rate in character spaces per minute divided by six, where character spaces refers to letters, one space between words and two spaces between sentences. The reading rate can further be affected, depending on the reading ability of the reader, as a reader with lower phonological or comprehension ability will have a decreased reading rate compared to a reader with higher reading abilities (Carver, 1990; Whittaker & Kitchin, 1993).

2.3.2.1.2 Visual factors

Visual factors which influence reading rate include: acuity reserve, contrast reserve, field of view, and visual distortions and symptoms. Visual acuity measurement is essential in any visual examination as it gives the practitioner an indication of the visual needs of the patient, particularly the print size, when reading (Faye, 1984; Lovie-Kitchin & Bowman, 1985; Jose, 1989). These authors suggested that when print size of a given text is close to or below acuity of the subject, then the reading rate depends on the print size. However, when print size is above acuity threshold, then print size and visual acuity are poor predictors of

the reading rate (Ahn & Legge, 1995). The difference between the goal print size that the subject intends to read and acuity threshold is referred to as acuity reserve (Jose, 1989). For example, studies have shown that reading rate in normally sighted and low vision subjects increased as acuity reserve increased (Legge, Pelli, Rubin, & Schleske, 1985; Legge, Rubin, Pelli, & Schleske, 1985; Lovie-Kitchin & Woo, 1987).

Contrast reserve refers to the print contrast relative to the contrast threshold of a subject. It may be expressed in the form of a ratio: Rc = C (L) / C (T) where C (L) is the letter contrast and C (T) is the contrast threshold of the patient (Whittaker & Kitchin, 1993). Ocular disorders such as opacities in the anterior segment of the eye and several retinal diseases result in an overall reduction in the contrast threshold of the subject. This in turn reduces the contrast reserve, which has been found to significantly affect reading performance (Brown, 1981; Rubin & Legge, 1989). Letter contrast is also highly correlated with reading rate (Rubin & Legge, 1989).

Field of view, also referred to as perceptual span, is the number of characters (letters and words) that are simultaneously visible (Whittaker & Kitchin, 1993). Field restrictions, as in central scotomas, enlarged print size, readers‟ eye movements and devices, reduce the field of view (Whittaker & Cummings, 1990). Several studies have investigated the effects of field of view on reading rate (Poulton, 1962; Rayner *et al*., 1981a; Duchnicky & Kolers, 1983; Legge, Rubin, *et al*., 1985; Lovie-Kitchin, & Woo, 1987; Whittaker & Kitchin, 1993). These studies have revealed a significant reduction in the reading rate with reduced field of view

as in low vision patients. Maculopathies force the individual to use the peripheral retina, called eccentric fixation, for reading. The use of the peripheral retina, compared to the central retina, results in reduced visual acuity and contrast sensitivity. This in turn results in reduced reading rates (Whittaker & Kitchin, 1993).

According to Wilkins (2003), individuals who are usually symptomatic to perceptual distortions of text such as apparent movement of the letters, blurring, or coloured halos; experience reduced reading rates. Wilkins *et al.* (1994) stated that reading performance may be affected by individuals experiencing eyestrain and headaches. Such individuals benefit from coloured overlays which reduce distortions and symptoms hence improve reading rate (Wilkins *et al*., 1994; Wilkins, Sihra, & Myers, 2005).

2.3.3 Visual Acuity and Reading Rate Charts

Visual acuity charts are routinely used in optometric settings as compared to reading rate charts. Each of these charts assesses different functions and is addressed below.

2.3.3.1 Visual Acuity Charts

Visual acuity is a measure of the smallest print size a person is able to read. Visual acuity is performed at both distance and near using acuity charts. These charts may consist of single optotype letters, figures or numbers. Near acuity charts may also contain random words, sentences as well as paragraphs. The

following six basic vision skills required for school include: (1) near vision (the ability to see clearly and accurately that which is on a desk or close at hand), (2) distance vision (the ability to see clearly and comfortably at a distance of ten feet (3 meters) or more, such as student‟s desk to the chalkboard), (3) binocular coordination (the ability to have both eyes working together to see a clear, single image), (4) eye movement skills (the ability to have both eyes aimed accurately, track across a line of print, and move eyes from object to object with ease), (5) eye hand coordination (the ability of the eyes to guide or direct the hands) and (6) focusing (maintaining clear vision while reading). If one or more of these skills is inadequate or absent, then the child will have to work much harder to perform the required task. As a result, a simple letter acuity chart may not yield an adequate assessment of visual functioning (Ahn & Legge, 1995; Wilkins, 1996).

2.3.3.2 Reading Rate Charts

Various reading rate charts, consisting of words, phrases or sentences, are used to assess reading performance. Oral single word reading tests allow the individual to read words aloud (Alcock *et al.*, 2000). These tests may measure speed, errors or both as well as reading rate. Continuous text passages may or may not be timed, and may also measure comprehension levels by involving questions and answers. Other more complex tests may include multiple choice questions, non-words, or misspelled words. The problem with multiple choice questions is that the individual may be able to answer the questions without actually reading the passage (Keenan & Betjemann, 2006).

2.3.4 Scoring of Reading Rate Values

Educators assess and monitor students‟ progress in reading by looking at oral reading fluency (ORF), which focuses on rate and accuracy of reading and compare students results to standardized norms (Shinn, 1998). Hasbrouck and Tindal (2006) published percentile ranks (90th, 75th, 50th, 25th, and 10th) and reading rate (correct words per minute) norms for grade one to grade eight at three different time periods (Autumn, Winter and Spring) across the school year. The reading rate values for grades one to grade eight at the 50^{th} percentile rank in Spring are 53, 89, 107, 123, 139, 150, 150 and 151 respectively, while at the 90^{th} percentile rank are 111, 142, 162,180, 194, 204, 202 and 199 respectively. However, these norms can only be used if the educators follow the Curriculum Based Measurement procedures where the academic growth of each individual is measured. Carver (1990) recorded the average reading rate of children with understanding of text from grades two to twelve ranging from 121 to 261 words per minute respectively. Carver (1990) further explained that reading rate in first and second grade is the slowest because reading involves memorising and learning respectively. As the grades progress, the type of reading changes to skimming and scanning hence reading rate increases.

2.4 READING ASSESSMENTS

Reading assessments may be categorized for screening, diagnostic, progress monitoring, and outcome based purposes (Kame‟enui, 2002). Screening measures consists of brief assessments which can identify children likely to have difficulty

and may even be able to predict future reading growth and development. Diagnostic measures involve more in-depth analysis of the learners‟ performance and guide in instructional decisions (Kame‟enui, 2002). Progress-monitoring measures involve assessments on a regular basis, and are able to estimate reading rate improvement, identify learners who are not making adequate progress, evaluate the various forms of instruction for struggling readers and identify ways to improve instructional programs for those learners (Kame‟enui, 2002). Outcome measures involve assessments that determine whether students are performing at their grade-level or show improvement (Kame‟enui, 2002). Reading assessments are conducted in both the education and optometric professions however, the tests that are used and the results vary.

2.4.1 Reading Assessments used by Educators

Anecdotal evidence suggest that Wide Range Achievement Tests (WRAT), Wechsler Intelligence Scale for Children-Revised (WISC-R), Neales Analysis of Reading Ability, Gray Oral Reading Test (GORT) (Appendix I), are common reading tests utilized in educational settings.

Alcock *et al.* (2000) indicate that WRAT includes: Oral word reading which is made up of letters and single word reading tasks, sentence comprehension, spelling and maths computation. These subtests are timed and administered individually, each being graded, meaning that they can distinguish one child‟s performance from another. WISC-R test consists of 12 subtests (10 mandatory, 2 optional) which include information, similarities, arithmetic, vocabulary, comprehension, picture

completion, picture arrangement, block design, object assembly and coding (Cummins & Das, 1980). A study by Keith *et al.* (2006) stated that although this test is useful, there are some limitations such as several subtests assessing more than one ability and some subtests are restricted in their assessment. The authors suggested that users may have to consider alternative interpretive measures when using this test.

According to Nation and Snowling (1997), the Neales Analysis Reading Ability (NARA) test measures both comprehension and reading accuracy skills. This diagnostic test is available in a book form and consists of six short paragraphs of limited words based on a central theme. The NARA test also contains supplementary tests such as discrimination of initial and final sounds, names and sounds of the alphabet, graded spelling, auditory discrimination, as well as word lists for assessing accuracy or word recognition. The NARA test is individually administered on each learner and is therefore time consuming.

The Gray Oral Reading Tests (GORT) is widely used and initially measures accuracy and fluency in word reading followed by comprehension skill (Keenan & Betjemann, 2006). The comprehension test consists of two forms, each containing 14 age level reading passages with five comprehension questions following each passage. The comprehension questions include surface level matching as well as deeper interpretations about the passage. However, the authors found that many children failed the initial word reading test but passed the comprehension tests. Further investigations revealed that some questions could be easily answered without the reader actually reading the passage. The authors also found that the

child will have to continue reading despite experiencing difficulty, and that the passages become more difficult as the child continues to read, which increases their frustration levels. GORT also does not eliminate prior knowledge and general knowledge aspects hence the poor results may not purely indicate a reading problem.

2.4.2 Reading Assessments by Eye Care Practitioners

Passages of text are widely used by optometrists for routine eye examinations when assessing reading acuity, reading speed and also when prescribing reading glasses and magnifiers (Mansfield, Ahn, Legge, & Leubker, 1993). However, most passages are suitable for adult fluent readers only. Watson *et al.* (1992) used conventional reading tests to assess a subject‟s reading ability however these tests were too long for slow readers. Whittaker *et al.* (1993) suggested that for future reading rate tests, comprehension should be controlled by; (1) using relatively easy texts, (2) using tests that require oral reading and, (3) characterize reading rate in terms of standard words per minute.

The Sloan Reading Cards are available for both adults and children (Sloan, 1977), and are available in both Snellen and Meter (M) notations with no indication of logMAR. There are 10 versions ranging from 1M to 10M. The texts used are continuous sentences for adults and a single sentence per version for children, for which it is only suitable for grade three (eight year old) level of reading. As suggested by Whittaker *et al.* (1993), the use of continuous texts may affect reading, in that the reader is able to predict upcoming words although they are not

seen, hence random words are more suitable. This test was only used to determine reading acuity which in turn also provided an estimate of the magnification required for reading (Sloan, 1977). Reading rate assessment was not mentioned. Reading assessment is possible using the Bailey-Lovie chart which comprises a set of random words (4, 7, 10 letter words) that do not form a sentence (Bailey & Lovie, 1980). These words decrease in size from 1.6 (6/240) to 0.0 logMAR (6/6) in 0.1-log-unit steps but are not suitable for young children with limited vocabulary (Bailey & Lovie, 1980; Elliott, Patel & Whitaker, 2001).

In 1989**,** Legge and colleagues introduced the Minnesota Low Vision Reading test, a computer-display system for measuring reading speed (Legge, Ross, Luebker, & LaMay, 1989). This test requires expensive equipment and may not be a practical testing tool. In 1993, a simplified and quick version of this test was created using printed cards called “Printed cards for measuring low vision reading performance” and later called the MNREAD printed cards (Ahn & Legge, 1995). The MNREAD Test determines reading acuity and the effect of print size on reading rate. Jeanes *et al.* (1997) recommended that for any study on reading speed on children, the size of the paragraphs should be standardized. Both the MNREAD (Ahn & Legge, 1995) and the Bailey-Lovie tests (Bailey & Lovie, 1980) are widely used in optometric settings. These tests are able to determine the reading acuity as well as the effect of print size on the reading rate, but neither is suitable for use with children with limited vocabulary.

The Radner Reading Chart is a German based reading test chart that determines both reading acuity and reading speed (Radner *et al*., 1998). Twenty four German

phrases, out of 32, were statistically chosen and used in designing the chart. This study by Radner *et al.* (1998) revealed that print size affected reading speed. Another study by Stifter *et al.* (2005) used this test chart to investigate the effect of the type and density of cataract and its effect on reading performance. These studies revealed significant impairment in reading speed hence reading speed should be considered in the clinical evaluation of patients. These studies were German based and were performed on adult speaking Germans.

The most recent chart, Rate of Reading Test (RTT)® or Wilkins Rate of Reading Test designed in 1995, measures reading rate and the effects of visuo-perceptual distortions of texts such as apparent movement of the words and letters, blurring and coloured halos on reading (Wilkins, Jeanes, Pumfrey, & Laskier, 1996). The test charts are available in paragraphs with two different font sizes and for each font size, there are four versions (A, B, C, and D) of the chart. Each version has similar words in a different arrangement to avoid memorizing of the words. There are ten rows of fifteen words each, with a total of 150 words per chart. Reading of the paragraphs is independent of syntactic and semantic constraints but requires all the usual visual and visuo-perceptual processing (Wilkins *et al*., 1996). Wilkins *et al.* (1996) created a recording sheet containing the same words as each version of the chart and each word has a number allocated to it from one to 150. Wilkins chart also has a pretest chart to ensure that the reader is familiar with the words that are used in the chart.

This test can be used to compare an individual's performance under one set of visual conditions with that under another. It has been used in many studies such

as: (1) The rate of reading: its reliability, and its validity in the assessment of the effects of coloured overlays (Wilkins *et al*., 1996), (2) Prolonged use of coloured overlays for classroom reading (Rice, Birch, & Jonathan, 2005), (3) Visual Stress (Wilkins, 1995), (4) Helping reading with colour (Wilkins, 1996) and effect of overlays on reading in albinism (Makgaba & Oduntan, 2008).

Performance of the Rate of Reading Test is reliable, and even though the Wilkins RRT manual states that the words are selected so that it can be used on children as young as seven years, Wilkins *et al*. (1996) stated that it is not strongly correlated with age. The Wilkins RRT does not take optometric factors like visual acuity into account in the design of the chart. Also, the print of the Wilkins RRT chart is not considered to be large enough for low vision children as the largest print on the Wilkins chart is approximately equivalent to 2M. This print size may not be large enough to accommodate many low vision children. Therefore, there is a need to design a chart that can be used to evaluate reading rate in normally sighted and low vision children.

2.4.3 Limitations of the current /present charts

According to Huckin (1983), many publishers of educational materials use specific formulas to predict reading ability. The author stated that some of these formulas are based on outdated reading tests that do not take current knowledge of the reading process and demands placed on the reader into account. These formulas were also used in new tests to adjust texts for appropriate age levels. However,

this was not the intention of these formulas, as it was derived for prediction of reading ability.

One of the difficulties of the current reading tests using passages is that the content of the passages is affected by the reader"s prior knowledge (Johnston, 1983; Johnston, 1984). As a result, these tests do not only assess reading ability, but knowledge as well, thereby affecting the results. Test designers have tried to eliminate this problem by using passages that contain more general knowledge texts, however, again those individuals with a wider general knowledge tend to do better. Abbot, Black and Smith (1985) indicated that when using connective text passages, the reader is able to predict the subsequent words or texts using syntactic, semantic functions and previous knowledge of such connections, which affect the reading result. Such tests used in an educational setting may assess grade or reading levels, but do not consider visual factors that can affect reading (Ahn & Legge, 1995). The tests designed for optometric use are either not suitable for children due to extended passages, limited vocabulary or not correlated with age.

2.4.4 Multidisciplinary approach to reading assessment

The American Committee on Children with Disabilities (1998) stated that reading is affected my multiple factors including an individual"s experience, ability and neurologic functioning including sensory input from the visual system. This learning process can also be affected by emotional and environmental factors. It is thus quite evident that a multidisciplinary team has to be involved in managing children with reading and learning difficulties.

The primary sensory input for reading is vision and treatable ocular problems in children should therefore be diagnosed early and managed effectively (Ogden, Hindman, & Turner, 1989). Farmer and Klein (1995) explained that there was no specific deficit in either visual or auditory temporal processing that accounted for all types of developmental dyslexia. They further stated that while many of these children have a problem with phonological processing skills, optometrists still have an important role in ensuring that these children have the best possible vision to ensure that their near learning environment is as comfortable as possible with special provision of refractive error, binocular stability and eye movement (Farmer & Klein, 1995; Ogden *et al*., 1989). This in turn will aid in preventing cognitive limitations in learning (Farmer & Klein, 1995). The role of optometrists should extend beyond the provision of refractive correction, visual efficiency therapy and screening for ocular and systemic diseases. Optometrists should also get involved in evaluating visual perceptual skills (Barret, 2009), screening of reading problems, as well as evaluate reading rate when prescribing therapy and optical devices. Children with reading disabilities that do not have ocular defects should be referred to other health care professionals for further assessment.

Speech and hearing therapists, as well as other health care professionals, may also intervene, assess, diagnose and treat associated conditions that could hinder reading and ultimately learning. Physicians including pediatricians, neurologists and other medical specialists may be involved in the diagnosis and treatment of health problems of children with reading problems (Bradley, 1988, Sedun, 1992). Pediatricians can also play a significant role in coordinating care between the

health care professionals and the family, and become involved in the treatment plan.

Skilled educators may use standardized test to diagnose reading disabilities, may implement remediation programs and monitor the progress of these children. Psychologists may also assist in the diagnosis and classification of reading as well as learning disabilities (Committee on Children with Disabilities, 1998).

2.5 LOW VISION IN CHILDREN

There are many definitions for low vision. According to the World Health Organization (WHO, 1992) "*a person with low vision is one who has impairment of visual functioning even after treatment and / or standard refractive correction, and has a visual acuity of less than 6/18 to light perception, or a visual field loss of less than 10º from the point of fixation, but who uses, or is potentially able to use vision for the planning and / or execution of a task*". This simply refers to any individual, despite standard refractive correction, that still has difficulty seeing but is not yet blind. Gilbert *et al*. (2008) defined low vision as the best corrected visual acuity of less than 6/18, but equal to or better than 6/120 in the better eye. This definition also states that individuals with visual field loss of less than 20 degrees in the better eye are also classified as having low vision. Individuals of visual acuity 6/18 and better fall in the „normal" vision category, while those with aided visual acuity of less than 6/120 are categorized as blind (Thylefors, Negrel, Pararajasegaram, & Dazie, 1995). Instead of defining low vision as only clinical measurements of visual impairment such as visual acuity and visual fields, other authors have

included functional implications such as the ability to perform daily activities, communicating, working and learning in the definition (Jose, 1992; Corn & Koenig, 1996; Lueck, 2004). It is important to note that children with low vision have a right to function visually to their maximum potential to enable them to access their environment, school, education *etc*. Mehr and Freid (1975) defined low vision as "*reduced central acuity or visual field loss which even with the best optical correction provided by regular lenses still results in visual impairment from the performance standpoint*". Greater effort should therefore be made to ensure that low vision individuals are able to maximize the use of their residual vision to ensure a better quality of life.

Children with low vision are considered those younger than sixteen years of age (Chapman *et al*., 1992; Silver, Gilbert, & Spoerer, 2001). However, in South Africa children will consist of those who are 18 years or younger, as also stipulated by Case and Deaton (1999). Low vision has serious implications for the low vision children that may include difficulty in life experiences, educational deprivation, social and emotional development as well as economic costs to the child, their families and society (Leat, Legge, & Bullimore, 1999; Resnikoff, 2004). The WHO (1992) also mentions that the visual impairment may also affect communication and the ability to perform sustained near vision tasks. Some daily life activities that may be affected include reading, mobility and identifying objects. These restrictions may result in psychological and emotional problems such as depression, which can also result in the decline of the general health of the individual (Gillman, Simmen, & Simon, 1986). Low vision children may also present with other disabilities which in turn further compounds and affects their

psychological and emotional wellbeing. Visual stimulation is essential for the bonding between parent and child, as well as interaction between siblings, family and peers. Visual impairment therefore also has serious implications for their social, emotional and communication aspects (WHO, 1992; Oduntan, 2005).

As the child progresses into the initial phases of education such as pre-school, low vision children may be deprived of basic learning as teaching may be in the form of visual communication such as drawings and pictures (WHO, 1992). A low vision child maybe enrolled into a mainstream school, school for the partially sighted or the blind (Alotaibi, 2006). In the mainstream schools, the child with visual impairment may learn at a slower rate, compared to a normal sighted child which can give a false impression of being „stupid" (WHO, 1992). Apart from having to deal with the psychological implications of having low vision, the child is made to feel worse because of their impairment. A low vision child placed in a school for the blind may have to learn to use braille. However, this child may still have some residual vision that can be maximally utilized with low vision aids which will benefit the child functionally.

Many of the low vision children especially in developing countries are economically disadvantaged (Oduntan, 2005). The cost of education for those children who have to attend special school, rehabilitation and professional services away from home are expensive, and the families may have difficulties meeting the needs of the low vision child. In some instances, the low vision child may not attend school, may drop out earlier due to the inability to cope or possibly to the inappropriate management of the impairment. This may confine the child to the home

environment who later in years may not progress into the workplace, thereby becoming dependent on others for survival. This individual may also need the care of family members, preventing them from seeking employment. The economic constraints placed on the low vision individual, family and society must be considered.

Children have an immature visual system and through the years of development, this visual system matures. However, for this development to occur effectively, the visual stimuli must be clear and relayed to the higher visual centers for processing (Gilbert & Foster, 2001). Visual deprivation therefore restricts further visual development which unfortunately may not be correctable in adult life. Such children require specific and special care to allow efficient development. As low vision children are not blind, treatment and management of their low vision lies in the hands of eye care practitioners.

2.5.1 Prevalence of low vision in children

The prevalence of visual impairment varies throughout the world (WHO, 2004), with results by Thylefors *et al.* (1995) showing that in 1990, approximately 148 million people globally were blind or had significant visual impairment, of which 110 million people had low vision. The study also reveals that there are three low vision people for every blind person. A further study, based on the 2002 population, estimated that of the 161 million people blind and visually impaired, 124 million people had low vision (WHO, 2004). Gilbert and Foster (2001) indicated that there are approximately 1.4 million blind children in the world, of

whom 75% are from poor regions of Africa and Asia. The prevalence of visual impairment in East and West Africa ranged from 0.5 to 1.10 per 1000 children (Waddel, 1998). Gilbert and Ellwein *et al.* (2008) stated that the prevalence of children with low vision ranges from 1.52 in 1000 children in developed countries to 2.75 in 1000 children in rural developing countries. This higher prevalence in poor developing countries could be attributed to poor health associated problems. The prevalence in urban developing countries is slightly lower than the rural areas possibly due to access to eye care facilities. The prevalence of low vision in South Africa was reported to be 0.32% (Pougnet, 1995) while more recently a study by Oduntan *et al*. (2002) showed that the prevalence of low vision in the Limpopo Province of South Africa was 2.43%.

2.5.2 Causes of low vision in children

Low vision in children may be the result of congenital or inherited conditions such as congenital cataracts, optic atrophy, congenital nystagmus, albinism, macular dystrophies and retinal conditions (Kalloniatis & Johnston, 1990). Chapman *et al.* (1992) stated that the major causes of low vision in developed countries are of inherited, congenital or perinatal etiology. However, in developing countries, infectious and nutritional factors as well as congenital cataracts and glaucoma are common causes of low vision. Other causes include retinopathy of prematurity, ophthalmic neonatorum, retinitis pigmentosa, aniridia, high myopia, cortical visual impairment, toxoplasmosis and Rubella (Chapman *et al*., 1992; Pougnet, 1995). Amblyopia, a preventable cause of low vision, can result in severe visual impairment particularly when the good eye is damaged through trauma etc. and

the amblyopic eye becomes the only source of visual information (WHO, 2004). Congdon, Friedman and Lietman (2003) also reported refractive error such as high myopia and hyperopia; infectious causes like onchocerciasis, trachoma, corneal ulcers and corneal scarring; nutritional and metabolic causes like vitamin A deficiency, diabetic retinopathy and hypertensive retinopathy as common causes of visual impairment. Cataract (51%), glaucoma (12.7%) and onchocerciasis (8.1%) were the leading causes of visual impairment in the Central African Republic (Potter, 1991).

Wilson *et al.* (1996) attributed cataracts as the main cause of visual impairment in the northern part of Cameroon. In the rural parts of KwaZulu-Natal in South Africa, cataracts and glaucoma were the leading causes of blindness (Cook, Knight, & Croften-Biggs, 1993). A study in Limpopo Province in South Africa, by Oduntan (2002), revealed that cataracts, corneal opacities and glaucoma were the main causes of low vision in that area. The researcher also stated that trauma was another common cause of low vision. In East and West Africa, malnutrition, congenital cataracts and infections were the main causes of visual impairment in children (Waddel, 1998) while in South Africa the leading causes are: malnutrition, infections as well as inherited genetic conditions such as retinitis pigmentosa, albinism, cataracts and glaucoma (Pougnet, 1995). A survey in South Africa revealed that 33% of the causes of visual impairment were hereditary (O‟ Sullivan, Gilbert, & Foster, 1997).

2.5.3 Management of low vision in children

According to Kalloniatis and Johnston (1989), the costs and the need to provide low vision care should not only be based on the prevalence of low vision in the population, but on the years that the individual would have to live with the condition. Therefore, children would have to live many years more than an adult with the low vision condition. If the average lifespan of an individual is 80 years, then a 5 year old child may have to live 75 years longer with the impairment as compared to an adult of 60 years who has only 20 years with the impairment. Hence poor management only adds to the difficulties incurred by the parent and child (Kalloniatis & Johnston, 1990). Low vision children have some residual functional vision which must be assessed and managed to enable maximum use of their limited vision (Lueck, 2004). This may be achieved with the use of low vision devices and rehabilitation. It is imperative that efficient low vision equipment and testing materials are readily available. Low vision assessments ranges from visual acuity assessments to prescribing of low vision devices.

As the definition of low vision often uses visual acuity as the basis of classification, it is vital to assess visual acuity with the most appropriate test chart. Lovie-Kitchin (1976) showed that logMAR distance letter acuity correlated highly with near word visual acuities. The researcher also suggested that reading rate as well as visual acuity measurements are essential when examining low vision patients (Lovie, 1976). This was further established by Jose (1989), who suggested that near test charts should contain logMAR unrelated words as an appropriate near assessment. Kalloniatis *et al.* (1990) states that logMAR charts are essential when

assessing low vision patients and suggested that the Bailie–Lovie logMar charts should be used. However, despite the Bailey-Lovie Charts being designed for low vision patients, it is not specifically designed for children.

Most low vision children may use low vision devices to assist them functionally (Chapman *et al*., 1992). Low vision devices include both optical and non-optical devices. Optical devices include those designed with lenses and are placed in front of the eye in order to view an object, and may include magnifiers and telescopes. Non-optical devices do not involve lenses but rather alterations with the environment such as illumination, contrast and use of large print books. While electronic devices, such as closed circuit television and computerized equipment are also used to help low vision patients, the cost of this equipment, particularly in developing countries, may hinder their availability. The parent as well as the child may require counseling to accept the visual condition, the device and the positive benefits of the child gaining visual independence with the device (Chapman *et al*., 1992).

2.5.4 Reading in low vision

The process of learning involves reading, and in an educational setting, even low vision children can learn through reading. The eye movements involved in reading of low vision persons is similar to that of normal sighted individuals (Fontinakis & Dickson, 1994). This includes fixation pauses, right saccadic movement to get to the next fixation target and left saccadic movement to get to the beginning of the next line. Low vision individuals read slower than normally sighted individuals even

with visual aids (Dickinson & Fotinakis, 2000). Such visual impairment has been found to affect reading performance (Kalloniatis, 1990) and therefore affect learning. According to Koenig (1992), there are two aspects of reading or literacy that should be assessed on low vision individuals. These include both basic and functional reading. Basic literacy is applied in an educational setting, which involves learning and developing reading skills, while functional literacy refers to the ability to use existing vision to be able to complete practical tasks involving reading and writing in daily living (D"Andrea & Farrenkopf, 2000).

While reading performance of low vision children may be evaluated in an educational setting as a measure of reading fluency, functional literacy needs to be evaluated by eye care professionals with and without optical devices. There is therefore a need to assess reading performance in low vision care.

2.5.4.1 Reading with low vision devices

Reading for low vision subjects may be made possible by increasing the magnification of the reading material (Dickinson & Fotinakis, 2000). This increase in magnification can be made possible by the use of low vision devices or by increasing the print size of the reading material (relative size magnification) or decreasing the viewing distance from the reading material (relative distance magnification). The problem with the latter is that the child has to accommodate more for such a close viewing distance resulting in visual stress. This situation may be resolved by using low vision devices (Cheong, Lovie-Kitchin & Bowers, 2002).

These devices may include magnifiers as well as telescopes and electronic reading aids. The magnifiers may either be hand-held, stand or spectacle mounted. Reading with magnifiers involves the device being moved along the line of print while the distance between the reading material and the device is kept constant to ensure a clear image is maintained at all times (Den Brinker & Bruggeman, 1996). The eye movements involved when reading with optical magnifiers are slightly different than without the device (Dickinson & Fotinakis, 2000). As the device is moved smoothly across the line of print, there is movement of the image in the opposite direction to the device. The eye follows the image with a slow pursuit movement until the required reading target is located. This is followed by fixational pause to analyze the word and right saccadic eye movement. According to Dickinson and Fotinakis (2000), these eye movements associated with the use of magnifiers resemble optokinetic nystagmus of which further studies have not been determined. As the magnification of the device increases, the field of view decreases thereby decreasing the forward saccade which in turn results in decrease reading rate. Dickinson and Fotinakis (2000) suggested that to compensate for this reduction in forward saccades, the reader should also increase head movement in the direction of the reading thereby increasing reading speed. A major difference to normal readers is that apart from eye movements in reading, there is also hand movement involved in moving the device, these hand and eye movements having to be synchronized to ensure a stable retinal image.

2.5.4.2 Reading rate in low vision children

As suggested by Jose (1989), reading rate is an important factor in assessing reading performance in low vision patients. Kalloniatis (1990) found that reading rate in low vision children nine years an older, correlated with their near visual acuity. The authors further stated that the better the uncorrected near visual acuity, the higher was the reading rate. Mangold and Mangold (1989) stated that an acceptable reading rate for low vision children up to grade three is 60 wpm. Low vision children from grade four to six should read at 70 wpm, while older children should read approximately 90 wpm (Fellenius, 1996). However, the reading rate will depend on the degree of visual impairment. As age increases, so the reading rate should also increase. This applies to both low vision and normal vision subjects provided a normal reading level is attained (Legge *et al*., 1997). With an increase in age, exposure to reading increases and vocabulary also increases. The ability to retrieve words from their mental lexicon increases, automaticity develops faster and fluency improves (Natan & Bulat, 2006). When comparing the reading rate of low vision children for each age group to that of normal sighted children, the reading rate is lower (Rumney & Leat, 1994). The researchers revealed that when reading, the forward saccade is smaller and limited to 3.5 characters in low vision persons, and larger in normal vision persons with 6.8 characters. The smaller saccadic movement may be the result of abnormal eye movements or the reduced visual span in low vision persons. Legge *et al*. (1997) also showed that the visual span of low vision persons is lower than that of normal vision persons, provided the print sizes are the same. This is in keeping with Jan *et al.* (2000), who stated that reading rate of persons with

vision loss was slower than to normal sighted persons. Lovie-Kitchin, Bevan, & Hein (2001) have reported that low vision children using appropriate magnification when reading, can achieve reading rates close to that of normal sighted children.

2.5.4.3 Charts used for measuring reading rates in low vision patients and their limitations.

There are a limited number of test charts that can be used to assess reading rate in low vision patients, with anecdotal evidence revealing that none are specifically suitable for low vision children presenting with a range in visual acuity. Those tests include: (1) The Bailey-Lovie Charts, which is not suitable for young children with limited vocabulary (Bailey & Lovie, 1980; Elliott, Patel & Whitaker, 2001); (2) Minnesota Low Vision Reading Test, a computer generated test which measures reading speed, but requires the use of expensive equipment and is not a practical testing tool (Legge, Ross, Luebker, & LaMay, 1989); (3) The MNREAD Printed Cards, which is a simplified version of (2), but contains words not suitable for children (Ahn & Legge, 1995); (4) Rate of Reading Test (RTT)® or Wilkins Rate of Reading Test is not specifically designed for optometric use, but maybe used to assess reading rate under various testing conditions, such as the use of overlays *etc*. (Wilkins *et al*., 1996); and (5) The Radner Reading Chart is a German based reading test chart that is more suitable for adult speaking Germans (Radner *et al*., 1998). With regards to children, learning is referred to as academic literacy in the form of reading and writing and in low vision, greater emphasis is placed on reading (Steer *et al.*, 2004), an important goal of low vision persons is the ability to read (Lovie-Kitchin & Whittaker, 1999). Impaired reading speed may affect

comprehension (Whittaker & Kitchin, 1993), and the use of an appropriate reading rate chart, particularly in determining near low vision device is critical.

2.6 CONCLUSION

The goal of this research is to produce a standard optometric reading rate chart that can be used by eye care professionals as well as a chart that is specifically designed for children with normal and low vision. A reading rate chart can be used in an optometric setting which will aid in assessing the progression of ocular pathology, binocular abnormalities, ocular motility disorders as well as other visual disturbances. This chart may also be useful to evaluate vision therapy and optical correction, such as low vision devices.

Approximately 75% of poor readers in third grade continue to be poor readers in ninth grade, and, unfortunately, reading disabilities persist into adulthood (Lyon, Alexader, & Yaffe, 1997). The personal and societal costs of reading problems are substantial. Illiteracy is positively correlated with unemployment, low wages, poverty, crime, and low self-esteem (Mecer *et al*., 2000). A possible outcome of this research is to improve the level of literacy in society through detection, early intervention and correction of difficulties that may hinder learning.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

Reading rate is an important indicator of reading performance and as children spend hours a day learning through reading, it is essential to measure their reading rate. As reading is a key goal for low vision patients, it is also important to assess their reading rate. It is therefore necessary to have an appropriate chart to measure the reading rate in children with normal vision and low vision.

3.2 ETHICAL AND LEGAL CONSIDERATIONS

The following ethical and legal issues were addressed:

1. Approval to conduct this study was obtained from the Biomedical Research and Ethics committees, School of Health Sciences, University of KwaZulu-Natal (Approval Number HSS/0525/2009).
2. Permission to allow the school children to participate in the study was obtained from the Department of Education and the principal of each school concerned.
3. The procedures followed were within the scope of optometric practice in South Africa.
4. The parent or guardian of each participant was informed of the procedure by an information document in English and Zulu (Appendices IV & V).

5. A signed consent form was obtained from each of the participants parents (Appendices II & III). This consent form was translated into Zulu for better understanding of the procedures and conditions involved in this study.
6. The parents were informed that participation was voluntary and he or she may withdraw the child at any stage from the study if he or she so wishes.
7. Each child and parent was informed that none of the test procedures would present any risk of injury.
8. Confidentiality was maintained by making no reference to the participants" name in the presentation of the data.
9. The aim, the purpose and procedure for the study were explained to the principal of each of the primary schools.

3.3 STUDY DESIGN

An observational (non-experimental) design was used in this study to design a reading rate chart that will be used to measure reading rate for children. This is an observational study because sets of data provided on the new chart were compared to establish the reliability of the chart. In addition, the data provided on the new chart was compared with those from an existing chart using the same subjects in order to establish its validity. Finally the new chart was tried on low vision learners.

3.4 STUDY PROCEDURE

The procedure employed in this study is presented in 4 parts as follows:

i. *Designing the Paediatric Rate of Reading (PRR) Chart:* Designing of the rate of reading chart consisted of designing the PRR test chart, the pre-test chart and the recording score sheets.

ii. *Determining the reliability of the PRR Chart:* Reliability of the test chart was determined on normal sighted participants, by comparing test and retest reading rate data obtained on the PRR Chart.

iii. *Determining the validity of the PRR Chart:* Validity of the test chart was determined on normal sighted participants, by comparing the reading rate data obtained on the PRR Chart to reading rate data obtained on the Wilkins Test Chart.

iv. *Testing the PRR Chart on low vision participants:* Reading rate, using the PRR Chart, was determined on low vision participants without and with low vision devices.

3.4.1 DESIGNING THE PAEDIATRIC RATE OF READING (PRR) CHART

Part 1 consisted of designing three components of the PRR Chart: designing the actual PRR test chart, the pre-test chart and the recording score sheets.

3.4.1.1 Population and sampling

A list of primary schools, in the Durban area of KwaZulu-Natal province, where English was offered as first and second languages was obtained from the Department of Education in Durban. The list contained 411 primary schools from which five schools were selected using systematic random sampling. The names of the five primary schools were:

1. Fairleigh Primary School in the Camperdown area.
2. Lotus Primary School in the Chatsworth area.
3. Parkview Primary School in the Chatsworth area.
4. Westville Junior Primary School in the Westville area.
5. Zwelibomvu Primary School in the Pinetown area.

3.4.1.2 Materials and procedure

i. Designing the PRR test chart

To establish which English reading books were used by grade one learners; a survey was carried out in the five selected primary schools in Durban. Words from the first English reading books used by grade one learners at each school were used in the design of the chart. All the words in the five books (285 words in total) were recorded on a recording sheet. In order to maintain an average word difficulty, those words containing three and four letters were selected for the study (Appendix IX). Those words with one or two letters and more than four letters were excluded. From the list of three and four letter words, ten words were

randomly selected and used in the design of the chart. Words containing special characters, punctuations as well as names were also excluded.

The same ten words were used in each row (line) but in different random orders (Bailey & Lovie, 1980; Ahn & Legge, 1995; Wilkins, Jeanes, Pumfrey, & Laskier, 1996). This was obtained by assigning the ten selected words to numbers one to ten (Appendix VI), and from the list of random numbers, a table was generated (Appendix VII) and the numbers were then replaced by the corresponding words (Appendix VIII). This allowed each line per chart as well as each version of the designed chart to be different from the others. The words were typed in a personal computer and were organized in one paragraph per page, with ten rows per paragraph thereby standardizing the length and relative difficulty of each line. The inter-word and inter-row spaces were made equal to those in the computer generated print, and all words were printed in lower cases.

A range of visual acuity letter sizes 1.45 mm, 1.75 mm, 2.33 mm, 2.91 mm, 4.65 mm and 5.82 mm corresponding to visual acuity of 1.0M, 1.2M, 1.6M, 2M, 3.2M and 4M and Snellen acuity of 6/15, 6/18, 6/24, 6/30, 6/48 and 6/60 respectively (Appendix X) were used to design the chart. The paragraphs with these acuity levels were named A, B, C, D, E and F versions respectively and each version was printed on a separate sheet.

Print size scaling and design: Print size for each level of visual acuity was calculated using the formula: $x = d \tan\theta$ where x represents the height (mm) of a letter such as o, x, c, e *et cetera* in the words, and the d is the distance (mm) at

which each letter subtends an angle of θ (which is 5 minutes of arc) at the eye (Grosvenor, 2002). Letters with up and down projections such as b, d, g, h, *etc.* were not considered in the scaling. The calculated values were compared with and were of the same values with those in an existing table: Visual Acuity Notations Conversion Table (The National Research Council, 2002). A graphic artist was consulted in generating the actual sizes of the various print used in the design (Appendix X). Acuity notations specified on the chart are meter (M), Snellen (Feet), Snellen (M), and Logarithm of Minimum Angle of Resolution (LogMAR) (Appendix XI).

Two font types, Times New Roman and Arial were used in the design of the chart. A personal computer was used to generate the printed words in Times New Roman and Arial and to ensure accurate scaling. Each version of the chart, versions A, B, C, D, E, and F consisted of both Times New Roman and Arial. The total number of versions in this test was twelve. Each version was printed on a 29.7 X 21 centimeter (A4) cardboard (Figure 1 to 12). The variables are the print sizes or acuity levels, font types and arrangement of the words in the chart. The words were printed in black on appropriately white card boards. Almost 100% contrast can be obtained if the printed characters are in black and the background is white.

ii. Designing the Pre-test chart

The reading test chart can only be conducted on a child who can correctly read all the words presented in the test chart, necessitating a pretest chart being designed.

The pretest chart consisted of all ten words that are used in the reading test chart but in large typefaces (5.82 mm). The ten words were arranged in two columns of five words each. For each of the two font versions (Times New Roman and Arial) two pretest charts were designed respectively. Each of the pretest charts were printed on a separate A4 size page (Figure 13 and 14).

iii. Designing the Recording Score Sheet

A recording score sheet was designed which contains the same word layout as each version (A, B, C, D, E or F) of the test (Figure 15 to 20). Space was provided on the top of the recording sheet to record the name, date of birth, age, grade of the child and the date that the test was administered. The version of the test chart (A, B, C, D, E, or F) and corresponding acuity levels, in Snellen, LogMar and meter notations, were provided. As omission (o) or addition (a) of words made by the subject during the testing procedure would affect the reading rate, large inter-row spaces were provided below each row of words to record various errors made during reading. Additions were recorded by an underscore (_) and omissions by circling the omitted word. Reading time in seconds, type and number of errors, reading rate, as well as the total number of correct words read, were also provided at the bottom of the page.

3.4.2 DETERMINING THE RELIABILITY AND VALIDITY OF THE PRR CHART

After designing the PRR Chart, it was necessary to establish its reliability and validity. In order to ensure reliability and validity of the test in this study, reliability

of the PRR Chart was established by comparing test and retest reading rate values on the same learners over a one week period. Validity was established by comparing the learners reading rate values obtained with the PRR Chart to reading rate values from the Wilkins Chart. As it was necessary to ensure that the test results obtained for both reliability and validity were in fact reliable; the examiner was conversant with all the testing procedures performed and all tests were administered by one examiner.

3.4.2.1 Population and sampling

To test for reliability and validity, it was necessary to establish the reading rate of the participating children. Children from two schools, for the normally sighted, were recruited to participate in this part of the study. The two schools were Pemary Ridge Primary and Hillview Primary, in Reservoir Hills, Durban, KwaZulu-Natal Province. These schools were chosen by convenience sampling to minimize the cost of traveling and to save time. Permission to conduct the study was obtained from the principals of both schools.

Children of the ages nine to twelve years old were recruited for both the validity and reliability data collection. This age range was chosen because these subjects were able to decode rapidly, automaticity having been developed (Kamhi & Catts, 1989; Garzia, 1996) and they had already passed the learning to read stage. These subjects were also at the maturity level to be able to understand the testing procedures. Younger subjects were still in the process of learning to read and were therefore not included in this study.

Approximately 250 consent forms and information documents (Appendices II to V) were given to the parents or guardians of the learners. As only 200 learners were required for the study; 100 for reliability and 100 for validity, the extra 50 forms took into account late submission of forms, poor parental response and failure in the pre– visual screening and pre-test evaluation. Only 210 learners returned the signed consent forms and these learners proceeded to the next phase of the study that involved the reliability and then the validity of the PRR Chart.

The inclusion criteria for both reliability and validity were as follows:

i. Subjects with signed consent forms.
ii. Subjects of both genders.
iii. Subjects with no ocular pathology determined in the pre-visual screening.
iv. Subjects able to read all words in the PRR pretest chart.

3.4.2.2 Materials and procedure

In this section, the materials and procedure for determining the reliability of the PRR Chart will be presented first followed by the validity of the PRR Chart.

3.4.2.2.1 Determining the reliability of the PRR Chart

Each of the 210 learners with the returned consent forms commenced with the PRR Chart pre-testing evaluation and pre-test visual screening, which is explained in detail below. Thereafter, the learners proceeded to the reading rate evaluation

with the PRR Chart to determine the reliability of the results obtained with the test chart.

PRR Chart pre-testing evaluation: The learners were tested individually, and were seated comfortably at a desk, where the pre-test chart was presented to them at a distance of 40 cm from their eyes. The learner was asked to read out the words aloud binocularly. If the learner had difficulty identifying any of the words he/she was excluded from the study. Only children who were able to read all the words proceeded to the pre-test visual screening.

Pre-test visual screening: The visual screening included assessing near visual acuity and internal ocular health. The near visual acuity was determined using the near logMAR chart held at 40 centimeters. Each learner‟s right, left and both eyes were measured. Ocular health assessment was then performed with an ophthalmoscope. Subjects with no ocular pathology were included in the study. The results of the pre-test screening were recorded on a visual screening record form.

Determining the reading rate to establish reliability of the PRR Chart: Reading rate is a measure of reading performance which involves automaticity, speed as well as reading with accuracy (Wise *et al.*, 2010). The more proficient this process is, the greater the cognitive capacity of the child to be involved in higher thought processes such as comprehension (Fuchs, Fuchs, Hosp, & Jenkins, 2001). Determining reading rate in children is therefore useful in understanding the child‟s level of reading competence, as well as the effectiveness of prescribing optical devices, as in the case of low vision patients.

Procedure: The first 100 learners who passed both the PRR Chart pre-testing evaluation and pre-test visual screening then proceeded to the reading rate evaluation with the PRR Chart to determine the reliability of the results. The reliability testing was performed in a classroom with constant illumination provided by overhead fluorescent light and a distant window. The equipment and materials required for the testing procedure included; the PRR Chart, a stopwatch, PRR record score sheet, a reading stand and pen.

Only two persons were present in the room during the test which included the examiner and the subject. The test procedure was explained in the same manner to each of the subjects. The learner was asked not to use his or her fingers to aid in the reading process. The near visual acuity determined in the pre-visual screening phase of the study, was used to determine the appropriately equivalent version of the PRR Chart to be used. The selected version of the PRR Chart was placed on a reading stand at a distance of 40 centimeters from the child. The test distance was maintained at this distance with a forty centimeter string attached to the chart. Each learner was asked to read aloud the words binocularly as rapidly as possible. When the examiner said “go”, the learner began reading the words and simultaneously the stop watch was started. As soon as one minute was reached the examiner said “stop”, stopped the stop watch and the last word uttered by the learner was noted on the score sheet by the examiner. Any error such as addition or omission was documented on the score sheet and deducted from the total words read. The reading rate was also documented on the score sheet and was determined as the number of words read correctly by the learner in

one minute. If the learner had finished the passage before one minute, then the words per minute was calculated as follows:

$$\text{Reading rate} = \frac{60 \times (\text{Total number of words correctly read})}{(\text{Total time taken in seconds})}$$

(Wilkins *et al*., 1996)

It was planned that if the learner experiences pain or extreme visual stress, the test would be discontinued. However, during the testing procedure no child experienced any of these symptoms. The reading rate on the same 100 learners was then retested one week later and the results documented on the score sheet. The testing procedures were the same as that of above. The demographic data of each learner and both the test and retest reading rate findings per learner were recorded in a data table.

3.4.2.2.2 Determining the validity of the PRR Chart

Approximately one week after the reliability test, the validity data was collected. The inclusion criteria were the same as that of determining the reliability of the PRR Chart.

Procedure: The second 100 learners that passed both the PRR Chart pre-testing evaluation and pre-test visual screening (as discussed in 3.4.2.2.1 above) then proceeded to the validity determination of the PRR Chart. In the first week of validity testing, the reading rate was determined (as that of reliability testing

above) using the PRR Chart, and documented on the respective PRR score sheet for each of the 100 learners. One week later, the reading rate on same 100 learners was determined using an appropriate version of the Wilkins Chart, comparable in size with the PRR Chart and recorded on the appropriate Wilkins score sheet. The demographic data of each subject and both the reading rates for the PRR Chart and the Wilkins Rate of Reading Test per learner were recorded in a data sheet.

3.4.2.3 Data analysis

Reliability and validity data were entered onto Statistical Package of Social Sciences (SPSS) version 18 and statistically analyzed using the Paired *t*-test, Pearson Correlation, and the Bland and Altman method (Bland & Altman, 1986, 2003). The Bland and Altman analysis (Bland & Altman, 1986, 2003) is used to assess the agreement between two sets of clinical measurements performed by the same test, as well as the agreement between two methods of clinical measurements. The results were presented in the form of frequency distribution, cross tabulation, pie charts, bar charts, box plot and scatterplot graphs.

3.4.3 TESTING THE PRR CHART ON LOW VISION PARTICIPANTS

Although the PRR Chart was designed for both normally sighted and low vision learners, the trial use of the chart was not done for the normally sighted learners as they were recruited when determining both the reliability and validity of the PRR

Chart. Having established the reliability and validity of the PRR Chart, the final part of the study included trial use of the chart on low vision learners.

3.4.3.1 Population and sampling

As there were only a few schools in the KwaZulu-Natal Province for visually impaired children, the Arthur Blaxall School for the Visually Impaired, in Pietermaritzburg, was identified for inclusion in the study. This school was also chosen due to convenience as the learners attend the optometry eye clinic at the University of KwaZulu-Natal. Permission to conduct this part of the study was obtained from the principal of the school. Approximately twenty five Information documents and consent forms were given to the school to distribute to the parents or guardians of the learners. Only twenty learners returned the signed consent forms. Fifteen learners were then randomly selected for this part of the study. The age of the learners ranged from 8 to 19 years old. The etiology of the low vision for the learners was confirmed in a clinical record which is in the schools possession and diagnosis and records have been signed by ophthalmologists. The inclusion criteria were as follows:

i. Learners with signed consent forms
ii. Both males and females were considered
iii. All ethnic groups were considered.
iv. All subjects irrespective of the low vision etiology were considered in the study.
v. Subjects able to read all words in the PRR pretest chart.

3.4.3.2 Materials and procedure

As part of the routine low vision examination, each learner underwent the following tests: case history, unaided and aided near and distance visual acuity, retinoscopy, subjective refraction, contrast sensitivity, colour vision, internal ocular health assessment and selection of optical device. Unaided distance and near visual acuity for right, left and both eyes were measured using the Bailey-Lovie distance chart and near logMAR chart respectively. Results were recorded in M notation and in logMAR. The PRR pre-test chart was administered first to the learner (as 3.4.2.2.1). Only subjects that could identify the words were used in the study. As only one of the 15 learners failed the PRR pre-test evaluation, 14 of the learners proceeded to the reading rate evaluation using the PRR Chart. The illumination provided by overhead fluorescent lighting was also kept constant in a clinical setting. According to the aided visual acuity determined after refractive error correction, the corresponding PRR Chart version was determined. The test chart was placed on a reading stand while the test distance per learner was maintained using a ruler at 40 cm or 25 cm depending on the working distance of the subject. The reading rate was then determined and recorded as in reliability above. Visual acuity of each subject using the near logMAR chart was reassessed and recorded with the optical device that produced the best near visual acuity. The corresponding version of the PRR Chart was determined based on the visual acuity with the low vision device and reading rate re-evaluated and documented.

3.4.3.3 Data Analysis

The reading rate without the device and reading rate with the device were entered onto SPSS version 18, and the data was analyzed using frequency distribution, tables, pie charts, Pearsons correlation and Paired *t*-test.

3.5 SUMMARY

Developing a new test requires a rigorous process to reduce possible bias and to ensure that it is age and purpose specific. In this study, the normal sighted children were used to validate the test, while the low vision learners were used to test its suitability. The results of the analysis will be presented in Chapter 4 and discussed in Chapter 5.

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

The results obtained from this study will be presented below in 4 sections; designing of the PRR Chart, the reliability of the PRR Chart, the validity of the PRR Chart and the testing of the chart on low vision participants with and without low vision devices.

4.2 DESIGNING OF THE PRR CHART

In the design of the PRR Chart, the PRR test chart, the pre-test chart and the recording score sheet will be presented.

4.2.1 The PRR test chart

The chart was printed on a separate 29.7 X 21 centimeter (A4) cardboard with the words printed in black on appropriately white card boards. Only ten words were used in the design of the chart. Only one paragraph of words per page was printed. Each paragraph consisted of ten rows (lines) of words and each row consists of the ten words with a total of one hundred words per chart. The same ten words were arranged in different random order per row per paragraph. This allowed each row per version, as well as each version of the designed chart to be

different. The inter-word and inter-row spaces were equal to those in the computer generated print and all words were printed in lower cases. The chart was available in two font types; Times New Roman and Arial. Each of these font versions was available in six additional versions that are A, B, C, D, E, and F (Figures 1 to 12: not printed to scale). There were therefore a total of twelve versions of the chart. Each version corresponds to the six visual acuity letter sizes of 6/15, 6/18, 6/24, 6/30, 6/48 and 6/60 with print sizes 1.45mm, 1.75mm, 2.33mm, 2.91mm, 4.65mm and 5.82mm respectively. Each version of the chart had four visual acuity notations; Meter (M), Snellen (Feet), Snellen (M) and Logarithm of Minimum Angle of Resolution (LogMAR).

Figure 1: Version A of the PRR Chart in Arial font

Version A

Arial Font

1.0M (20/50) (6/15) (0.4 LogMAR)

said yes cat you the look see can play help
can play you the cat see help yes said look
cat help look see the you yes said can play
you look yes help said play cat the see can
look cat help you the can said play yes see
the yes cat can help look see you said play
yes play cat help can said the see you look
the you can help cat see look said yes play
look cat play you yes said can see the help
the you see play cat can look said yes help

Figure 2: Version B of the PRR Chart in Arial font

Version B

Arial Font

1.25M (20/63) (6/18) (0.5 LogMAR)

look you said see help can the cat yes play
help play yes said look cat can the you see
said you look cat play help yes see the can
look cat you see said can help yes play the
can see help you look play the cat yes said
see play look said yes the you can help cat
yes cat help look see you said play can the
you look cat yes can see the said play help
cat the help play yes said you look can see
said play cat see can help the yes you look

Version C

Arial Font

1.6M (20/80) (6/24) (0.6 LogMAR)

can help yes play cat you said the look see
yes the look see you can help cat said play
look you can the cat said play see yes help
yes help said look see the can you cat play
cat see play yes can you said help the look
the look you help said yes can play cat see
said yes look play you see cat help the can
cat help said can the look you see yes play
said you see help play can yes look cat the
look the cat said you help see can play yes

Figure 3: Version C of the PRR Chart in Arial font

Version D

Arial Font

2.0M (20/100) (6/30) (0.7 LogMAR)

said can cat play see you yes help the look
help play said you yes look the can cat see
can see help said cat you play yes look the
see you look can said play cat the help yes
cat help said yes the can see you play look
play see look cat said the you can yes help
you can play cat see said look the help yes
the see cat you said play help can yes look
play cat can yes you look the said help see
the you look help can yes play see cat said

Figure 4: Version D of the PRR Chart in Arial font

Version E

Arial Font

3.2M (20/160) (6/48) (0.9 LogMAR)

the cat see play you can look said yes help
see play can cat look you yes help said the
help you yes said see can look play the cat
can look cat you help said see the play yes
you yes the play look can cat see said help
can said you yes see play help cat the look
play the see look can cat said you help yes
said cat play yes you help see the look can
look the help you play yes cat can see said
yes look see cat can play help said you the

Figure 5: Version E of the PRR Chart in Arial font

Version F

Arial Font

4.0M (20/200) (6/60) (1.0 LogMAR)

help the said look can yes see cat you play
can play cat the said look yes see you help
yes said help see can you cat the play look
help cat play see the yes can look said you
look you yes said can the see cat help play
can look cat the help see you play yes said
see play look help cat can yes the said you
can help you see said look cat play yes the
you help the said yes play can look cat see
look help play can the you said see yes cat

Figure 6: Version F of the PRR Chart in Arial font

Version A

Time New Roman Font

1.0M (20/50) (6/15) (0.4 LogMAR)

said yes cat you the look see can play help
can play you the cat see help yes said look
cat help look see the you yes said can play
you look yes help said play cat the see can
look cat help you the can said play yes see
the yes cat can help look see you said play
yes play cat help can said the see you look
the you can help cat see look said yes play
look cat play you yes said can see the help
the you see play cat can look said yes help

Figure 7: Version A of the PRR Chart in Time New Roman font

Version B

Time New Roman Font

1.25M (20/63) (6/18) (0.5 LogMAR)

look you said see help can the cat yes play
help play yes said look cat can the you see
said you look cat play help yes see the can
look cat you see said can help yes play the
can see help you look play the cat yes said
see play look said yes the you can help cat
yes cat help look see you said play can the
you look cat yes can see the said play help
cat the help play yes said you look can see
said play cat see can help the yes you look

Figure 8: Version B of the PRR Chart in Time New Roman font

Version C

Time New Roman Font

1.6M (20/80) (6/24) (0.6 LogMAR)

can help yes play cat you said the look see
yes the look see you can help cat said play
look you can the cat said play see yes help
yes help said look see the can you cat play
cat see play yes can you said help the look
the look you help said yes can play cat see
said yes look play you see cat help the can
cat help said can the look you see yes play
said you see help play can yes look cat the
look the cat said you help see can play yes

Figure 9: Version C of the PRR Chart in Time New Roman font

Version D

Time New Roman Font

2.0M (20/100) (6/30) (0.7 LogMAR)

said can cat play see you yes help the look
help play said you yes look the can cat see
can see help said cat you play yes look the
see you look can said play cat the help yes
cat help said yes the can see you play look
play see look cat said the you can yes help
you can play cat see said look the help yes
the see cat you said play help can yes look
play cat can yes you look the said help see
the you look help can yes play see cat said

Figure 10: Version D of the PRR Chart in Time New Roman font

Version E

Time New Roman Font

3.2M (20/160) (6/48) (0.9 LogMAR)

the cat see play you can look said yes help
see play can cat look you yes help said the
help you yes said see can look play the cat
can look cat you help said see the play yes
you yes the play look can cat see said help
can said you yes see play help cat the look
play the see look can cat said you help yes
said cat play yes you help see the look can
look the help you play yes cat can see said
yes look see cat can play help said you the

Figure 11: Version E of the PRR Chart in Time New Roman font

Version F

Time New Roman Font

4.0M (20/200) (6/60) (1.0 LogMAR)

help the said look can yes see cat you play
can play cat the said look yes see you help
yes said help see can you cat the play look
help cat play see the yes can look said you
look you yes said can the see cat help play
can look cat the help see you play yes said
see play look help cat can yes the said you
can help you see said look cat play yes the
you help the said yes play can look cat see
look help play can the you said see yes cat

Figure 12: Version F of the PRR Chart in Time New Roman font

4.2.2 Pre-test Chart

The pretest chart consisted of the same ten words that were used in the reading test chart but in a larger type faces. The ten words were arranged in two columns of five words each. For each of the two font versions, Times Roman and Arial, two pretest charts were available. Each of the pretest charts were also printed with black on white background and on a separate page (Figure 13 & 14).

Pre - Test Chart

Arial Font

the	play
cat	help
look	you
said	can
see	yes

Figure 13: Pre-test Chart in Arial font

Pre - Test Chart

Time New Roman Font

the	play
cat	help
look	you
said	can
see	yes

Figure 14: Pre-test Chart in Times New Roman font

4.2.3 Recording score sheet

A recording score sheet was designed which contained the same word layout as each version (A, B, C, D, E and F) of the test (Figure 15 to 20). Space was provided on the top of the recording sheet to record the name, date of birth, age, grade of the child and the test date. The version of the test chart (A, B, C, D, E, or F) and corresponding acuity levels, in Meter (M), Snellen(ft), Snellen (M.) and LogMAR notations, were also provided. At the end of each line, a word count ten to one hundred was provided. Large inter-row spacing was provided below each row of words to indicate the errors (omissions and additions) made in the word reading. At the bottom end of the recording score sheet space was allocated to document reading time in seconds, type and number of errors, reading rate, the total number of correct words read, and comments.

SCORE SHEET (VERSION A)

NAME: _____DOB: _____ AGE: ___GRADE: ___DATE OF TEST:_____

1.0M 20/50 6/15 0.4LogMAR

said yes cat you the look see can play help 10

can play you the cat see help yes said look 20

cat help look see the you yes said can play 30

you look yes help said play cat the see can 40

look cat help you the can said play yes see 50

the yes cat can help look see you said play 60

yes play cat help can said the see you look 70

the you can help cat see look said yes play 80

look cat play you yes said can see the help 90

the you see play cat can look help yes said 100

Reading Time: _____(sec)

Errors (addition): _____

Errors (omission): _____

Total errors: _____

Total words: _____

Reading Rate: _____(wpm)

Comments: _____

Figure 15: Score-sheet Version A

SCORE SHEET (VERSION B)

NAME: _____DOB: _____ AGE: ___GRADE: ___DATE OF TEST:_____

1.25M 20/63 6 / 18 0.5LogMAR

look you said see help can the cat yes play 10

help play yes said look cat can the you see 20

said you look cat play help yes see the can 30

look cat you see said can help yes play the 40

can see help you look play the cat yes said 50

see play look said yes the you can help cat 60

yes cat help look see you said play can the 70

you look cat yes can see the said play help 80

cat the help play yes said you look can see 90

said play cat see can help the yes you look 100

Reading Time: _____(sec)

Errors (addition): _____

Errors (omission): _____

Total errors: _____

Total words: _____

Reading Rate: _____(wpm)

Comments: _____

Figure 16: Score-sheet Version B

SCORE SHEET (VERSION C)

NAME: _____DOB: _____ AGE: ___GRADE: ___DATE OF TEST:_____

1.6M 20/80 6 / 24 0.6LogMAR

can help yes play cat you said the look see	10
yes the look see you can help cat said play	20
look you can the cat said play see yes help	30
yes help said look see the can you cat play	40
cat see play yes can you said help the look	50
the look you help said yes can play cat see	60
said yes look play you see cat help the can	70
cat help said can the look you see yes play	80
said you see help play can yes look cat the	90
look the cat said you help see can play yes	100

Reading Time: _____(sec)

Errors (addition): _____

Errors (omission): _____

Total errors: _____

Total words: _____

Reading Rate: _____(wpm)

Comments: _____

Figure 17: Score-sheet Version C

SCORE SHEET (VERSION D)

NAME: _____DOB: _____ AGE: ___GRADE: ___DATE OF TEST:_____

2.0M 20/100 6 / 30 0.7LogMAR

said can cat play see you yes help the look 10

help play said you yes look the can cat see 20

can see help said cat you play yes look the 30

see you look can said play cat the help yes 40

cat help said yes the can see you play look 50

play see look cat said the you can yes help 60

you can play cat see said look the help yes 70

the see cat you said play help can yes look 80

play cat can yes you look the said help see 90

the you look help can yes play see cat said 100

Reading Time: _____(sec)

Errors (addition): _____

Errors (omission): _____

Total errors: _____

Total words: _____

Reading Rate: _____(wpm)

Comments: _____

Figure 18: Score-sheet Version D

SCORE SHEET (VERSION E)

NAME: _____DOB: _____ AGE: ___GRADE: ___DATE OF TEST:_____

3.2M 20/160 6/48 0.9LogMAR

the cat see play you can look said yes help	10
see play can cat look you yes help said the	20
help you yes said see can look play the cat	30
can look cat you help said see the play yes	40
you yes the play look can cat see said help	50
can said you yes see play help cat the look	60
play the see look can cat said you help yes	70
said cat play yes you help see the look can	80
look the help you play yes cat can see said	90
yes look see cat can play help said you the	100

Reading Time: _____(sec)

Errors (addition): _____

Errors (omission): _____

Total errors: _____

Total words: _____

Reading Rate: _____(wpm)

Comments: _____

Figure 19: Score-sheet Version E

SCORE SHEET (VERSION F)

NAME: _____DOB: _____ AGE: ___GRADE: ___DATE OF TEST:_____

4.0M 20/200 6 / 60 1.0LogMAR

help the said look can yes see cat you play	10
can play cat the said look yes see you help	20
yes said help see can you cat the play look	30
help cat play see the yes can look said you	40
look you yes said can the see cat help play	50
can look cat the help see you play yes said	60
see play look help cat can yes the said you	70
can help you see said look cat play yes the	80
you help the said yes play can look cat see	90
look help play can the you said see yes cat	100

Reading Time: _____(sec)

Errors (addition): _____

Errors (omission): _____

Total errors: _____

Total words: _____

Reading Rate: _____(wpm)

Comments: _____

Figure 20: Score-sheet Version F

4.3 RELIABILITY RESULTS

The reliability results will be discussed in 2 parts; demographic profile of the learners and the reliability of the PRR Chart.

4.3.1 Demographic profile

The profile of the 100 learners who participated in the study are presented according to: age, gender, ethnicity, grade and age versus grade.

Statistically, the age groups of the learners were not normally distributed. The ages ranged from 9 to 12 years with the mean age of 10.63 ± 0.90SD. In the age group 9 to 12 years, the highest number of 43% was the 11 year olds and the lowest of 12% were the 9 year olds (Table 1).

Table 1: The distribution of learners who participated in the study by age.

Age (years)	**Number (*N*)**	**Percentage (%)**
9	12	12.0
10	29	29.0
11	43	43.0
12	16	16.0
Total	**100**	**100**

There were 58% female and 42% male who participated in the study and only 2 ethnic groups. The participants were in grades 4 to grade 7 as shown in Table 2. There were 13% of the learners in grade 4, 35% each in grade 5 and 6, and 17% in grade 7.

Table 2: The distribution of learners by grade in number and percentage.

Grades	**Number (*N*)**	**Percentage (%)**
4	13	13
5	35	35
6	35	35
7	17	17
Total	**100**	**100**

The learners who participated in the study were in grades 4 to 7 as shown in Table 3. Grade 4 comprised of subjects aged 9 to 11 years, grade 5 from 9 to 12 years, grade 6 from 10 to 12 years, and grade 7 from 10 to 12 years. The highest age distribution of the learners in each grade were as follows; 66.7% of grade 4 were 9 years old, 55.2% in grade 5 were 10 years old, 55.8% in grade 6 were 11 years old and 56.3% in grade 7 were 12 years old. Table 3 also shows that 2.3% of those in grade 4 were 11 years old and 25.3% in grade 5 were 12 years old.

Table 3: Cross-tabulation of learners by age and grade, with 9, 10, 11 and 12 years of age in grade 4, 5, 6, and 7 respectively.

Age (years) of subjects	Grade of child/number and percentages				Total
	4	5	6	7	
9	8 (66.7)	4 (33.3)	0 (0.0)	0 (0.0)	12 (100)
10	4 (13.8)	16 (55.2)	8 (27.6)	1 (3.4)	29 (100)
11	1 (2.3)	11 (25.6)	24 (55.8)	7 (16.3)	43 (100)
12	0 (0.0)	4 (25.0)	3 (18.8)	9 (56.3)	16 (100)
Total	13 (13.0)	35 (35.0)	35 (35.0)	17 (17.0)	100 00)

4.3.2 Results on the reliability of the PRR Chart

The results of the repeated reading rate values (R1 and R2) on the normal sighted learners are presented in this section. The results were analyzed in three ways: the paired *t*-test, Pearson correlation, and by the Bland and Altman method.

The reading rates test (R1) and retest (R2) results, means and standard deviations are shown in Table 4. The mean reading rate R1 and R2 were 77.65 $\pm$ 25.30 and 78.23 $\pm$ 24.70 respectively. Results show that there was no significant difference ($p=0.287$) between R1 and R2.

Table 4: The comparison of reading rates test (R1) and retest (R2).

	Reading Rate (R)				
	Minimum	**Maximum**	**Mean**	**Standard Deviation**	**Sig. (2-tailed)**
Test (R1)	**52.35**	**102.95**	77.65	25.30	
Retest (R2)	**53.53**	**102.93**	78.23	24.70	.287

Pearson correlation (r = 0.976) illustrated in Figure 21, shows that R1 and R2 correlate strongly.

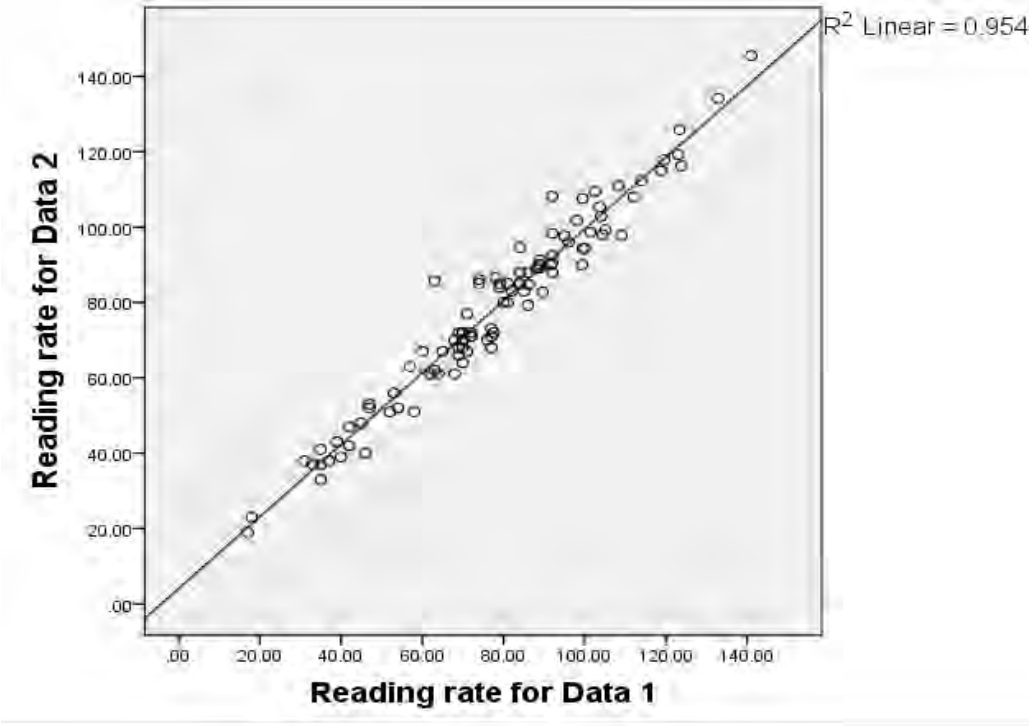

Figure 21: Scatterplot showing reading rate test and retest in words per minute at first and second testing session 1 week apart using the PRR Chart. Test and retest measurements shows a strong correlation.

In the Bland-Altman scatterplot Figure 22, the horizontal lines represent the mean difference (black continuous line) and the 95% limits of agreement (red and green dotted lines). The mean difference is set at -0.5819, while limits of agreement, which is defined as the mean difference plus and minus 2 times the standard deviation of the differences, with the upper (red) and lower (green) 95% limits of agreement are set at +10.068 and -11.2318 respectively.

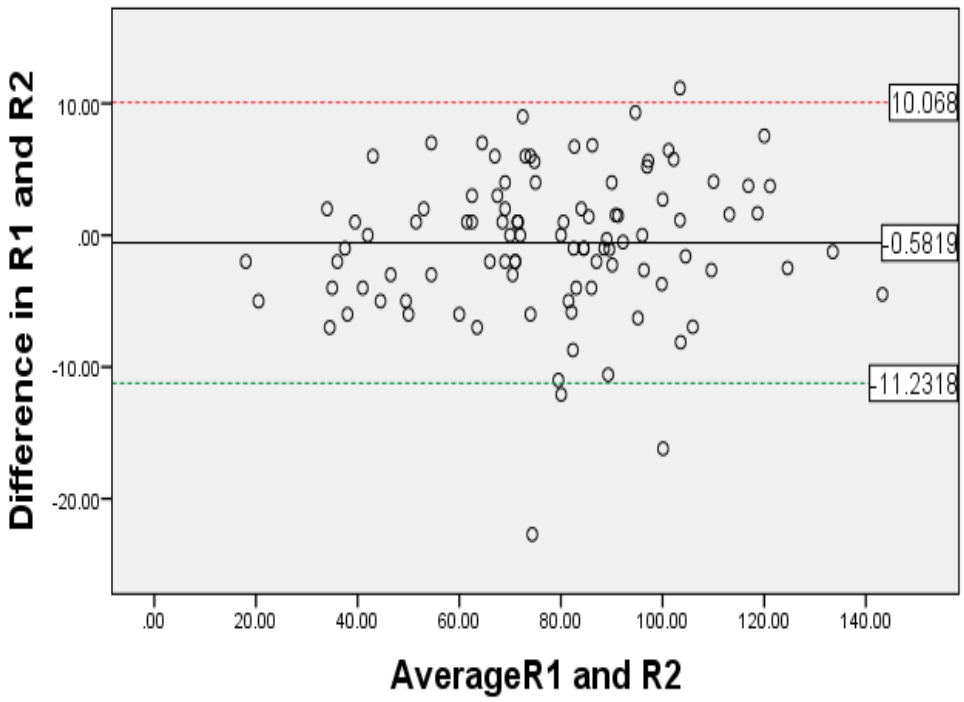

Figure 22: Differences between reading rate test (R1) and retest (R2) for individual learners obtained with PRR Chart are plotted against the averages of the reading rates R1 and R2, 1 week apart according to the Bland and Altman method. The derived confidence intervals are also shown (dotted lines).

4.4 VALIDITY RESULTS

The results obtained from the validity evaluation on normal vision learners are presented below. These results are presented in 2 sections; the demographic profile of the learners, and the validity of the PRR Chart.

4.4.1 Demographic profile

The profiles of the subjects are discussed according to: age, gender, ethnicity, and grade. There were a total of 100 subjects used in the study. The age of the subjects ranged from 9 to 12 years old with the mean age of 10 ± 1SD. The percentage distributions are illustrated in Figure 23.

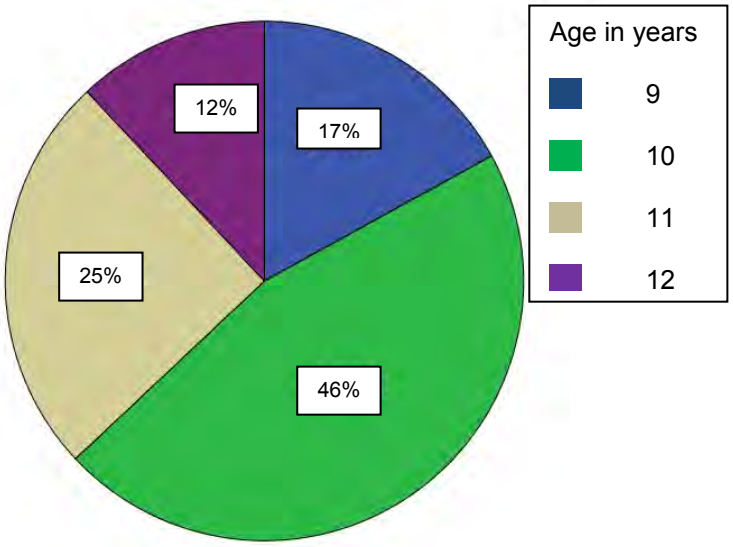

Figure 23: The percentage distribution of learners by age.

The gender distribution of those who participated in the study is 39% male and 61% female. Table 5 shows that; majority of the females and males were 10 years old representing 42.6% and 51.3% respectively. Other information is presented in Table 5.

Table 5: The distribution of learners who participated in the study by age and gender.

Age of subjects (in years)	Female *N* (%)	Male *N* (%)
9	12 (19.7)	5 (12.8)
10	26 (42.6)	20 (51.3)
11	18 (29.5)	7 (17.9)
12	5 (8.2)	7 (17.9)
Total	**61(100)**	**39 (100)**

The ethnic groups as percentages of subjects who participated in the study are 2% Indian and 98% Black. The grade distribution of the subjects ranged from grade 4 to grade 5 as shown in Table 6. Of the total number of subjects, 45% were in grade 4 and 55% were in grade 5. In grade 4 and 5, 45.9% and 54.1% were females respectively while 43.6% and 56.4% were males respectively.

Table 6: The distribution of learners by grade and gender.

Grade of subjects	Female *N* (%)	Male *N* (%)	Total *N* (%)
4	28 (45.9)	17 (43.6)	45 (45)
5	33 (54.1)	22 (56.4)	55 (55)
Total	61 (100)	39 (100)	100 (100)

In grade 4 the minimum age was 9 years coincident with the 25 percentile rank and the maximum age was 11years as illustrated in Figure 24. There were two outliers (represented by case 65 and 66 on the graph) whom were 12 years of age who fall outside the age range for grade 4. In grade 5 the minimum and maximum age were 9 and 12 respectively. The median age for both grade 4 and 5 were 10 years.

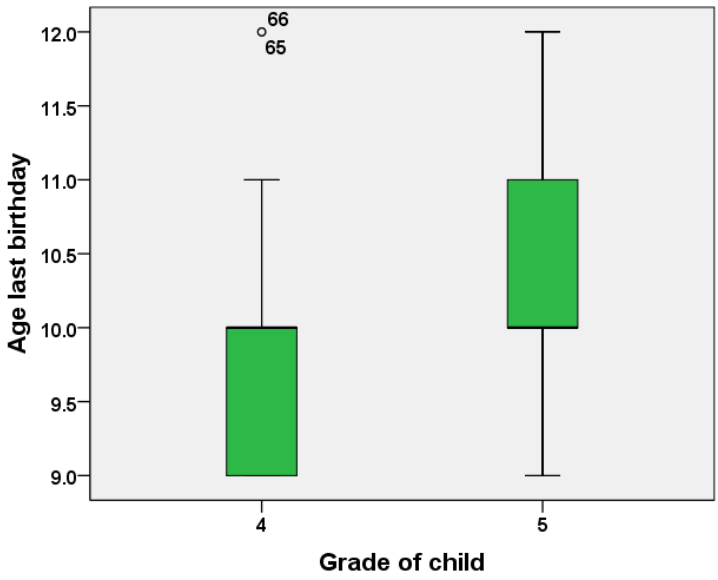

Figure 24: The median age distribution of learners by grade.

4.4.2 Results of the validity of the PRR Chart

There was a normal parametric distribution of the reading rate for the Wilkins Test and PRR Chart, with the mean and standard deviation as 75.82 $\pm$ 23.64 and 74.92 $\pm$ 23.58 respectively, as shown in Table 7.

Table 7: The paired statistics of the reading rate determined with the PRR Chart and the Wilkins Test.

Test Charts	Reading Rate (R)					
	Minimum	**Maximum**	**Mean**	**Standard Deviation**	**Correlation**	**Sig. (2-tailed)**
PRR Chart	**51.34**	**98.50**	74.92	23.58	**0.993**	**0.00**
Wilkins Test	**52.18**	**99.46**	75.82	23.64		

Further, the difference in performance between the two tests was analyzed in three ways: by the Paired t- test, Pearson"s Correlation and by Bland and Altman method. The paired t-test ($p < 0.01$) shows a significant correlation between the reading rate determined by the PRR Chart to that of the Wilkins RRT chart that is beyond chance. Furthermore, the Pearson"s correlation ($r = 0.993$, $R^2 = 0.986$) shows a strong positive relationship between the two test charts.

The Bland-Altman analysis of the Wilkins Test and the PRR Chart are shown in Figure 25, with the Confidence Interval set at 95%. The continuous horizontal line represents the mean difference of the reading rate between the two charts, while the dotted lines represents the upper (red) and lower (green) limits of agreement. The mean difference of the reading rates between the two charts was +0.90 and the confidence limits constructed around this mean with the upper limit at +6.33 and lower limit at -4.53.

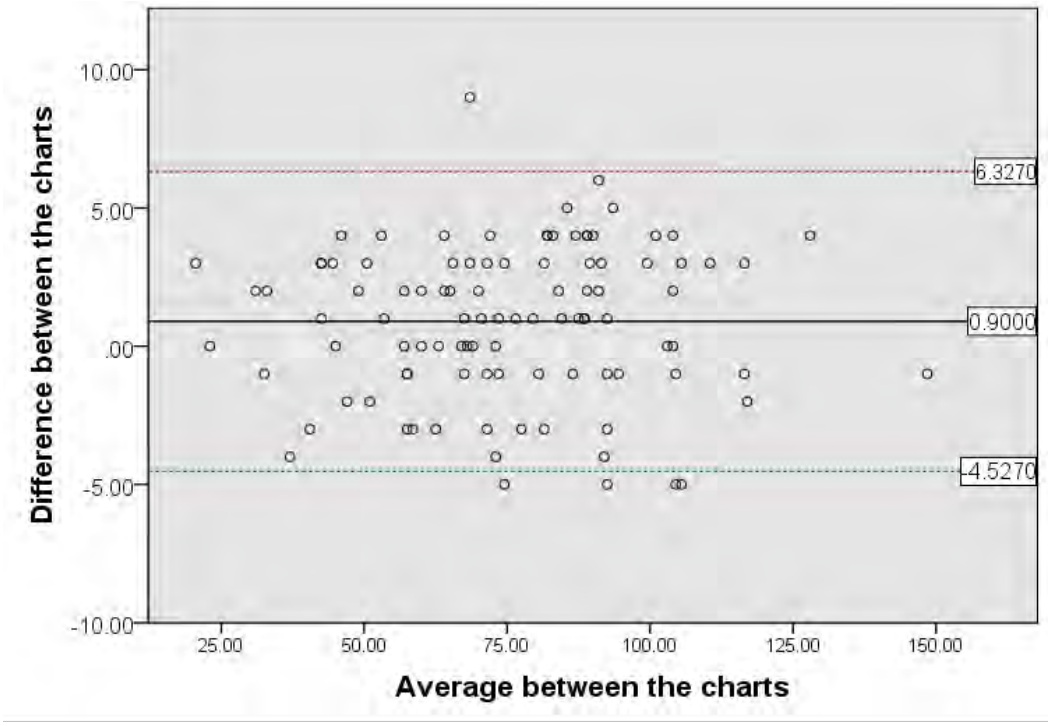

Figure 25: The differences between the reading rate measurements for the individual learners obtained with the Wilkins Test and the PRR Chart are plotted against the averages of these data according to the Bland and Altman method. The upper and lower confidence intervals are represented by dotted lines.

4.5 TESTING OF THE PRR CHART ON SELECTED LOW VISION LEARNERS

The results on the trial use of the chart on 14 low vision learners are presented below and presented in three sections; the demographic profile, their low vision etiology and the comparison of the visual acuity, total errors made and reading rate obtained without the device and then with the device as tested with the new chart.

4.5.1 Demographic profile of the learners

The demographic profiles of the 14 low vision learners are presented below according to the age, gender, grade, and ethnicity.

Their ages ranged from 8 to 19 years with mean 13.86 ± 3.34. Their age distributions are in Table 8.

Table 8: The distribution of low vision learners by age who participated in the trial use of the PRR Chart.

Age of subjects (years)	Number (*N*)	Percentage (%)
8	1	7.1
10	1	7.1
11	3	21.4
12	1	7.1
14	1	7.1
15	1	7.1
16	2	14.3
17	3	21.4
19	1	7.1
Total	**14**	**100**

The gender distributions of those who participated in the study were 85.7% female and 14.3% male, and 100% of the learners were Black. The grades of the

learners are shown in Table 9. A large proportion of the learners were between grades 6 and 10.

Table 9: The distribution of the low vision learners by grade, number and percentage.

Grades	Number (*N*)	Percentage (%)
1	1	7.1
2	1	7.1
3	1	7.1
4	1	7.1
6	3	21.4
8	3	21.4
10	3	21.4
11	1	7.1
Total	**14**	**100.0**

4.5.2 Etiology of low vision

The percentages of the etiology of the low vision among the learners are illustrated in Figure 26. Bilateral aphakia, corneal dystrophy, coloboma of iris, retina and choroid, retinitis pigmentosa, high myopia and nystagmus represented 7.14% each. Subjects with congenital cataracts and albinism represented 21.43% and 35.71% respectively.

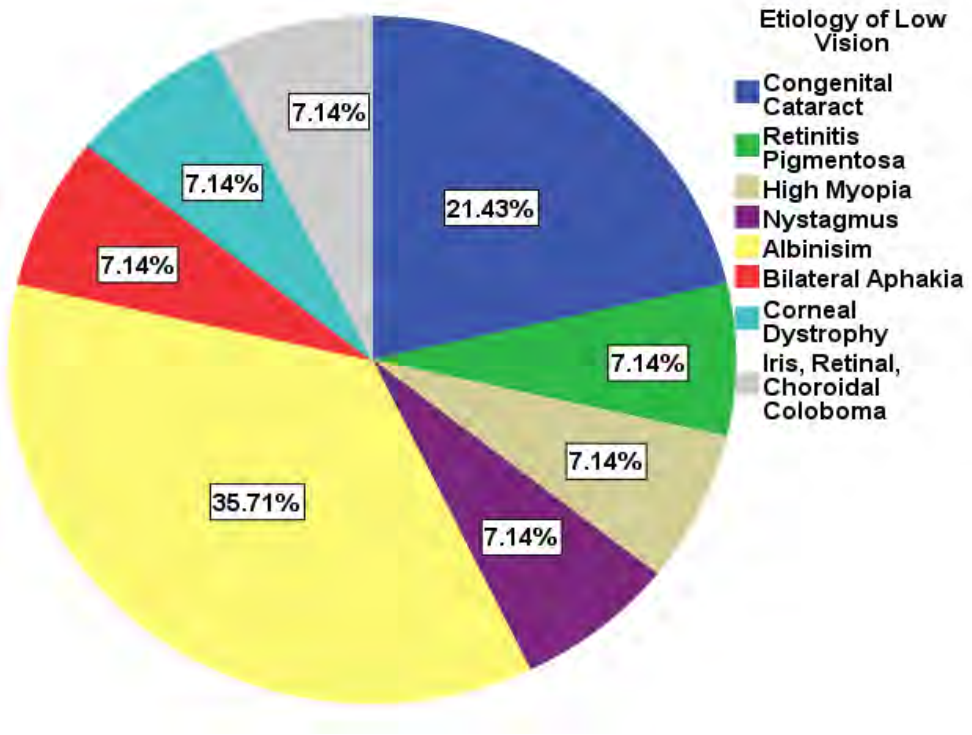

Figure 26: Etiology of low vision as a percentage of the total number of learners who participated in the study, with albinism representing the leading cause of low vision.

4.5.3 Results obtained without and with low vision devices

The results include visual acuity, total errors made and reading rate obtained without and with the low vision devices are presented below.

The unaided near visual acuity was determined either at 25 cm or 40 cm, depending on which test distance was appropriate for each low vision learner. Of the total sample, 35.72% performed near visual acuity assessment at 25cm with and without low vision device, while 64.72% assessments were recorded at 40cm.

The visual acuity at 25cm ranged from 3.2M to 8M without device to 1.6M to 3.2M with the device. The visual acuity at 40cm ranged from 1.25M to 6.3M without the device, and to 1.0M to 3.2M with the device.

Table 10 shows that chart versions A to F and A to D were used in the reading rate assessment of the low vision learners without and with devices respectively. Only one learner did not require a low vision device, and the reading rate was therefore not determined with a device.

Table 10: Reading Rate findings without and with low vision devices prescribed for the trial use of the PRR Chart on low vision learners

S/N	Chart Version without Device	Reading Rate Without Device	Errors Without Device	Chart Version with Device	Reading Rate with Device	Errors With Device
1	E	88	27	A	68	8
2	D	109	13	D	133	9
3	C	74	3	A	79	3
4	E	59	2	A	75	5
5	C	43	3	A	50	3
6	D	50	13	A	72	5
7	F	28	17	D	29	19
8	E	40	2	A	47	3
9	C	81	23	A	87	14
10	F	39	3	A	66	4
11*	A	48	10	-	-	-
12	E	74	6	A	54	17
13	D	34	11	A	44	11
14	C	55	11	A	70	3

* The subjects visual acuity improved with spectacle prescription and did not require low vision device.

The low vision devices used in the study are shown in Table 11. One learner (7.1%) did not require a near low vision device. Low vision devices were prescribed for 92.9% of the learners. Dome magnifiers were prescribed to 50% of the learners with 35.7% using 2x magnification and 14.3% using 3 x magnifications. Other devices prescribed were stand, bar and hand magnifiers at 14.3% each.

Table 11: The characteristic of the low vision devices used in the study.

Type and magnification of Low Vision Device	**Number (N)**	**Percentage (%)**
No Device	1	7.1
2X Dome Magnifier	5	35.7
3X Dome Magnifier	2	14.3
3X Stand Magnifier	2	14.3
1.5X Bar Magnifier	2	14.3
3X Hand Magnifier	2	14.3
Total	14	100.0

The minimum and maximum errors made by the learners without and with the low vision device were 2 to 18 and 2 to 14 respectively. The mean and standard deviation of the errors made without and with low vision devices are 10 ± 8 and 8 ± 6 respectively.

The mean reading rate without and with the device, as shown in Table 12 below, were 59.32 ± 24.08 wpm and 67.04 ± 25.63 wpm respectively. Pearson‟s correlation coefficient (r = 0.822, R^2 = 0.675) showed a strong correlation while the Paired t-test (p = 0.087) showed no significant difference between the reading rates obtained without and with the low vision devices.

Table 12: The Correlation Coefficient and Paired t-test between the average reading rate values determined without and with the low vision devices using the PRR Chart.

Average Reading Rate	**Mean**	**Std. Deviation**	**Correlation**	**Sig. (2-tailed)**
Without the device	59.32	24.078		
With the device	67.04	25.630	0.822	0.087

Figure 27 shows a positive relationship between the reading rates obtained without the device to the reading rate obtained with the low vision device with R^2 = 0.675.

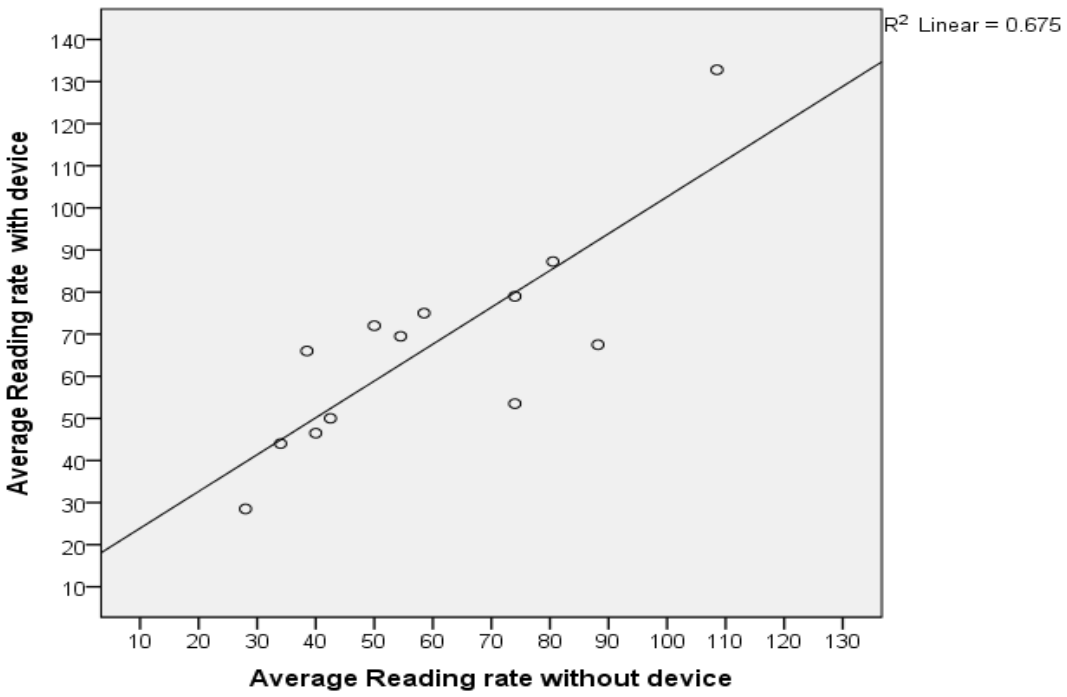

Figure 27: The correlation between the average reading rate without and with the low vision device. The reading rate with the low vision device is higher than without the device.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

Following this short introduction, this chapter discusses factors taken into consideration in the design of the chart as well as the results in terms of the chart design, reliability and validity based on data obtained from normally sighted children. In addition, findings on the trial use of the chart on a selected number of low vision subjects and possible uses of the PRR Chart are discussed. Finally, this chapter establishes whether the study aims were met.

As indicated in chapter two, reading is a very important aspect of primary school children‟s activities, and accounts for a large proportion of what they learn. The process of reading has many components and if any component is affected, it will impact on the reading performance of the child, which can affect their educational pursuit. Also, reading speed is an important aspect of reading performance as a slow reader might be considered as a poor reader and a fast reader considered a good reader. Furthermore, anecdotal reports suggest that fast readers tend to do better in their academic work than slow readers. While reading speed is important, reading rate is more important as it does not consider the number of words that are read per given time, but it also considers the accuracy of reading. It is therefore important to measure reading rate for children rather than the

reading speed. This being the case, it is important that an appropriate chart is available for measuring reading rate in children. Unfortunately, existing charts that can be used to measure reading rate, such as Baily-Lovie (1980) and MNREAD (1995), were not specifically designed for that purpose, therefore have their limitations. Also, Wilkins RRT chart (1996), which is designed for that purpose, has its limitations as indicated in literature review (chapter 2).

Factors considered in the design of the chart

Wilkins RRT chart (Wilkins *et al*., 1996) can be considered to be the most appropriate existing test chart for evaluating reading rate because it has several factors that enable and facilitate reading rate evaluation as discussed in literature review (chapter 2). Unfortunately, from an Optometric perspective, Wilkins RRT chart has limitations that are considered to be essential in the design of reading rate charts. Firstly, the paragraphs in the chart do not have acuity notations that indicate the level of vision of each child prior to the use of the chart. This is essential for record purposes for future examiners. Also, according to Lovie-Kitchin and Whittaker (1999), reading performance ideally should be determined at the level of the patients near visual acuity. As Wilkins RRT chart does not have visual acuity notations, it may be assumed that the chart does not take visual acuity values into consideration.

Secondly, the print of the Wilkins RRT chart is not considered to be large enough for many children with low vision. Although not indicated on the chart, the largest print on the Wilkins chart is approximately equivalent to 2M. This print size may

not be large enough to accommodate many low vision children, even at a reading distance of 20 centimeters where the 2M print size is equivalent to 4M (relative distance magnification). Previous charts for evaluation of vision for low vision patients (including children) have acuity values greater than 2M. For instance, MNREAD (Ahn & Legge, 1995) has values ranging from 0.16 to 4M, Near Reading Card for partially sighted designed by Feinbloom has values 0.8M to 3M (Jose, 1989), the Bailey and Lovie reading chart version W1 (Bailey & Lovie, 1980) has acuity values from 0.25 to 5.0M and the Lighthouse (continuous text) card designed for adults range from 0.4 M to 8M (Bailey & Lovie, 1980; Elliott, Patel & Whitaker, 2001). It is important that charts designed to measure reading rate has paragraphs that have prints that can be used to measure reading rate for the low vision patients as well. As reading is one of the most important goals of low vision patients (Elliot *et a*l., 1992), aspects of reading, including reading rate should be given a priority in their rehabilitation.

Currently, reading in low vision patients is not only based on the print size but the speed of reading is also taken into consideration when prescribing low vision devices (Lovie-Kitchin & Whittaker, 1999). It is therefore important that reading rate, which takes cognizance of both the reading speed and reading accuracy, be given a priority in the rehabilitation of low vision patients with regards to reading tasks. This being the case, an appropriate chart which can be used to measure reading rate is necessary and this is one of the goals of the present study.

5.2 THE DESIGN OF THE PRR CHART

As the purpose of this project was to design a chart to measure reading rate in children as young as six years old, common and frequently used words in textbooks written in English and used by South African primary school children were used in the design of this chart. As indicated in the methodology, ten words containing three and five letters were chosen to design the chart as these were considered to be of an average difficulty for children between six and 12 years old. The variability in reading speed due to linguistic factors as well as syntactic and semantic properties of the text were minimized by using the same ten words in each row (line) but in different random orders as recommended by several authors (Bailey & Lovie, 1980; Ahn & Legge, 1995; Wilkins, Jeanes, Pumfrey, & Laskier, 1996). Such design ensures that the legibility and difficulty value of each is constant. Bailey and Lovie (1980) also stated that unconnected words were considered to be more appropriate in the design of reading charts rather than sentences or prose. This random arrangement of the words in this present chart was also aimed to eliminate memorization.

Although Ferraro and Ferraro (1989) suggested 150 words per paragraph and subsequently Wilkins *et al.* (1996) used the same number of words, 100 words per paragraph were used in the design of the present chart. This number of words per paragraph was chosen as the chart was designed specifically for children including those with low vision. Children, especially the younger ones such as those that are six years old, are expected to have low reading speed. With this in mind, it was considered unnecessary to have paragraphs with 150 words. Also,

children with low vision are known to have low reading speed. This is in agreement with the report of Mangold and Mangold (1989) who stated that an acceptable reading rate for low vision children up to grade three is 60 words per minute (wpm). Low vision children from grade four to six should read at 70 wpm while Fellenius (1996) reports that children older than six years should read about 90 wpm. As print sizes of words up to 4M acuity (5.82 mm) were to be included in the chart, printing 15 words of that size per row would create an unnecessarily large chart that may not fit into an A4 paper.

The maximum print size was limited to 4M in the present chart because it was found to be the size that can conveniently be accommodated on an A4 size cardboard. The best corrected visual acuity of low vision patients are equivalent to Snellen 1.2M (6/18) or worse being represented in versions B onwards of the chart. In order to cater for participants who require larger than 4M print sizes, the reading distance can be reduced (relative distance magnification) (Dickinson & Fotinakis, 2000). This refers to reducing the test distance of the chart from 40 cm to the required test distance which in turn increases the retinal image size. For instance, if the test distance of the 4M chart (version F) was originally placed at 40 cm, and the test distance was reduced to 20 cm, then the retinal image size of the 4M chart is doubled to 8M (Dickinson & Fotinakis, 2000). The minimum print size version of this chart was 1M because it was generally agreed that 1M print is the minimum print size needed by low vision sighted children for most of their reading tasks (Jose, 1989; Elliot *et al*., 1992). Anecdotal evidence also indicated that most reading books used in primary schools have sizes greater than 1M. The print sizes

in the five books used in this research ranged from 3 mm to 5 mm, which were represented in versions D 2M (6/30) and E 3.2M (6/48) respectively.

In order to provide for a wide range of visual acuities, the acuity values in Snellen notation ranges from 1.0M (6/15, 0.4 logMAR) to 4M (6/60, 1.0 LogMAR) equivalent were used. The four acuity notations commonly used by eye care practitioners (Meter (M), Snellen (ft), Snellen (M) and LogMAR) were provided for each version of the chart in order to cater for those who preferred to use the different notation. Each version of the PRR Chart (A, B, C, D, E, and F) was printed on a separate card for consistency, as version F could only go on one chart. The paragraphs were printed in black on approximately white cardboard to provide maximum contrast. Percentage contrast has been defined as 100 $(C_1 – C_2) / C_1 + C_2$ with C_1 being the luminance of the white background and C_2 being the luminance of the black print (Rabbetts, 1998). When C_2 approaches zero, the contrast of the print material on the background approaches 100% (Rabbetts, 1998).

In order to accommodate the common font types that the children are used to in their textbooks, Times New Roman and Arial fonts were used in the design of the chart. The Wilkins Rate of Reading Test chart is available in Times New Roman font type (Wilkins *et al*., 1996), also near reading charts by Bailey and Lovie was designed with Times New Roman font type as this is considered to be a common font used in everyday written communication (Bailey & Lovie, 1980). According to Sheedy *et al*. (2005), text legibility in terms of font type is necessary in reading,

with Arial font being one of the most legible fonts necessary for word identification. Therefore Arial font type was also used in the chart.

The pretest charts in Times New Roman and Arial fonts were provided to test the child to ensure that he or she was familiar with the words in the test charts. Only children who were able to read all the words in the pretest chart were tested with the chart. Any of the fonts can be used as a pretest chart. The pretest chart was printed in 4.0M to ensure that even a partially sighted reader could see the words used in the test, however where more than 4.0M letter acuity sizes were required by a partially sighted child, relative distance magnification was applied.

A record score sheet to be used for each subject was provided with the chart which has the same word arrangement as each of version of the chart. This allowed the examiner to follow the subject as the subject read during the testing procedure thus enabling the examiner to record the subject‟s responses. The recording score sheet also contained the title versions A to F for the corresponding test charts as well as visual acuity notations (Meter (M), Snellen (M), Snellen (ft), logMAR) which allow the examiner quick access to the appropriate recording sheet.

The difference between the recording score sheet and the test charts was that each of the ten lines per paragraph contained word counts from ten to one hundred at the end of each line, as suggested by Ferraro and Ferraro (1989) and adopted by Wilkins *et al.* (1996). This enabled the examiner quick reference to the number of words read by the subject rather than time consuming effort of

counting each word per line per paragraph. The recording score sheet had spaces provided for the date of test and subjects details, such as name, date of birth, age, and grade. This ensured that the examiner was able to maintain efficient record keeping for each subject. Each recording score sheet provided space for recording the reading time in seconds, total number of words read, errors (additions and omissions), and reading rate. These documentations allowed for comparing current with future data. The score sheet also had a space for comments, such as the type of optical devices, magnifiers and non-optical devices such as illumination levels could be recorded. This provided the examiner additional information about the testing process.

5.3 RELIABILITY AND VALIDITY OF THE PRR CHART

According to Joppe (2000), reliability may be defined as the extent to which test results obtained from a study population over a specific time period, is consistent and similar. A research instrument producing consistent results under a similar methodology would therefore be considered reliable. The author also defines validity when the test results obtained is a true reflection to what it is set out to measure when compared to the gold standard. When a new instrument, device or test chart is designed, it is important to establish reliability and validity of the values obtained from the instrument, device or test chart in order to assure the prospective users that the values from the instrument, device or test chart are reliable and valid and that the results can be accurately applied and interpreted.

5.3.1 Reliability of the PRR Chart

In this section of the reliability of the PRR Chart, the demographic profile, with respect to the age of the participants, as well as the test and retest reading rate results (reliability) will be discussed.

Demographic profile: In determining the reliability of the new chart, the age of the normal sighted participants that were recruited for that purpose ranged from nine years to twelve years with mean of 10.63 ± 0.90 years. This age group was chosen because they were in the fourth stage of reading, which is the „reading to learn stage" (Kamhi & Catts, 1989; Garzia, 1996). They had passed the „learning to read" stage. These participants were able to decode words rapidly and automaticity had already developed (Kamhi & Catts, 1989; Garzia, 1996). Some children younger than nine years might still be in the process of learning to read stage hence their responses may not be reliable in repeatable measurements, were therefore excluded in this part of the study. This is in agreement with the views expressed by Borgers *et al.* (2000), who stated that subjects older than eight years are sufficiently developed to participate in individual or group interviews or tests for research purposes. The one hundred subjects included to establish reliability of this test chart were considered to be adequate to provide reliable values as well as to detect statistical significance of the results obtained in the study.

Reliability: As suggested by Good *et al.* (2005), test and retest measurements should not be administered in a single session, as the learning effect does affect

the measurements. Therefore the reading rate test and retest were done 1 week apart to prevent this learning effect, this time being considered long enough to avoid learning effect. The reading rate calculation formula by Wilkins *et al.* (1996) was used in this study.

The Paired *t*-test (p = 0.287) revealed no significant difference between the test and retest reading rate values. A Paired *t*-test value of $p > 0.05$, indicates that the reading rate values obtained from the test and retest are similar or very close this being statistically reliable. Pearson correlation showed a high correlation (r = 0.978, R^2 = 0.954) between the test and retest reading rate values. The closer „R^2" is to one, the stronger the correlation between the results. Furthermore, in the Bland and Altman scatterplot for repeated measurements, the mean difference between the test and retest measurements was calculated as −0.58. This result may be due to the second reading rate values obtained being slightly higher than the first, although the difference was still small and insignificant. This could be attributed to the subjects being more familiar with the testing process therefore producing slightly better results on the second attempt. According to Bland and Altman (2003), if 95% of the differences in the reading rate measurements lie within the limits of agreement, then there is good agreement between the two sets of measurement. In Figure 22, 96% of the differences in the test and retest reading rate measurements lie within the 95% limit of agreement. Only 4% of the reading rate differences of the learners lie outside the limits of agreement. Hence the reading rates values obtained from the new reading rate test chart is reliable.

5.3.2 Validity of the PRR Chart

This section will be discussed according to the demographics (age) of the learners and validity of the results obtained, by comparison of reading rate values from the PRR chart and those from the Wilkins chart because the latter is the only chart that has design features close to the new one.

Demographics: Older normal sighted school children (nine to twelve years) were recruited for the validity study because they were considered to be able to read words in the two charts effectively.

Validity: The Paired *t*-test ($p < 0.01$) showed a significant difference between the two tests reading rate values. According to McAlinden *et al*. (2011), when measurements (in this case reading rate) are determined using two different designed tests, there is bound to be a difference in the results obtained between the two tests, hence even a small difference can yield *p*-values less than 0.05. This also being the case when results are obtained on human subjects due to variability between subjects (McAlinden *et al*., 2011). Pearson‟s correlation test ($r = 0.993$, $R^2 = 0.986$) showed a strong positive correlation between the reading rate results obtained with the new chart and the Wilkins RRT chart. The closer the „*r*‟ value to one, the stronger the correlation exists between the results. A value greater than zero indicates a positive relationship between the results, and as the reading rate values with the new chart increased, so too did the values obtained with the Wilkins RRT chart. Furthermore, the mean difference in the reading rate performance between the two tests was small (+0.90) and is depicted in the Bland

and Altman scatterplot Figure 30. This suggests that the Wilkins RRT chart produced slightly higher reading rate values compared to the new chart. A possible reason for the increased read rate with the Wilkins Chart is that in its design, each of the lines of words in the chart contains words of two letters as well. Each line in turn often contains more than one of these words. Such words may be very simple, requiring less linguistic skills than the words with more letters, as in the newly designed chart. Arditi (1999) also showed that there was longer processing time when viewing words with more letters compared to shorter word length. Furthermore, in the Bland and Altman scatterplot, the difference in the reading rate values obtained between the two tests was plotted against the average reading rate values of the two tests, with 95% limits of agreement. The scatterplot revealed that 95% of the reading rate differences lie within the 95% limit of agreement, with only 5% lying outside the upper and lower limits. These findings suggest that the two charts are in good agreement, with the PRR Chart being valid and that the two charts can be used interchangeably where possible.

5.4 TESTING THE USE OF THE PRR CHART ON LOW VISION LEARNERS

One of the principal objectives for designing the new chart was to create a chart that has print sizes large enough to be used by partially sighted (low vision) children. In the reliability and validity as aspect of the study, reading rate data was obtained on normal sighted learners. A trial use of the new test chart on low vision learners was therefore carried out. This section discusses the demographic profile (age and race), the etiology of low vision as well as the comparison of the visual acuity, total errors made and the reading rate obtained from the low vision learners

without and with low vision devices. Briefly, the observation of the learners with the PRR Chart without and with the use of the low vision devices is mentioned. Finally, illumination levels necessary for normally sighted and low vision individuals will be discussed

Demographic profile: The ages of the learners in this part of the study ranged from 8 to 19 years with mean age of 13.86 ± 3.34. This age range was selected as the PRR Chart was designed for children as young as six years old and older. All the learners who participated in the study were Black, as the majority of the learners at the selected school were Black.

Etiology of low vision: Albinism (35.71%) and congenital cataract (21.43%) were the highest causes of low vision among the learners (Figure 31). This is in accordance with studies that show that albinism and congenital cataracts are among the most common causes of low vision in children in South Africa (Pougnet, 1995; O‟ Sullivan, Gilbert, & Foster, 1997; Oduntan, 2001). Kalloniatus and Johnston (1990) also stated that low vision in children is mainly the result off congenital (cataracts) and inherited (albinism) conditions.

Comparison of visual acuity without and with low vision device: The visual acuity range of the new chart ranged from 1M to 4M when performed at 40 cm. However, if the working distance were to be reduced, this range may be extended to 8M (relative distance magnification). The near visual acuity of low vision children in the study was determined either at 25 cm or 40 cm, as the test distance for those subjects who could not see the largest test chart at 40 cm was reduced to 25 cm

to incorporate relative distance magnification. Relative distance magnification applied in this study is in accordance with that of Dickinson & Fotinakis (2000). The visual acuity determined at 25 cm ranged from 3.2M to 8M without device and 1.6M to 3.2M with the device. The visual acuity at 40 cm ranged from 1.25M to 6.3M without the device and from 1.0M to 3.2M with the device. It is therefore clear that visual acuity improves with the administration of low vision devices. Similarly, as that of visual acuity, corresponding versions of the new chart were used in the evaluation of reading rate of the low vision children. Versions A to F was used without the device, and versions A to D were used with the low vision device. The wide range of print sizes in the new chart was able to accommodate for the wide range of visual acuities of the learners in evaluating their reading rates. It was also evident that the varied print sizes in the new chart were necessary to assess low vision patients.

Comparison of errors made without and with low vision device: The maximum errors, the mean and standard deviation made by the learners with the low vision device compared to without ranged from eighteen to fourteen, ten to eight and eight to six respectively. This revealed that the administration of the low vision devices reduced the total errors made by the learners. As reading rate refers to the total number of correct words read in one minute (Crawford, Tindai, & Stieber, 2001; Bouldoukian, Wilkins, & Evans, 2002), which takes errors into account, this implies that with an improvement in the total errors made, the reading rate should also improve accordingly with the aid of low vision devices.

Comparison of reading rate without and with low vision device: Considering that the difference between the reading rate mean and standard deviation without device to with the device was 7.72 ± 1.55, clinically there was a significant difference between the two. Inspection into each case individually revealed that 85% of the learner"s reading rates improved with the low vision device. This reveals that an increase in visual acuity is associated with a corresponding increase in the reading rate. Low vision aids are therefore effective in improving the reading ability of low vision learners, and from a functional perspective, the PRR Chart proved to be a useful test in managing low vision.

It was observed that the 15% who presented with decreased reading rate with the device had difficulty using the device. Dickinson and Fotinakis (2000) suggested that due to decrease in field of view with the device, there is a decrease in forward saccades which in turn may cause a reduction in reading rate. To compensate for this reduction, the reader should also increase head movement in the direction of the reading thereby increasing reading speed. Therefore when using near low vision devices for reading, the reader has to practice synchronizing hand movement with the device, eye movements as well as head movements to ensure a stable retinal image.

Observation: Observational assessment of the low vision children when reading the PRR Chart without and with low vision device revealed an immense increase in enthusiasm, confidence and motivation. Most of the subjects showed excitement in wanting to read further. Considering the psychological implications of low vision, the ability to improve reading using the PRR Chart and low vision

devices has a positive impact on the state of mind on the low vision child. The PRR Chart proved useful in that the chart was suitable for very young children of six years old. Assessing reading rate with low vision devices at an early stage gives the child exposure to written words so that automaticity can develop, and reading can be matched to that of normal vision children.

Illumination: Illumination levels required for tasks vary depending on the actual task that needs to be performed, as well as whether the subject performing the tasks is normally sighted or partially sighted. Increased illumination generally increases the contrast of the object relative to its background which in turn results in object resolution. According to Macnaughton (2005), an increase in illumination level results in an increase in visual task performance, such as reading, until a plateau is reached. In this case further increase in illumination level does not positively influence visual performance. Beyond this point, additional increase in illumination level results in glare thereby reducing visual performance. Incandescent and fluorescent are the most common light sources for everyday activities however, additional lighting may be provided by table lamps as well as glare control devisors such as tinted ophthalmic lenses, visors and spectacle side shields to name a few (Oduntan n.d.,).

As illumination levels play a significant part in reading (Cornelissen, Bootsma, & Kooijman, 1994), in an office set up, illumination levels range between 200 to 800 lux (van Bergem-Jansen & Padmos, 1989). It has been found that partially sighted subjects reading performance can be improved by either lowering or increasing light levels from that of normal light levels depending on the ocular condition

(Cornelissen, Bootsma, & Kooijman, 1994). Subjects with albinism have increased sensitivity to light levels (photophobia) therefore benefit from low levels of illumination. On the other hand, subjects with age related macular degeneration may prefer higher illumination levels up to 2000 lux (Oduntan n.d.,). Macnaughton (2005) also stated that the level of illumination for performing tasks may be also dependant on the age of the subject. With increasing age, the amount of light entering the eye is decreased and contrast decreases. Therefore the elderly may benefit from further increase in illumination levels as compared to younger individuals.

The average illumination level for normally sighted individuals is considered to be 1000 lux and the illumination in an optometric examination room is between 500 lux to 560 lux Cornelissen *et al.* (1994). Considering that the level of illumination is affected by various factors, it is imperative that an optometric examination room has adjustable lighting between 538 lux (50 foot-candle) for photophobic subjects to over 1076 lux (100 foot-candles) Cornelissen *et al.* (1994). The author also concluded that illumination levels must be adapted as per subject requirement as there is no standard illumination for all subjects.

5.5 POSSIBLE USES OF THE PRR CHART

The PRR Chart is an optometric test chart for measuring reading rate and therefore can to assess and monitor reading acuity, reading rate and reading progress with and without optometric interventions including vision therapy and optical devices. This test can also assess the effect and progression of visual

problems such as ocular pathology, binocular abnormalities, ocular motilities and other visual disturbances on reading. The PRR Chart includes a wide range of visual acuity levels therefore it can be used to assess normal vision to low vision patients.

The words used in the design of the PRR Chart, allows this test to be used on children as well as adults. The PRR Chart is a standardized test chart hence can be used in further research studies. The PRR Chart can be used from an educational perspective as a screening tool to assess reading ability of children specifically assessing automaticity and compare findings to age and grade norms. The PRR Chart can be used in the future to develop reading rate norms for participants of different age and grade groups. These norms may assist in diagnosis of reading problems such as fluency. The chart may also be used in remedial programs to monitor progress in reading. This holistic approach enables children with poor results to be referred to the appropriate professionals

5.6 CONCLUSION

In the design of the PRR Chart, the most frequently used words used by grade one learners were used. This ensured that the chart was specifically designed for children as young as six years old. The design of the PRR Chart took into account optometric factors such as visual acuity, the print sizes in the chart being large enough to examine low vision patients. The chart can therefore be used on both normally and partially sighted (low vision) children. The data obtained from the chart proved to be both reliable and valid, thereby assuring prospective users that

the PRR Chart can be administered with confidence. As reading rate is a sensitive measure of reading performance, the PRR Chart can be used to assess reading rate in order to determine the reading performance of children. This test chart will be beneficial in the visual management of low vision children especially when prescribing low vision reading devices. Evaluation of reading performance following visual therapy is also possible using the PRR Chart, which is a simple and quick clinical test to administer and allows for efficient record keeping.

CHAPTER SIX

LIMITATIONS AND RECOMMENDATIONS

The limitations of the chart and recommendations for using the PRR Chart are presented below.

6.1 LIMITATIONS OF THE CHART

The following possible limitations could have influenced the study:

i. Poor parental response and delays in returning the consent forms that delayed the field work.

ii. The field work was conducted during school hours and data collection therefore revolved around the school program.

iii. The illumination level required for the use of the chart was not established, however the illumination levels, as recommended by Jose (1989) was maintained using fluorescent lighting.

iv. The PRR Chart was designed for children as young as six years old, as they are in the process of learning to read, and does not take into consideration children younger than six years of age.

6.2 RECOMMENDATIONS FOR USING THE PRR CHART

The following recommendations are made when testing children with the PRR Chart:

i. It is important to ensure that the testing room is free of any distraction in terms of visual and auditory stimuli.

ii. All testing materials must be easily accessible, which may include and not limited to: the PRR Chart, stop watch, light meter, additional lighting source, occluder, ruler or tape measure and a range of optical devices.

iii. The pre-test chart must be presented first to the subject to ensure that the subject is familiar with the words in the chart.

iv. The near visual acuity measurements of the subject must be determined and corrected such that the appropriate version of the chart can be administered.

v. The appropriate version of the reading chart, based on the best corrected near visual acuity, should be identified.

vi. The selected version of the reading test chart must be placed at the relevant test distance as per subject and this distance must be maintained.

vii. The required illumination level must be maintained at all times using a light meter.

viii. The testing procedure as well as the need to read rapidly and accurately must be explained to the subject prior to the administration of the test.

ix. The examiner should also ensure that the appropriate score sheet, with the subjects details, is available at hand to document the subjects results.

x. As the subject commences with the reading, simultaneously the stop watch should be started.

xi. The errors (omissions and additions) should be documented on the score sheet.

xii. As soon as the subject completes reading the „passage" on the test chart, the examiner should simultaneously stop the stop watch and record the time taken on the recording score sheet.

xiii. The examiner should record the following on the score sheet: the time to complete the test in seconds, the total number of words read, the total number of errors made, the reading rate as well as necessary comments pertaining to the test.

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APPENDIX I

READING TESTS FOR EDUCATIONAL USE

Neales Analysis of Reading Ability

Wechsler Intelligence Scale for Children-Revised (WISC-R)

Wide Range Achievement Test

The Gray Oral Reading Tests (GORT)

APPENDIX II

PATIENT CONSENT FORM: ENGLISH VERSION

DISCIPLINE OF OPTOMETRY

CONSENT FORM

Research Study: Design, validity and reliability of a pediatric rate of reading (PRR) chart.

Dear Parent

Vision is a dominant sense in learning and contributes to 85% of information acquired. Reading forms an essential component of learning and therefore needs to be assessed when investigating inadequate school performance. Many children with reading difficulties perform poorly in school which may impact on their overall performance in later years. The personal and social costs of reading problems are substantial and it is apparent that inadequate teacher training in reading, large classes, limited resources and the increasing number of children with special reading needs who require explicit and intensive reading instructions overwhelm many teachers.

Existing reading rate test charts are not specifically designed for children, hence young children may have difficulty with some of the words used in the chart. Also such reading rate charts do not take the child"s vision into consideration.

Therefore there is a need for a reading rate chart that will be designed for children that will also take their visual status into consideration.

The purpose of this research is to develop a reading rate chart specifically for children and evaluate the information from this chart to provide instructional support for teachers and parents with regards to the reading ability of the child and those children with a reading problem.

Your child will receive a free eye screening which will investigate if there is a need for a more comprehensive eye examination. If any ocular problems are present, a referral letter will be provided. Only those individuals who have normal visual functioning will be eligible to undergo further testing to determine the reading rate. None of the procedures to be performed will adversely affect your child‟s eye or vision. You will not be identified in person but rather results of the group will be released. The results obtained from this study will be included in scientific publications. You have the right to withdraw your child from the study at any time.

If you understand the information provided and voluntarily wish to participate in this study please sign your name below. This research is being done by Mrs U Nirghin with permission from the Research and Ethics committee of the University of KwaZulu Natal.

_____

Parent on behalf of child Date

_____

Researcher Witness

APPENDIX III

PATIENT CONSENT FORM: ZULU VERSION

IFOMU LESIVUMELWANO SOKUBAMBA IQHAZA OCWANINGWENI ESIKOLENI SEZIFUNDO ZAMEHLO

Ucwaningo: Ukwakha, isiqinisekiso kanye nokwethembeka kweshadi elisetshenziselwa ukuhlola izinga lokufunda ezinganeni.

Mzali ohloniphekileyo

Ukubona kuyingxenye ebalulekile kakhulu ekufundeni, kangangoba kulekelela ngama-85% olwazini olusuke ludingeka. Ukufunda kuyingxenye ebaluleke kakhulu esifundweni, ngaleyo ndlela kuyadingeka ukuba kuhlolisiswe kahle uma kuphenywa imbangela yokungaphumeleli kubantwana ezikoleni. Izingane eziningi ezinezinkinga zokufunda azenzi kahle esikoleni okungaba nomphumela ongemuhle ekuphumeleleni kwazo eminyakeni ezayo. Ziyabonakala izinkinga zokufunda futhi kuyacaca ukuthi ukungaqeqesheki ngendlela kothisha ekufundeni, amakilasi amakhulu, ukungeneli kwezinsiza kanye nokwanda kwesibalo sezingane ezinezidingo eziyisipesheli zokufunda ezidinga imiyalelo yokufunda ecacile kuba yinkinga kothisha.

Amashadi esimanje okuhlola izinga lokufunda awakhekanga ngendlela engakwazi ukumelana nesimo sezingane, kanti nezingane ziba nenkinga /ingcindezi yokufunda amagama asetshenziswe kuleli shadi, la mashadi esimanje awayibhekelelanga indlela nesimo sokubona ezinganeni, ngaleyo ndlela kunesidingo seshadi elizokwakhiwa ngendlela ezokwazi ukumelana kalula nesimo sokubona ezinganeni.

Inhloso yalolu cwaningo ukusungula ishadi elizobhekana ngqo nezinga lokufunda ezinganeni, liphinde futhi likwazi ukusinikeza umhlahlandlela ozolekelela othisha kanye

nabazali ekuthuthukiseni ukufunda enganeni kanye nalezo zingane ezinenkinga yokufunda zingazuza ngokohlelo lokuqeqeshwa ngongoti.

Ingane yakho izothola ukuhlolelwa amehlo mahhala, okuyobe sekucacisa ukuthi ngabe sikhona yini isidingo sokunye ukuhlolwa kwamehlo okunzulu, uma kutholakala inkinga iyobe isidluliselwa lapho engasizakala khona. Kuyoba yilezo ezibona kahle eziyobe seziqhubeka nokuhlolwa kubhekwa indlela ezifunda ngayo. Akukho okuyokwenziwa okungakhinyabeza iso lengane yakho noma ukubona kwayo. Igama lakho liyohlala liyimfihlo kepha imiphumela iyokhishwa ngokweqembu. Imiphumela etholakele kulolu cwaningo iyoshicilelwa kumajenali. Unelungelo lokuhoxisa ingane yakho ocwaningweni noma nini.

Uma uqonda ulwazi olunikeziwe futhi uzithandela wena ukubamba iqhaza kulolu cwaningo uyacelwa ukuba usayine igama lakho ngezansi. Lolu cwaningo lwenziwa uNkosikazi U Nirghin ngemvume ayithole ekomitini le- Research and Ethics, KwiFaculty yakwa Health Sciences eYunivesithi yaKwaZulu-Natali.

Mzaliegamenilengane

Usuku

_____

_____

_____

Umcwaningi

Ufakazi

Umtholampilo wamehlo e-UKZN (E5 525)-031 260 7294

APPENDIX IV

INFORMATION DOCUMENT: ENGLISH VERSION

INFORMATION DOCUMENT

Study title: Design, validity and reliability of a pediatric rate of reading (PRR) chart.

Greeting: Dear Participant

Introduction:

I, Mrs U Nirghin, am conducting a research to design a Reading Rate Chart for children from six to twelve years of age. Reading rate refers to the number of words read accurately in one minute and is thus aimed to determine the overall reading performance of a child.

Vision is a dominant sense in learning and contributes to 85% of information acquired. Reading forms an essential component of learning and therefore needs to be assessed when investigating inadequate school performance. Many children with reading difficulties perform poorly in school which may impact on their overall performance in later years. The personal and social costs of reading problems are substantial and it is apparent that inadequate teacher training in reading, large classes, limited resources and the increasing number of children with special

reading needs who require explicit and intensive reading instructions overwhelm many teachers.

Existing reading rate test charts are not specifically designed for children, hence young children may have difficulty with some of the words used in the chart. Also such reading rate charts do not take the child‟s vision into consideration. Therefore there is a need for a reading rate chart for children that will also take their visual status into consideration.

The purpose of this research is to develop a reading rate chart specifically for children and evaluate this chart to provide instructional support for teachers and parents with regards to the reading ability of the child and those children with a reading problem.

Invitation to participate: We are inviting your child to participate in this research study.

What is involved in the study?

By being part of this study, you agree to have your child‟s eyes screened to see if there is a need for glasses, to examine the health of his / her eyes as well as determine your child‟s reading rate. All tests to be used in the eye examination are not harmful to your child‟s eyes in any way.

Risks: There are also no potential risks for being involved in the study.

Benefits: Receiving information about the quality of your child‟s reading ability.

Treatment: Referral for visual and/or reading assessment will be advised.

Reimbursements: There are no financial reimbursements for being part of this study.

Confidentiality: Efforts will be made to keep personal information confidential. Absolute confidentially cannot be guaranteed. Personal information may be disclosed if required by law. Organizations that may inspect and/or copy your child‟s research records for quality assurance and data analysis include groups such as the Research Ethics Committee and the Medicines Control Council. Your child‟s participation in the study is completely voluntary and a refusal to participate will involve no penalty. You may discontinue your child‟s participation from the study at any time.

For further information please contact:

Mrs U Nirghin

University of KwaZulu-Natal

Discipline of Optometry

Tel: (031) 260-7940

APPENDIX V

INFORMATION DOCUMENT: ZULU VERSION

INCWADI YOLWAZI

Ucwaningo: Ukwakha, isiqinisekiso kanye nokwethembeka kweshadi elisetshenziselwa ukuhlola izinga lokufunda ezinganeni.

Mbambiqhaza ohloniphekile: Ngiyakubingelela.

Isingeniso

Mina Mrs U.Nirghin, ngenza ucwaningo olumayelana nokwakha ishadi lezinga lokufunda ezinganeni ezineminyaka esukela kweyisithupha kuya kweyishumi nambili ubudala. Izinga lokufunda lisho isibalo samagama afundwa ngendlela esikhathini esiwumzuzu owodwa futhi lihlose ukubheka ukufunda konke okuphelele kwengane.

Ukubona kuyingxenye ebalulekile kakhulu ekufundeni, kangangoba kulekelela ngama-85% olwazini olusuke ludingeka. Ukufunda kuyingxenye ebaluleke kakhulu esifundweni, ngaleyo ndlela kuyadingeka ukuba kuhlolisiswe kahle uma kuphenywa imbangela yokungaphumeleli kubantwana ezikoleni. Izingane eziningi ezinezinkinga zokufunda azenzi kahle esikoleni okungaba nomphumela ongemuhle ekuphumeleleni kwazo eminyakeni ezayo. Ziyabonakala izinkinga zokufunda futhi kuyacaca ukuthi ukungaqeqesheki ngendlela kothisha ekufundeni, amakilasi amakhulu, ukungeneli kwezinsiza kanye nokwanda kwesibalo sezingane

ezinezidingo eziyisipesheli zokufunda ezidinga imiyalelo yokufunda ecacile kuba yinkinga kothisha.

Amashadi esimanje okuhlola izinga lokufunda awakhekanga ngendlela engakwazi ukumelana nesimo sezingane, kanti nezingane ziba nenkinga /ingcindezi yokufunda amagama asetshenziswe kuleli shadi, la mashadi esimanje awayibhekelelanga indlela nesimo sokubona ezinganeni, ngaleyo ndlela kunesidingo seshadi elizokwakhiwa ngendlela ezokwazi ukumelana kalula nesimo sokubona ezinganeni.

Inhloso yalolu cwaningo ukusungula ishadi elizobhekana ngqo nezinga lokufunda ezinganeni, liphinde futhi likwazi ukusinikeza umhlahlandlela ozolekelela othisha kanye nabazali ekuthuthukiseni ukufunda enganeni kanye nalezo zingane ezinenkinga yokufunda zingazuza ngokohlelo lokuqeqeshwa ngongoti.

Isimemo sokubamba iqhaza ocwaningweni: Simema ingane yakho ukuba ibe yingxenye yalolu cwaningo.

Yini ebandakanyekayo kulolu cwaningo?

Ukuba yingxenye yocwaningo kusho ukuthi uyavuma ukuthi ingane yakho ihlolwe amehlo, ukubona ukuthi ayizidingi yini izibuko, ukuhlola impilo yamehlo ayo kanye nokubheka izinga lokufunda kwengane yakho. Konke ukuhlolwa okuzokwenziwa akunabungozi emehlweni engane yakho.

Ubungozi: Abukho ubungozi ongabhekana nabo ngenxa yocwaningo.

Inzuzo: Ukuthola ulwazi olunzulu oluyikhwalithi ngendlela ingane yakho ekwazi ngayo ukufunda.

Ukwelashwa: Ukwedluliselwa kanye/noma kuyokwelulekwa ngokuhlolwa kokufunda.

Imihlomulo: Akukho nkokhelo ngokuba yingxenye yalolu cwaningo.

Imfihlo ngocwaningo: Kuyozanywa ngayo yonke indlela ukugcina imininingwane iyimfihlo. Ngeke kuqinisekiswe ukuba yimfihlo ngokugcwele. Imininingwane yomuntu ingakhishwa uma idingwa umthetho. Izinhlangano ezinelungelo lokucubungula noma zikopishe amarekhodi ocwaningo lwengane yakho ukubheka ikhwalithi kanye nokucubungula ulwazi olutholakele kubandakanya amaqembu anjenge-Research Ethics Commitee kanye ne-The Medicine Control Council. Ukubamba iqhaza kwengane yakho ocwaningweni kungukuzithandela kanti nokuhoxa kwayo ocwaningweni ngeke kube nanhlawulo. Ungahoxisa ukubamba iqhaza kwengane yakho nganoma yisiphi isikhathi. Yonke imininingwane yomuntu iyohlala iyimfihlo.

Uma udinga ukuchazeleka kabanzi ngocwaningo ungathintana no:

Mrs U Nirghin

University of KwaZulu-Natal

Discipline of Optometry

Tel: (031 260-7940

APPENDIX VI

NUMBERS ASSIGNED TO WORDS

1 – the

2 – said

3 – see

4 – to

5 – help

6 – can

7 – yes

8 – play

9 – cat

10 – look

APPENDIX VII

EXAMPLE OF RANDOM PLACEMENT OF NUMBERS INTO TABLE

6	5	7	8	9	4	2	1	10	3
7	1	10	3	4	6	5	9	2	8
10	4	6	1	9	2	8	3	7	5
7	5	2	10	3	1	6	4	9	8
9	3	8	7	6	4	2	5	1	10
1	10	4	5	2	7	6	8	9	3
2	7	10	8	4	3	9	5	1	6
9	5	2	6	1	10	4	3	7	8
2	4	3	5	8	6	7	10	9	1
10	1	9	2	4	5	3	6	8	7

APPENDIX VIII

EXAMPLE OF REPLACEMENT OF NUMBERS BY WORDS

can	Help	yes	play	cat	you	said	the	look	see
yes	The	look	see	you	can	help	cat	said	play
look	You	can	the	cat	said	play	see	yes	help
yes	Help	said	look	see	the	can	you	cat	play
cat	See	play	yes	can	you	said	help	the	look
the	Look	you	help	said	yes	can	play	cat	see
said	Yes	look	play	you	see	cat	help	the	can
cat	Help	said	can	the	look	you	see	yes	play
said	You	see	help	play	can	yes	look	cat	the
look	The	cat	said	you	help	see	can	play	yes

APPENDIX IX

LIST OF MOST FREQUENTLY USED WORDS

the	help	will
Said	can	cat
See	yes	went
You	play	down
Fox	with	hill
Look		

APPENDIX X

PRR CHART VERSIONS WITH CORRESPONDING SNELLEN ACUITIES AND PRINT SIZE MEASUREMENTS

Version	Acuity	Print Size (mm)
Version A	6/15	1.45
Version B	6/18	1.75
Version C	6/24	2.33
Version D	6/30	2.91
Version E	6/48	4.65
Version F	6/60	5.82

APPENDIX XI

PRR CHART VERSIONS WITH CORRESPONDING METER, SNELLEN AND LOGMAR NOTATIONS

Version of Chart	Meter	Snellen (Meter)	Snellen (Feet)	LogMAR
F	4	60	200	1.0
E	3.2	48	160	0.9
D	2	30	100	0.7
C	1.6	24	80	0.6
B	1.25	19	63	0.5
A	1.0	15	50	0.4
	0.80	12	40	0.3
	0.63	9.5	32	0.2
	0.50	7.5	25	0.1
	0.40	6.0	20	0.0
	0.32	4.8	16	-0.1
	0.25	3.8	12.5	-0.2

APPENDIX XII

LETTER TO DEPARTMENT OF EDUCATION

To Whom it may concern

KwaZulu-Natal Department of Education

Private Bag X9137

Pietermaritzburg

3200

KwaZulu-Natal

20 September 2009

Ref: Permission to conduct research at schools in KwaZulu- Natal

I, Urvashni Nirghin, am a postgraduate at the University of KwaZulu-Natal and I am currently studying for my Masters degree.

The title of my study is: *"The Design, Reliability and Validity of a Paediatric Rate of Reading Chart".* This study involves the collection of data for the design of the chart as well as for testing the reliability and validity of the newly designed chart. This data will be obtained from the various schools in the KwaZulu-Natal area as stipulated in the attached document. The research proposal, a letter of approval from the Biomedical Research and Ethics Committee obtained from the University of KwaZulu-Natal as well as the dates and a list of schools required for data collection, is also attached.

Permission to perform the research will be subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist the researcher in the investigation.
2. Principals, educators, learners and schools will not be identifiable in any way from the results of the investigation.
3. The researcher will make all the arrangements concerning the investigation.
4. Educators programmes will not to be interrupted.
5. A photocopy of the letter of permission from the KZN DoE will be submitted to the principal of the school(s) where the intended research is to be conducted.
6. The research is limited to the schools whose names have been provided to the KZN DoE as in the attached letter.

I humbly request for permission to conduct the study and your assistance will be greatly appreciated.

Mrs. Urvashni Nirghin

University of KwaZulu-Natal

College / School of Health Sciences

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