An Investigation of Myopic Visual Function and the Effect of Holistic Vision Therapy

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Abstract

Vision therapists working in the complementary healthcare sector treat vision problems holistically using a wide range of techniques including massage, vision coordination exercises and changes in lifestyle habits e.g. diet and behaviour patterns. These techniques differ from conventional optometry practically and theoretically and are said to be able to improve myopic vision and restore emmetropic vision. Vision therapy for the treatment of myopia involves the removal or decrease in prescription of refractive lenses alongside the therapy and lifestyle changes, whereas optometric practice prescribes refractive lenses only. Theoretically vision therapy is part of a holistic model of health which views all parts of a person as being interconnected, as compared to the reductionist model of optometry in which the eyes are treated independently of the rest of the person. This thesis explores these differences in approach to myopia. The theoretical background to myopia researched from both contexts and the results from a pilot study assessing the work of a vision therapist are presented.

Vision tests were made using the high and low contrast Bailey-Lovie charts, the Regan Repeat Letter chart, Single Optotypes, the Crowded Logarithmic Acuity Test and the Pelli-Robson chart. Cycloplegic and non-cycloplegic refraction, autokeratometry and axial length readings were taken. Questionnaires were given out and participants who took part in the vision therapy sessions were also interviewed about their experience.

The vision and visual acuity and physical parameter results are presented in chapters 6 and 7. Aspects of visual style were explored and it was concluded that the role eye movements play in vision is different for corrected acuity as compared with unaided vision. It is also concluded that vision therapy did not affect the chart performance or physical parameters of the participants. Experiential data is presented in chapter 8 and vision therapy was found anecdotally to promote fluctuations in vision.

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Chapter 1

Background

1.1 Myopia

1.1.1 Definition

Helmholtz (1871) described the myopic eye as "one for which the far point is a short distance away, sometimes only a few inches from the eye". Donders (1864) defined it as "one in which the focus of the dioptric system lies in front of the retina". More recently, Curtin (1985) defined myopia as "the state of refraction in which parallel rays of light entering the eye at rest are brought to a focus in front of the retina".

emmetrope myope

Figure 1.1.1 Schematic representation of a myopic eye as compared with an emmetropic eye.

1.1.2 Incidence

The rate of myopia incidence varies widely across the world. In order to describe these differences the effect of geographical location and type of environment will be discussed. The lowest documented myopia rates are for Tibetan children of Katmandhu most of whom are emmetropic (Garner et al, 1995). North America, Australia and Europe have the next greatest rate of incidence. A sample adult population (both urban and rural) in Victoria, Australia showed a 17% rate of myopia (Wensor et al, 1999) and 2 studies put the rate in the US adult population at 25% (Mutti et al, 1996) and 43% (McCarty, 1997). The trend in Western countries appears to be an incidence of myopia of 30-35%

(Grosvenor & Goss, 1999) and the highest rates are found in Asia with one study stating that among Hong Kong schoolchildren (ages 8-19) 62% are myopic (Lam et al, 1999).

1.1.3 Lifestyle Factors

Regardless of geographical location myopia incidence can also vary with the type of environment; higher myopia incidence rates are found in those living in urban environments and those who undertake increased amounts of near work. Children raised in a rural community in Nepal showed a myopia incidence of 2.95% whereas those of the same ethnicity who moved into Tibet where there is more schooling showed an incidence of 21.7% (Garner et al, 1999). Also, in India the myopia incidence in rural areas is 3% compared with a national average of just under 20% (Mohan et al, 1988). As the level of education increases so does the incidence of myopia (Curtin, 1985) and there are certain professions that tend to involve near work in which a disproportionate number of myopes are employed, for example, clinical microscopy (Adams & McBrien, 1992).

Animal studies also suggest a link between a restricted visual environment and myopia. Monkeys raised in an environment restricted to the nearpoint have a tendency to become myopic (Young, 1961; Young, 1981). This will be discussed further in section 1.2.1.

1.1.4 Genetic Versus Environmental Factors

There has long been debate as to whether or not myopia has a hereditary or genetic component. A study involving indiginous families in Alaska suggested no major hereditary component (Young et al, 1969) and a study in Greenland did not find a strong familial association for refractive error (Alsbirk, 1979). Through twin studies and statistical genealogical studies, however, myopia has been shown to have a level of correlation with heredity. The concordance of refractive error is greater in uniovular than biovular twins (Chen et al, 1985) demonstarting a genetic involvement. The method of transmission is, however, not understood; it may be that there is a separate transmission of each component of refraction and a correlation factor between them (Curtin, 1985; Hui et al, 1995).

1.1.5 Anatomical Correlates of Myopia

There are four components of the eye which combine to produce the overall refractive power. These are corneal power, anterior chamber depth, lens power and axial length. The population distribution of axial length is the only one not to demonstrate a Gaussian curve being skewed with a tail towards a longer eye length. It has been suggested that it is this increase in axial length (mainly due to an elongation of the posterior vitreous chamber) which is the most common refractive element to cause myopia (Curtin, 1985). Vitreous chamber depth and axial length have been observed as being greater for myopes

than for emmetropes as has the ratio of corneal radius/axial length (Grosvenor & Scott, 1991). Further evidence for refractive errors being predominantly axial in nature is the finding that there is a relationship between the degree of hyperopia and axial length (Strang et al, 1998).

1.1.6 Classification

The classification system to be used in this thesis splits myopia into 4 basic types: 1)*congenital myopia* which is present at birth and throughout life, *2)youth onset myopia* which appears between the ages of 5-6 and physical maturity in the mid- to late teens, 3) *early adult onset myopia* which has its onset after physical maturity but before the age of about 40, and 4)*late adult onset myopia* which has its onset after the age of 40 (Grosvenor & Goss, 1999). Youth and early adult onset myopia are the only types of myopia that will be investigated in this work.

1.2 Mechanisms of Myopia Development

1.2.1 Animal Studies

During growth the development of the visual system is sensitive to environmental factors and patterns of growth will adapt to the conditions imposed. The effects of refractive lenses, light and peripheral occlusion on the growth of the refractive state will be reviewed.

Neonates are not usually emmetropic but with favourable conditions neonatal refractive errors progress towards emmetropia. This process is called emmetropization (Wallman et al, 1981) and is studied by manipulating refractive states in animals (usually chicks and to a lesser extent tree shrews and monkeys) by fitting them with positive, negative or cylindrical lenses and observing the compensation that takes place in the eye of the animal. Myopia can be induced using negative lenses and the physical characteristics associated with this induced myopia that have been documented are axial elongation (Wallman & Adams, 1987), a thinning of the choroid (Phillips & McBrien, 1995; Wildsoet & Wallman, 1995) and thicker than normal rods and cones (Liang et al, 1995).

The underlying mechanisms of the emmetropization process are not well understood. What is known is that it is a vision dependent process (Rabin et al, 1981) and an active emmetropization response is dependent on the clarity of image falling on the retina (McBrien et al, 1999). Chromatic cues are not necessary (Schaeffel & Howland, 1991) and neural activity in the retina is thought to play a part (Raviola & Wiesel, 1990). There have also been studies which have reduced experimentally induced myopia with the use of a drug (tetrodotoxin) to block retinal ganglion cell action potentials. This reduction was

obtained by a nonaccommodative mechanism (suggesting that accommodation is not involved in the process) and showed evidence for local ocular control of emmetropization (McBrien et al, 1993; Leech et al, 1995; McBrien et al, 1995; Cottriall & McBrien, 1996).

1.2.2 Effect of Light/Dark Regulation

Another factor which has been shown to affect emmetropization is the regulation of light and dark. Rearing chicks under conditions of constant light produces hyperopia. A shallowing of the anterior chamber, a flatter that normal corneal curvature and an elongation of the vitreous chamber is observed in these animals. These studies suggest the need for normal circadian rhythms, or at least a dark period, in the regulation of eye growth (Li et al, 1995; Stone et al, 1995). There has also been a strong correlation between myopia and ambient light exposure during sleep in children before they reach 2 years of age, suggesting that the absence of a daily period of darkness during early childhood is a potential precipitating factor in the development of myopia (Quinn et al, 1999).

1.2.3 Effect of Field Restriction

As well as experimental manipulations using refractive lenses, extreme myopia has also been induced in chicks by restricting vision to the frontal field (Wallman & Turkel, 1978). See figure 1.2.3 for an illustration of the experiment. See chapter 4 for a discussion of peripheral vision.

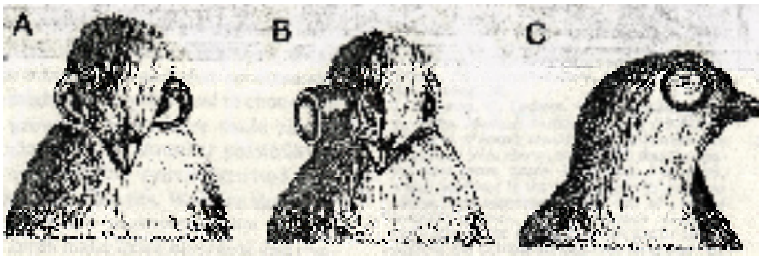


Figure 1.2.3 Devices used to restrict the frontal visual field (A) and the lateral field (B) and to prevent form vision (C). From Wallman and Turkel, 1978.

1.2.4 Modelling Emmetropization

Van Alphen (1961) proposed a model for emmetropization which was based on autonomic innervation characteristics of the ciliary muscle and the elasticity of the sclera. A more recent model (Flitcroft, 1998) incorporates a classical model of accommodation and convergence with blur driven feedback control of eye growth. This model has been extended with computer modelling to include the parameters of ocular refraction, oculomotor performance and the spatial sensitivity of the retinal elements (Flitcroft,

1999). Blackie and Howland (1999) have extended the Flitcroft (1998) model (a differential equation model comprised of 3 feedback loops: growth, accommodation and convergence) to include the effects of illumination on accommodation, vergence and pupil diameter. The parameters of accommodative controller gain, vergence controller gain, tonic accommodation, tonic vergence, accommodative convergence and convergence accommodation are used in the mathematical model which attempts to simulate the emmetropization process. The model predicts an increase in the progression of myopia under conditions of reduced illumination and extended periods of near work. It also predicts that the prescription of negative lenses (increasing the accommodative demand on a less efficient accommodative system compared to emmetropes) augments the advancement of myopia.

1.2.5 Applying the Animal Work to Humans

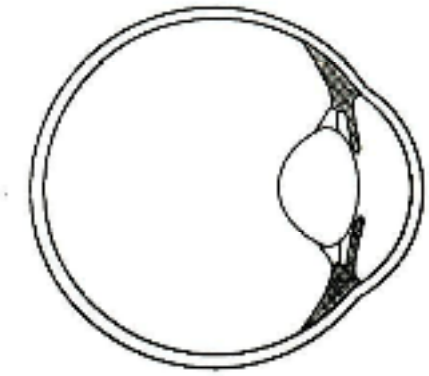
Experimental work with animals cannot be applied to the human situation without some consideration. Arguments against the application of animal models to the aetiology of human myopia include the points that the chick visual system is different to the human and the sensitive period for deprivation myopia in animals appears to be too early to account for human early onset myopia (Zadnik et al, 1995). Unilateral lid suture in adolescent monkeys, however, was found to induce myopia raising the possibility that visual experience may be involved in the genesis of youth onset myopia in primates (Smith et al, 1999).

There is evidence that a similar process of emmetropization takes place in human eyes. Studies have shown a trend towards emmetropia in infants from 1 to 3 years of age when the initial refraction was myopic (Ingram & Barr, 1979; Ehrlich et al, 1995). Extrapolating the findings of animal studies to humans suggests that young eyes can control their refractive state according to visual input (Wildsoet, 1997) and leads to the hypothesis that the human eye growth can be altered by spectacle lenses (Flitcroft, 1999).

1.3 Accommodation

Accommodation is the function whereby the refractive power of the optical system of the eye can change so that images of both distant and near objects can be brought to a clear focus on the retina (Rabbetts, 1998). The action of the ciliary muscle in this process is shown in figure 1.3. Accommodation innervation is from the autonomic nervous system which is predominantly parasympathetic but which also has a sympathetic component. Parasympathetic stimulation produces an increase in accommodation to focus near objects. The sympathetic component is inhibitory (it helps to offset large increases in

parasympathetic tone with sustained fixation), slow and subject to individual variation (Gawron, 1983; Gilmartin, 1986).



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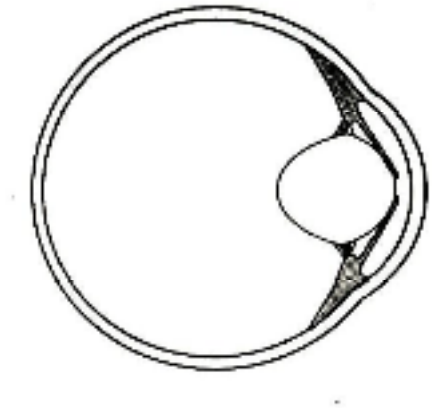

accommodated

1. Figure 1.3 An illustration of the ciliary muscle's action on the lens during accommodation. After Kaufmann (1992).

1.3.1 Tonic Accommodation

Tonic accommodation is the resting state of the accommodation system when there is no stimulus to accommodate. Studies have found lower dioptric levels of tonic accommodation in corrected myopes than in emmetropes. Rosenfield and Gilmartin (1997) measured the tonic accommodation as 0.4D for corrected youth onset myopes and 0.75D for emmetropes. McBrien and Millodot (1987) measured 0.49D for corrected adult onset myopes, 0.92D for corrected youth onset myopes and 0.89D for emmetropes. The tonic accommodation values have been found to become lower as myopia develops but not before its onset (Gwiazda et al, 1995). The accommodation level as measured in darkness and as measured when viewing is through a pinhole were found to be different in emmetropic and myopic subjects (Strang et al, 2000) suggesting that when there is no blur stimulus but visual information is present then the system does not rest in the tonic or dark focus position.

1.3.2 Accommodative Lag

Subjects with myopia showed higher lags of accommodation than emmetropes for higher accommodative stimulus levels (McBrien & Millodot, 1986). An even greater lag for myopes was found when the accommodative stimulus was a target viewed at the same distance through a series of minus lenses (Abbot et al, 1998). Also myopes have been shown to be less sensitive to blur and this has been suggested as a possible explanation for the accommodative lag (Rosenfield & Gilmartin, 1999).

1.3.3 Nearwork Induced Transient Myopia

Nearwork-induced transient myopia has been defined as the short term myopic shift in far point of around, on average, 0.25D, which occurs immediately following a sustained near visual task and persists for up to 30 seconds (Rosenfield & Gilmartin, 1998). This accommodative adaptation (an incomplete relaxation of accommodation) has been measured as a mean shift of 0.34 D after an 8-minute fixation period at the near point (Ebenholtz, 1983), 0.6D after 1 hour of nearwork (Owens & Wolf-Kelly, 1987) and 0.29D after a 2 hour task at 20cm (Ehrlich, 1987). These shifts do eventually return to baseline.

1.3.4 Associated Observations

People who exhibit a sluggish blur-driven accommodative response are likely to exhibit an increased lag of accommodation to near, have a reduced sympathetic input to accommodation, esophoria at near and an increased AC/A ratio (that is, a tendency to over converge to the accommodative stimulus). The chronology and synergistic associations of

these changes are, however, unclear (Rosenfield & Gilmartin, 1999). Schor (1999) modelled interactions between accommodation, convergence and refractive error, the results suggesting that adaptable tonic vergence could potentially reduce the progression of myopia by reducing the lag of accommodation.

1.4 Mechanical factors

The link between near-work and myopia has also been explored with reference to the mechanical implications of convergence and tension in the extraocular muscles. The sclera of myopes has been found to have thinning, narrowing and dissociation of the collagen fibre bundles (Ong & Ciuffreda, 1997). It is not clear if this stretching is the result of the causal forces of the myopia or just an associated characteristic. Greene (1980) calculated that the oblique muscles can exert significant amounts of localised tensile stress on the posterior sclera. With the increase in vitreous pressure associated with convergence this concentrated stress may be sufficient to stretch the sclera out of shape permanently (Greene, 1980). See figure 1.4 for an illustration of a stretched sclera. Ong and Ciuffreda (1997) argue that there is little evidence pertaining to Greene's calculations and that myopia is not primarily due to biomechanical aspects of accommodation, vergence and the intraocular pressure relationship.

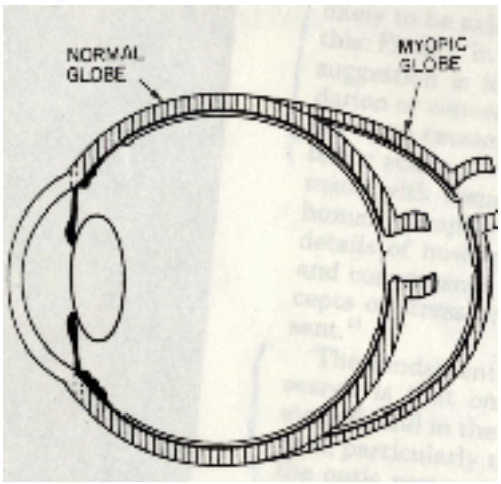

Figure 1.4 Geometry of the axial myopic globe superimposed on the normal emmetropic globe. This section represents a horizontal section through the left globe as viewed from above. From Greene (1980).

1.5 Mental Effort and Suggestion

1.5.1 Volitional Control of Accommodation

It has been shown that trained subjects can exhibit volitional control over their accommodation, that is, "thinking far" or "thinking near" can override presented stimuli (Malmstrom & Randle, 1976; Randle, 1988). For one of the volitional control exercises used by Randle, subjects were required to hold focus for a far distance while the target was stepped from far (0.50D) to near (3.50D) and vice versa. He demonstrated that 8 of his 12 myopic subjects could significantly extend their far points. Substantial changes were also evident in pre- and post-task measures of refractive error and Snellen acuities but there did not appear to be a relationship between these changes and the corresponding facility to control the farpoint (Gilmartin et al, 1991). The range of volitional negative accommodation observed is 0.5 to 2D (Richter & Franzen, 1994). Accommodation training will be considered further in chapter 2.

1.5.2 Effect of Mental Effort

Performing a mental task has been shown to change the level of accommodation. A mean increase in accommodation of 0.28D was measured when subjects with a mixture of corrected refractive errors added numbers at a distance of 40cm as compared with simply reading them (Kruger, 1980). A group of emmetropes showed an increase in accommodation of 0.09D when adding numbers as compared with reading them with an accommodation stimulus of -1D. The same task showed a decrease of 0.09D with a -3D stimulus and a decrease of -0.04D with a -5D stimulus (Bullimore & Gilmartin, 1988). Winn et al (1991) measured a 0.17D increase in accommodation (stimulus distance 30cm) for a group of emmetropes when the task involved responding to a particular letter instead of just reading the letters.

1.5.3 Hypnotic Suggestion

Hypnotic suggestion has also been reported to change visual perception and more specifically to increase the visual acuity of myopic subjects. Small changes in visual acuity have been observed contingent upon social-verbal approval e.g. praise for correct answers (Giddings & Lanyon, 1974) and monocular scores for a spatial discrimination task improved for myopes after listening to music and to taped suggestions (Sheehan et al, 1982). The greatest increases in measured acuity have been found for those subjects with the poorest acuity and this improvement was not observed to be because of any alteration of the refractive power of the eye (Graham & Leibowitz, 1978).

1.6 Perceptual Effect of Blurred Vision

Monocular diplopia (or an array of clear images) has been observed in situations of uncorrected myopic blur and blur induced by introducing positive lenses in front of an emmetropic eye. This phenomenon of uncorrected monocular vision showing diplopia or a distortion of multiple clear images in the presence of hyperopic defocus (uncorrected myopia or emmetropia with blur induced by positive lenses) has been documented (Obstfield, 1991) and explanations put forward using an extension of Mach effect theory (Remole, 1980; Remole, 1991). This phenomenon has been successfully modelled as an interaction between defocus and ocular spherical aberration (Woods et al, 1996). In a clinical situation this effect would allow correct identification of the letter although a single clear image is not available.

1.7 Short Term Adaption to Refractive Changes

It has been observed that uncorrected vision improves after a period of exposure to blur. Low myopes read 0.039 logMAR units more after a 90 minute distance task wearing no prescription than after having performed the same task wearing their full prescription (Pesudovs & Brennan, 1993). Similarly, after emmetropes performed a 30 minute distance task through a +1.00D lens a significant improvement in visual acuity of 0.09 logMAR units (nearly one line) was measured (Mon-Williams et al, 1998).

Chapter 2
The Treatment of Myopia

2.1 Optometric Compensatory Treatments

The most common method of treating myopia is to alter the refractive state at the front of the eye to compensate for the myopic refractive error and allow light entering the eye to focus on the retina. This can be done by one of several methods:
(1) *Spectacles* Concave refractive lenses made of glass or plastic are worn in front of the eye. The strength of the lenses is determined in an optometric examination.
(2) *Contact lenses* As for spectacles but they are usually made of plastic and are worn directly on the cornea.
(3) *Orthokeratology* is the procedure in which rigid contact lenses are fitted in such a way as to temporarily flatten the corneal apex and thus compensate for the myopia.
(4) *Surgery* Surgery to permanently alter the refractive state of the cornea is also available. Radial keratotomy (RK) is a procedure in which incisions are made into the corneal stroma to flatten the central cornea. Laser Photorefractive Keratectomy (PRK) is a process in which a laser is used to ablate the central cornea. Another surgery method, Laser in situ Keratomileusis (LASIK) begins with the removal of a corneal flap followed by the use of a laser to ablate the stroma. The flap is then replaced (Grosvenor, 1999).

2.2 Attempts to Reverse or Control Myopia

It has been suggested, based on the literature on myopiogenesis (see chapter 1) that, however useful, spectacle intervention (or any of the other methods described above) for the optical correction of myopia may lead to its exacerbation (Blackie and Howland, 1999). Comparing myopia progression for full time spectacle wearers, distance wearers only and non-wearers did not, however, show any significant differences (Ong et al, 1999). Similarly one study followed patients with exotropia who were overcorrected with minus lenses. The rationale behind such treatment is that negative lenses stimulate accommodation which in turn stimulates accommodative convergence (AC/A ratio). Exotropia is therefore combatted with minus lenses. No significant increase in the rate of myopia progression was found for those overcorrected (Kushner, 1999).

Attempts to halt or reverse myopic progression have been numerous and have employed a wide range of methods from the prescription of bifocals or contact lenses to visual training.

2.2.1 Bifocals

The prescription of bifocals for young people is based on the idea that excessive or sustained accommodation promotes myopic increases (Goss, 1982). Myopia is regarded as an adaptation to nearpoint stress in which distance visual acuity is sacrificed in order to achieve heightened visual efficiency at near. Early relief of the nearpoint stress with low plus is thought to prevent myopia (Jennings, 2000). Private practice records (Roberts & Banford, 1967; Oakley & Young, 1975; Neetans & Evans, 1985) have shown a slowing of the rate of myopia progression in bifocal wearers as compared with those in single vision lenses (between 0.1D and 0.42D less per year). A clinical trial of +1.00D and +2.00D add bifocals worn by subjects aged 6-15 for 3 years showed no significant difference in myopia progression as compared with subjects wearing single vision lenses (Grosvenor et al, 1987). Contrasting with this are studies which found a slowing of myopic progression using +1.50D and +2.00D adds (Leung & Brown, 1999) and a slowing of progression to a slight degree with a +1.50D add (Fulk et al, 2000). In summary there is no consensus regarding the efficacy of bifocals which may partly be due to variation in experimental design and heterogeneity in the subject samples.

2.2.2 Contact Lenses

As the result of a 3 year study it was concluded that, for wearers of rigid gas permeable (RGP) lenses myopia progressed at a significantly slower mean rate than for wearers of spectacles, however, due to the large standard deviations of both groups it would not be possible to predict the effect for a given patient. The slower rate for the RGP lens wearers was associated with corneal flattening although the flattening as measured by the keratometer was not enough to account for all the myopia control (Perrigin et al, 1990). Another study showed no difference in myopia progression between a group of adolescent spectacle wearers and soft contact lens wearers (Horner et al, 1999). In conclusion, soft contact lenses appear to have no effect on myopia progression whereas rigid lenses can slow myopia progression but not in any reliable or predictable way.

2.2.3 Auditory Biofeedback

Another technique which is used to attempt myopia control and reduction is biofeedback of accommodation. This technique involves using an infrared optometer to record the vergence of light reflected from the retina. This signal is then converted to an auditory tone. As accommodation decreases the pitch increases giving feedback of the accommodative state. This feedback allows for volitional control which ideally could be transferred to the everyday environment. The treatment consists of a series of training sessions on the apparatus accompanied by home based peripheral awareness and relaxation techniques and a correction to 6/9 acuity (Angi et al, 1996).

Trachtman (1987) reported a compilation of 240 case histories from 11 optometry practices using biofeedback for which the median change in refractive correction was +0.87D with a range of 0 to +4.75D. Koslowe et al (1991) found no change in unaided visual acuity, retinoscopy or subjective refraction between treatment and control groups when testing the biofeedback equipment. Angi et al (1996) showed a significant improvement in unaided visual acuity of 0.16 logMAR units for the right eye and 0.11 logMAR units for the left eye. The refractive errors did not decrease, but a psychological assessment showed that the treated myopes had an improved subjective perception of psychological well being and often reported a sensation of warmth and increased eye volume after training. There were also reports of monocular diplopia with the perception of a central blurred image accompanied by a clear image alongside.

Figure 2.2.3 The biofeedback visual training system. See text for a description of biofeedback visual training. From Angi et al, 1996.

The discussion of clinical trials of this technique have been criticised for a lack of a plausible physiological model linking accommodation and myopia development (the initial cases were based on the assumption that the myopia was caused by a ciliary muscle spasm) (Gilmartin et al, 1991).

2.2.4 Visual Training

Visual training for myopia control is a term used to cover a range of different methods, most of which attempt to reduce myopia by encouraging an extension of the farpoint. One large scale study of vision training (methods unspecified) evaluated the outcome using Snellen charts and cycloplegic retinoscopy. Most subjects had an improvement in unaided vision which averaged approximately 2 lines of letters, however, the results for the cycloplegic retinoscopy did not show an overall trend towards myopia reduction (Woods, 1946).

Berens et al (1957) studied the effects of a tachistoscopic training procedure on myopia. The training procedure involved reading digits projected onto a screen. When all the digits were correctly identified the distance to the screen was increased, the number of digits being shown increased and the exposure time decreased. This procedure was carried out three times a week for ten weeks. The mean unaided visual acuity increased in the

experimental group while it decreased in the control group and cycloplegic retinoscopy showed a significant decrease in myopia in the treatment group of +0.22D and a significant increase in myopia of -0.29D in the control group.

Giddings and Lanyon (1974) showed that positive reinforcement on a visual acuity task could produce short term decreases in myopia. Whilst viewing slides of 4 rings, and having to determine which ring had a gap, a positive reinforcement group were told when they were correct, a noncontingent reinforcement group received verbal encouragement on a random basis unrelated to whether the response was correct and a control group received no response from the experimenter. The positive reinforcement group had less myopia at the end of the training period as measured by retinoscopy without a cycloplegic. This change was 0.22D more than the change in the control group and 0.20D more than the change in the noncontingent reinforcement group. (Values not stated.)

Rosen et al (1984) used a training program which consisted of instructions for avoiding eyestrain, for eye relaxation massage techniques and for fixating on targets at increasing distances. There were 3 groups in the experiment; behavioural training plus feedback, behavioural training only and a no treatment control group. The behavioural training plus feedback group were told when they made correct responses on a Landolt ring discrimination task such as that described above. Both training groups showed significantly greater increases in acuity than the control group (6/38 to 6/20 and 6/40 to 6/30 as compared with no change at 6/40). Refractive error changes showed a trend towards decreased myopia of approximately a quarter of a dioptre in the two treatment groups, but this was not found to be statistically significant.

Instead of digits or letters one study used a computer game that had to be played at increasing distances. The reported findings from this study was an increase in visual acuity (Gil & Collins, 1983). Another method used is similar to the biofeedback techniques described above but with the inclusion of a projected target for the trainees to clear. Successful extensions of the farpoint of the order 0.2D were achieved but were hypothesized to be instrument specific (Randle, 1988).

Vision training has also been shown to alleviate transient near work myopia. A 10 week training procedure involved rocking fixation and focus repeatedly from far to near targets and trying to maintain a target in focus whilst flipping between viewing through positive and negative lenses. Monocular accommodative facility showed an improvement as measured by an autorefractor in 5 subjects after the training period (Ciuffreda & Ordonez, 1998).

The range of training methods attempted is wide although most are based on increasing accommodative flexibility and extending the myopic farpoint. This has been done using various projections and computer screens with targets of varying sizes and at varying distances. There were also various levels of feedback given in the form of auditory signals as to the state of accommodation or verbal encouragement and information as to how much of the target was seen correctly. Different methods of vision training have shown small improvements in acuity and objective refraction although there is no widespread agreement on the mechanisms producing these changes.

2.2.5 Behavioural Optometry

The training procedure used in the paper by Woods (1946) was carried out by Dr. A.M. Skeffington whose work forms the basis of the branch of optometry called behavioural optometry. He postulated that visual disorders are frequently the end-points of either interference in visual development or are adaptations to stress - notably near-point visual stress. This has led to the tenets of behavioural optometry that vision is a developed motor skill, that ophthalmic lenses can be used for prevention, protection, compensation and enhancement, and that vision is trainable (Holland, 1996). There is, however, concern that behavioural optometry can not perform under evidence-based scrutiny which means that although it is widely practised and is a very active international movement it does not enjoy the credibility of mainstream optometry (Jennings, 2000).

Chapter 3
Holistic Vision

3.1 Natural Vision

3.1.1 Background

There are claims of methods that improve myopic sight without optical correction or surgery, the oldest documented ones being from within the Indian yoga systems and traditional Chinese medicine. Today there exists a field in which vision problems such as myopia are approached holistically. There are many different methods used within this field which I will refer to collectively as vision therapy. Although there are many different approaches to vision therapy most incorporate the work of W. H. Bates, an American ophthalmologist.

In 1920 "The Cure of Imperfect sight by Treatment Without Glasses" by W. H. Bates was published. This book presents the idea that sight can improve with the removal of spectacles and sets forward the techniques to aid this improvement. The main idea is that imperfect sight is caused by strain and the objective is to remove the strain; normal sight being restored once this has been achieved. This strain can take the form of physical tension not allowing full movement of the eye, which in turn can lead to a pattern of staring in which rapid changes of fixation are not possible. The proposed techniques to aid the improvement process are palming, sunning, swinging (see below) and the restoration of central fixation, since any tendency to eccentric fixation will mean that foveal sight will not be used. "Since central fixation is impossible without mental control, central fixation of the eye means central fixation of the mind. It means, therefore, health in all parts of the body" (Bates, 1920). It is at this point, regarding vision as part of overall health, in essence a holistic viewpoint, that Bates's theories depart from conventional optometry. Contemporary natural vision work uses the techniques and ideas that Bates proposed whilst incorporating them in a holistic health model that allows for the possibility of other approaches if necessary (e.g. cranio-sacral therapy, Alexander technique).

A holistic approach to health includes the view that a symptom indicates an underlying health problem which may need attention, the symptom being the best attempt the body can make to heal itself. Treatment generally involves attempts to boost overall health in order to allow the body's regulatory systems to overcome any problems e.g. working to restore strength and flexibility in the whole of the back to relieve localised back pain. Natural vision and vision therapy techniques are based on the idea that reduced vision is a symptom indicating more general problems that can be addressed.

There is also an assumption with vision therapy that seeing is learned and so a process of re-education is possible. There are techniques to aid this process but it is not simply a question of doing exercises to achieve a result. Working in this way places each person in a position of responsibility in which he or she is expected to apply the learned techniques (Birnbaum, 1981; Friedman, 1981) and a determination to view vision as part of the whole human process is also crucial to success (Mansfield, 1992). There are currently many books in print which outline different methods for vision improvement (Benjamin, 1929; Huxley, 1943; Corbett, 1949; Kavner, 1978; Rosanes-Berrett, 1983; Goodrich, 1985, Kaplan, 1987, 1995; Mansfield, 1992; Schneider et al, 1994; Berne, 1995; Liberman, 1995; Quackenbush, 1997). As well as these books there are courses and workshops available during which the techniques are taught. Sections 3.1.2 through to 3.2.4 summarise the work in these texts.

3.1.2 Physical Correlates

The associated characteristics of myopia implicit in the holistic perspective are set out in these texts. It is suggested that the body of a myope will follow a specific pattern of pronounced tension in the forehead, jaw, neck, shoulders, upper arms and lower back. He or she will also have reduced peripheral awareness and a prolonged central fixation time. A combination of vision exercises, bodywork and body relaxation exercises has been found to be far more effective at improving vision than simply doing vision exercises alone (Schneider et al, 1994).

3.1.3 Emotional Correlates

It is not only the physical characteristics of myopes that are reported to follow a pattern but perceptual style and personality type also. The typical myope is said to be academically proficient and in a state of compressed anxiety and unconscious apprehension (Goodrich, 1985). There have also been many correlational studies linking myopia with personality characteristics. These have linked myopia with introvertedness, shyness, over-control of emotions and a high tolerance for anxiety (Lanyon & Giddings, 1974). Many of the vision therapy approaches include a psychotherapy aspect dealing specifically with these issues.

3.2 Vision Exercises

Within the natural vision literature there are a common body of exercises that are generally recommended as beneficial for myopia. The first recommendation is that whenever safe (i.e. not for tasks that require a certain standard of acuity e.g. driving) no refractive correction should be worn and when this is not possible a reduced prescription should be

used. There are also techniques for encouraging co-ordination, flexibility and movement, these factors being considered as essential to good vision.

3.2.1 Movement Stimulation

1) *Blinking* is encouraged wherever possible and can be co-ordinated with breathing, jaw flexion and neck rotations. This is suggested to help reverse a pattern of rigidity and staring.

2) *Stimulating peripheral vision* is attempted by patching across the nose to block out central vision (see figure 3.2.1a). Throwing and catching a ball with the hands to the side, or any form of peripheral movement detection are said to add further benefit to this activity.

Figure 3.2.1a Stimulation of peripheral vision using movement of the hands with a nosecard used to block central vision. Illustration from *The Handbook of Self-Healing* (Schneider et al, 1994).

3) *Swinging* the head and body through 180^{o} encourages co-ordination of the visual system with movement. The aim of the exercise is to smoothly observe the apparent motion of the surroundings in the opposite direction to the movement of the body and to fixate each point as it moves through the central line of vision (see figure 3.2.1b).

Figure 3.2.1b Swinging using the outstretched hand as a reference point for the oppositional movement. Illustration from *The Handbook of Self-Healing* (Schneider, 1994).

4) *Swaying* from side to side whilst looking, for example, through a window and observing the movement of the foreground and background in opposition to one another is also said to stimulate this co-ordination of vision and movement. This is best done with a rocking motion keeping the neck and back in one line i.e. swaying from foot to foot and not bending at the waist or the neck.

5) *Shifting* exercises are designed to restore the natural free movement of the eyes and counter the tendency for slower, larger and less frequent saccadic eye movements that are said to accompany deteriorating vision. These exercises involve shifting one's point of focus from place to place in imitation of normal eye movements. This can be done, for example, by taking a picture and tracing with the focus of attention around details of the picture. Though this movement must be consciously practised at first, with time it becomes an automatic and effortless process. A smaller and subtler oppositional movement as described for swinging can also be observed when accurate shifting is achieved. (The point of fixation will always be in the centre of the visual field so that if the gaze moves to the right the point that was being observed will now be moved to the left in the visual field.)

3.2.2 Relaxation

1) *Palming* is the name given to the technique of sitting with the palms covering the eyes (see figure 3.2.2). This allows the eyes a time of total rest and is best done in darkness. Palming for an hour a day is recommended.

Figure 3.2.2 Two different ways of palming. Illustration from *The Handbook of Self-Healing* (Schneider, 1994).

2) Facing the sun with closed eyes and slowly rotating the head is said to warm the muscles around the eyes and stimulate the retina. This is known as *sunning*. Alternating between palming and sunning is said to aid pupil flexibility making the transition from dark to light less painful.

3.2.3 Nutrition

Good eyesight and eye co-ordination are said to depend on good nutrition. There is no single recipe for a good diet for all people since people vary in their nutritional needs, however, a diet rich in fresh fruit and vegetables (eaten raw as much as possible) and avoiding foods high in fats (e.g. crisps), processed sugars and white flour is recommended.

3.2.4 Possibility of improvement

With regard to improvements in myopia the general consensus within the field of vision therapy is that, although by no means guaranteed, restoring good vision is possible (Schneider, 1994). This argument,that myopic vision can improve, places natural vision techniques outside of contemporary optometry practice.

3.3 Personal Experiences of Natural Vision

Case studies and personal experiences of natural vision techniques, although anecdotal in origin, are worthy of discussion because the techniques are novel and have not been rigorously investigated. Analysing the experiences of those who have tried the techniques and written about them is useful in determining which direction further research should

take. One thread which runs through these articles is the connection between vision and posture. It is suggested that the sharp acuity achieved with negative lenses for myopic vision brings with it stress and muscular tension, that is, that the most relaxed and healthy eye is one which moves and sees well and that poor vision and muscular tension come together. In addition the necessity of always looking through the optical centre of corrective lenses for best vision can lead to reduced flexibility with a tendency to move the head, neck and upper body instead of using eye movement only (Gallop, 1994).

Another widespread theme is that of the spatial percepts of myopic vision. Visual information is used for balance, an awareness of spatial volume and orientation and interactions within this space. It is suggested that there is a tendency in myopic vision to over concentrate on a central target making peripheral awareness poorer (Birnbaum, 1978). There is also often an emphasis on near-centred tasks that are two dimensional and do not include adequate motor involvement i.e refined physical movement and co-ordination are not necessary (Gallop, 1994). The effect that minus lenses have on spatial perception is described as visual compression with the deep three-dimensional reality of good vision becoming in subtle ways a two-dimensional image (Orfield, 1994). The following quotation is from someone who followed a program of vision therapy with a behavioural optometrist over a time span of seven years.

"I saw space visibly expanding - people grew taller and the volume of space expanded enormously. Seeing space, very different from having 20/20 sight is the vision thing which is lost with strong lenses when central sight is all that is prescribed for. Regaining it is what makes reducing and controlling my myopia worthwhile." (Orfield, 1994)

This idea of spatial perception being altered by minus lenses also includes the perception of motion with the relative speeds and distances as altered by minus lenses having very specific perceptual consequences (see chapter 4). The following is an observation of what it was like to wear a reduced prescription.

"The 'apparent motion' of the trees and hedges where I walked caused me to perceive distances in new ways. I noted that the apparent speed of the stationary objects that seemed to move past me and around each other was all related to their distance from me as I walked past them. I felt as if the pillars were whizzing by, the pavement rolled under my feet. It was quite different from the telescopic sight in my strong lenses." (Orfield, 1994)

As well as noting the experiences of working with vision some of what is involved when change is attempted is also discussed in this literature. The difficulty of measuring comfort, awareness, thinking or behaviour compared with the ease with which refractive

errors, axial length and corneal curvature can be measured is an inherent problem of researching the holistic approach to vision. Balance, movement and awareness, all of which are important when working with vision holistically, are developed and malleable, but deep rooted, emotionally charged and sensitive when it comes to change. In order to deal with these and other issues when trying to manipulate myopia there is a need for a sound plan to avoid the fear and panic that often accompanies the first awareness of blur (Gallop, 1994).

Chapter 4
Theoretical Possibilities for Holistic Hypotheses

4.1 Theoretical Possibilities

4.1.1 Introduction

The main aim of this thesis is to explore vision therapy techniques as they are practised today within complementary medicine using conventional optometry tests. Although there exists a wealth of popular literature on the subject there is at present a lack of academic study and this brings about a contrast of styles in the literature review: one, from the natural health literature (chapter 3), which introduces the ideas and concepts employed in vision therapy; and the other (chapters 1 and 2), a more structured approach taken from academic papers which explore the workings of the visual system and the implications of clinical interventions. It should be made clear that the aims of these two bodies of work are quite different. The natural health literature usually consists of a collection of techniques designed to be read and used by an individual with no specialist training; in essence they are "do it yourself" books. They are included here because they are the only source which set out the techniques to be applied. By contrast the clinical and scientific academic literature records the attempts to understand the workings of the visual system and the effect of interventions by specific experimental methods and is designed to be read by a specialised audience. Direct comparison between the two bodies of work is difficult not only because the approaches differ but also because the situations described will also differ. For example a case study in a natural vision text may involve a person removing their -3D prescription and describing changes that take place during therapy. There is no analogue for this within the clinical literature where such a person would remain with their prescription, although in some cases it may be modified slightly. In this sense it could be said that, within the field of natural vision, unique experimental situations exist. Looking at these techniques as experimental, the next step is to explore the theoretical possibilities that they open up. In order to do this the idea that analysing the process of vision, specifically myopic vision, using the theoretical tool of a holistic viewpoint is investigated. This is done by taking the statements from the natural vision literature (chapter 3) which stand without a scientific rationale and comparing them with some of the theoretical possibilities explored in chapter 1.

4.1.2 Can Vision Be Trained?

The theoretical hypotheses that are put forward to explain the practice of vision therapy stem from the idea that vision is a learned activity and is a process which involves physical, psychological and perceptual elements. Through the manipulation and training of these different elements it is argued that vision is also trainable (Sherman, 1993;

Holland, 1996). This training is similar to the conditioning of other involuntary visceral and glandular responses e.g. blood pressure (Miller, 1969) and can be done by bringing a greater awareness to the area to be trained, as is the case in yoga systems, or by being shown through some sort of feedback device (e.g. biofeedback accommodation trainer, see section 2.2.3) the state of a particular autonomic function.

4.2 Minus Lenses, Peripheral Awareness and Movement

In order to explore and attempt to explain the perceptual consequences of minus lenses their effect is examined.

4.2.1 Minification

Relative spectacle magnification (RSM) may be defined as

$$RSM = \frac{\text{the retinal image size of a distant object in the corrected eye}}{\text{the retinal image size of that object in the standard reduced emmetropic eye}}$$

It can be shown (Obstfeld, 1978) that the RSM can be given by the formula for spectacle magnification (SM)

$SM = \omega/\omega_0$ (Obstfeld, 1978)

where ω= angle of incidence of light at the cornea with no correction in place and ω_0= angle of incidence at the cornea after correction.

The approximate percentage change produced by the spectacle correction in the retinal image size is given by

$SM\% = dF_{sp}$

where d is the vertex distance between the spectacle correction and the front of the eye and F_{sp} is the power of the correcting lens.

Using these formulae and taking the example of a -6D lens at 1cm from the cornea the relative angular difference can be calculated.

SM% = 1 x (-6)

= -6

Therefore the image in the corrected eye is 6% smaller than that in the uncorrected eye. Looking now at the angular field of view it is assumed that the angle viewed wo =130^{o} in the uncorrected eye. Using the result from the calculation for spectacle magnification then

94/100 = ω/130

ω=122.2^{o}

This then means that information that would fall across the stretch of retina allocated to 130^{o} in the uncorrected eye would fall across the smaller area of retina allocated to approximately 122.2^{o} in the corrected situation. See figure 4.2.1 for a diagrammatic representation of this (not to scale).

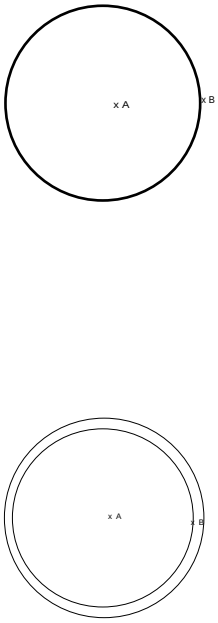

Figure 4.2.1 Diagrammatic representation of two retinae. The top circle shows the uncorrected situation of a whole retina. The outer circle of the bottom diagram represents the retina and the inner circle represents the corrected image as it falls on the retina.

This minification means that the visual field is imaged onto a smaller section of the corrected myopic retina than would be the case for an emmetropic eye. Taking the example of an object in the periphery this minification will mean that the object will be viewed by a more central part of the retina for a corrected myope than would be the case for the emmetropic eye. The advantages of cell specialisation with cells at the edge of the retina detecting motion more easily may be in this circumstance reduced, i.e. motion detection would not be so strong. This could account for the observations on myopic visual style (section 4.2.4).

It is assumed that the emmetropic eyeball and the myopic eyeball are the same size. This is not correct, however the assumption is made since the amount of cells available is the same and so although the myopic retina is stretched and the area over which the minified image is falling may be the same size as the emmetropic retina the amount of cells available is reduced and the cell type will be different.

4.2.2 .*Relative Slowing*

From section 4.2.1 the distance from an object point A to an object point B as imaged on a corrected myopic retina will be reduced as compared with the same points imaged on an emmetropic retina.

Let the time taken for an object to travel from A to B be t. This must be the same in both situations since it takes place outside the eyes. Let the distance between the image of A and B on the emmetropic retina be d_e. Let the distance between the image of A and B on the corrected myopic retina be d_{cm}. Using the formula velocity = distance/time (v=d/t) then

$v_e=d_e/t$

and

$v_{cm}=d_{cm}/t$

Combing these formulae gives $v_e/v_{cm} = d_e/d_{cm}$.

Since $d_e>d_{cm}$ this implies that $v_e>v_{cm}$.

The relative retinal image velocity is therefore different in these two situations, the movement of the image being relatively slower (and travelling across fewer cells) in the corrected myopic situation.

4.2.3 Eye Movements

The changes that negative lenses bring about to the size and speed of the visual world may well also have consequences for eye movements. If there is a reduced peripheral awareness, as is being hypothesised in natural vision texts, then there will be less motivation to perform quick eye movements to more clearly observe something that "catches the corner of the eye". This in turn could lead to a lack of flexibility in the extraocular muscles and a relative slowing of eye movements although targets will always be accurately observed.

4.2.4 Peripheral Awareness

If wearing negative lenses reduces movement awareness in the periphery then removing them and retraining the vision may bring back this awareness. This is put forward as an explanation for the description in chapter 3 in which the sensation of walking with

changing vision is described: "I felt as if the pillars were whizzing by, the pavement rolled under my feet" (Orfield, 1994).

The minification effect of negative lenses will mean that there are areas of the peripheral retina that are not used for perception (see section 4.2.1). This reduced stimulation in the periphery can be compared to the peripheral occlusion which has (in chicks, see section 1.2.3) been shown to induce myopia (Wallman, 1978). If these effects hold true for humans and the lack of peripheral stimulation is enough to simulate occlusion then wearing negative lenses will induce and augment myopia (that is a stretching of the posterior segment of the eye).

4.3 Changing Myopic Visual Style

One of the important points about natural vision work is that corrected myopic vision is seen as being different from emmetropic vision. These differences can be highlighted by describing the visual characteristics of individuals with myopia. These include (1) a heightened central visual field sensitivity and/or reduced peripheral field awareness in open space, (2) a tendency to scrutinise visual details while suppressing the surrounding field in nearpoint activities and (3) a tendency to prolong central fixation (Friedman, 1981).

If these characteristics are correct, any attempt to alleviate myopia would aim to alter these tendencies, that is, work towards a situation of expanding peripheral field awareness and promoting rapid, fluid, accurate eye movements. These are the basic aims of the vision exercises outlined in section 3.2.1 which are described again here but with an emphasis on the theoretical arguments above. In this way the myopic eye can be viewed as one that sees well through minus lenses and the process of vision therapy is to try to actively change the visual style to enable a change to emmetropia to take place.

4.3.1 Peripheral Stimulation

If emmetropia relies on healthy functioning of all parts of the retina then doing exercises to stimulate peripheral vision may help to promote emmetropia.

4.3.2 Shifting

The exercise of shifting aims to recoordinate the eye movements and localisation of the visual system and regain accuracy of fixation. If the effect of minus lenses as outlined above in section 4.2.1 is considered then any attempt to remove the spectacles would imply a need to reconfigure the way that the visual system moves from looking at a point A to looking at a point B. Shifting exercises are a way to practise this co-ordination.

4.3.3 Swinging

Movement and motor skills are seen as essential to good vision with proprioception (awareness of body orientation) and spatial localisation being of particular importance (Birnbaum, 1984). As well as encouraging this awareness of body orientation, swinging will also provide movement in the periphery to stimulate this aspect of vision.

4.3.4 Swaying

Swaying is a means of relearning the apparent relative distance motion of objects in relation to each other which is distorted with the use of minus lenses as described in section 3.3. The quotation "the 'apparent motion' of the trees and hedges where I walked caused me to perceive distances in new ways" (Orfield, 1994) describes the sensation of swaying.

4.3.5 Sunning and Palming

The hypothesis that Bates puts forward is that poor vision is the result of strain. This is the basic tenet of all natural vision work, the aim of which is to reduce this strain and achieve relaxed visual function with the assumption that this also brings increased vision. Palming as a relaxation activity does just this. It could also be argued that the scotopic situation is the one in which the peripheral retina is most likely to be used and that if this area of the retina is under used then more time in this condition is necessary. Palming can provide this situation as well as an opportunity to relax the central vision. This could also account for the finding that children who sleep with nightlights (i.e. no real rest for the central retina because there is no true scotopic time and therefore no time when the dark adaption cells get a chance to work) are more likely to become myopic (see section 1.2.2). Again an analogy can be drawn between this and the situation of peripheral occlusion i. e. constant light means constantly working the central retina without any time for the peripheral retina to be stimulated.

Sunning can also be viewed in the same way as a gentle means to stimulate retinal cells not normally used when corrected with lenses and as an aid to regulating light/dark rhythms necessary to normal functioning.

4.4 Problems With Previous Trials

It should be noted that none of the clinical trials mentioned in chapter 2 approach vision therapy in the same manner as contemporary natural vision workers do, the main differences being that a long term, individual and supported approach will usually be taken as opposed to the short term specific tasks required in the majority of these trials.

(The importance of personal support can be seen if a parallel is drawn with fitness or diet programs where success is much more likely in the context of a group or with the help of a personal trainer). Also with a holistic approach other therapies may be involved in the work with vision e.g. massage, cranio-sacral therapy and the Alexander technique as well as the use of the vision exercises already described.

If change is taking place it will be, at least at first, unstable and when placed in any unfavourable situation the eye with myopic tendencies will show them to the greatest extent. Conventional chart testing could be said to be one of these conditions with a reduction in peripheral stimulation. This will mean that chart testing of an unstable eye will most likely record the worst possible vision.

4.5 Discussion of Possible Physiological Changes

Natural vision therapy techniques imply a change has taken place in order for visual performance to increase. If it assumed that real visual changes are taking place and do not just reflect an increased confidence and skill at interpreting blurred letter charts the possibilities for what the physiological changes might be are:

1. Changes in the refractive power
    a)change in corneal curvature
    b)change in axial length
    c)change in crystalline lens power
2. Changes in the way the eye is used
    a) improved co-ordinated use of foveal vision
    b) neural clean up of blur

4.6 Purpose of the Experimental Work

The purpose of the experimental work was to:

1) investigate the effect that an introduction to vision therapy had on the chart performance, autorefractor reading, and autokeratometry reading of a myopic population.

2) explore differences between corrected and uncorrected myopic vision.

3) investigate the experience of vision therapy from the participants' viewpoints.

Chapter 5
Experimental Method

5.1 Physical Parameter Measurement

5.1.1 A-scan Ultrasound

The Mentor/Teknar Ophthalsonic A-scan was used to measure the axial length of the eyes of the participants. It transmits ultrasound at 7.0 MHz into the cornea and collects reflections from the lens and the retina with a piezoelectric element in the probe. This information is used to obtain measurements of the anterior chamber depth, lens thickness and the axial length of the eye. The auto-biometric repeat reading mode was used and the average of 10 readings calculated. The cornea was anaesthetised using 1-2 drops of 0.4 % Benoxinate Hydrochloride and the hand held transducer held to the cornea to take the readings as shown in figure 5.1.1. The participant was asked to fixate a point on the wall to steady fixation and applanation was made as close to the visual axis as possible. The instrument has an alignment system which makes an auditory signal to indicate when this is achieved.

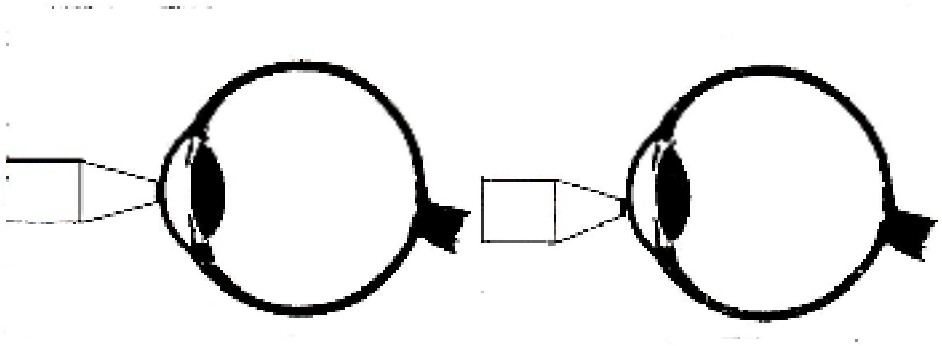

Figure 5.1.1 An illustration of the a-scan probe application. The first picture shows correct alignment flush to the cornea along the visual axis. The second picture shows an incorrect alignment. Diagram from Mentor/Teknar Ophthalsonic A-scan manual.

5.1.2 Autorefractor

The Humphrey Automatic Refractor Model 570 which works on the retinoscopy principle was used for all the refractions. Measurements were taken in the objective refraction mode

and the spherical and cylindrical components of the refractive error measured were provided on a printout. Each measurement is the average of 20 readings. For each autorefractor measure 5 consecutive readings were taken, the mean sphere for each found and then the mean of these calculated.

5.1.3 Autokeratometer

The Humphrey Autokeratometer was used. The mire of the autokeratometer is composed of three infra-red emitting diodes arranged in a triangular shape. It uses a solid state detector that records the exact position of each diode image after reflection from the cornea. It uses this information to calculate the radius of curvature of the cornea. It gives a reading of corneal curvature in dioptres and millimetres along two axes, one closest to the horizontal and one closest to the vertical meridian. Each reading of corneal curvature from the machine is derived from 10 measurements (Henson, 1996). For each autokeratometry measure 5 consecutive readings were taken.

5.1.4 Technical Data Reliability

The table below shows the confidence limits for change of the ocular anatomical parameters (Zadnik et al, 1992). For these measures a Canon R-1 autorefractor, a Bausch and Lomb keratometer and an Allergan-Humphrey A-scan were used. These values give a guide to the difference needed to determine if a change has taken place, although different models of the instruments are being used. One study showed, however, that for autorefractors the model used does not vary the results significantly (Winn et al, 1998).

	stdev (n=40 normal pre-presbyopic adults))	*95% confidence limit (sd x1.96)*
non-cycloplegic autorefraction	± 0.37D	± 0.73D
corneal curvature	± 0.48D	± 0.94D
axial length	± 0.18mm	± 0.35mm

Table 5.1.4 Confidence limits for autorefractor, autokeratometer and A-scan readings (Zadnik et al, 1992).

5.2 Visual Acuity Charts

5.2.1 High and Low Contrast Bailey Lovie charts (HCBL, LCBL)

The Bailey-Lovie distance visual acuity test chart has 5 approximately equally legible letters on each row and the separation of letters within rows and between rows is uniform to control for contour interaction. The between-letter spacing is equal to 1 letter width and the between row spacing is equal to the height of the letters in the smaller row. This ensures that as far as possible the only variable reading down the chart is the angular size of the letters. The progression of letter sizes follows a geometric progression whose ratio is equal to $_{10}\sqrt{10}$. This allows for easy conversion of vision scores when test distances other than the standard 6m are used as is the case when low acuity is being measured (Bailey & Lovie, 1976). Both high (90%) and low (8%) contrast versions of this chart are used. The mean difference in score between the 2 charts has been measured as 0.26 log units (2.5 lines). This result was found across a range of uncorrected refractive errors (+4.00 to -7.00D) (Brown & Lovie-Kitchin, 1989). Figure 5.2.1 shows a high contrast Bailey-Lovie chart.

Figure 5.2.1 Bailey-Lovie chart.

5.2.2 Regan Repeat Letter (RRL) Chart

The repeat letter format of the RRL charts is designed to measure visual acuity independently of abnormal fixational eye movements due to the repeated nature of the central letter (Kothe & Regan, 1990). See figure 5.2.2 for an example of a card from the RRL chart. The central area of each 15cm x 15cm card is covered by an array of identical letters. These are surrounded by several rows of assorted letters one letter width apart, generating contour interaction without providing any clue to which letters form the central array. The chart task is to identify the letter in the central array. Four letters were presented at each acuity level. The letter sizes follow the same geometric progression as the Bailey-Lovie chart allowing for score conversion at different distances.

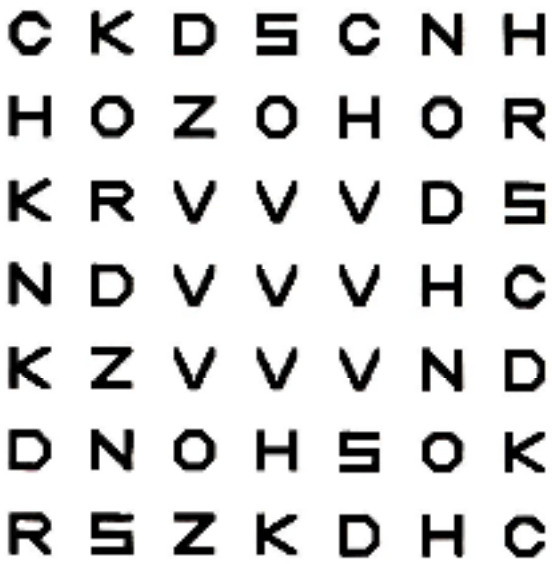

Figure 5.2.2 An example of a Regan Repeat Letter chart test card.

5.2.3 Crowded Logarithmic Acuity Test (CLAT)

This test was originally designed for children and as such all the letters used are symmetrical about the mid-line to avoid lateral confusion. There are 4 high contrast letters with surrounding contours on each card. The letters are selected from the set X V O H U and Y. The letter size progression of the CLAT follows the same pattern as that of the Bailey-Lovie chart i.e. letter size follows a geometric progression whose ratio is equal to $\sqrt[10]{10}$. Letter spacing is equal to 0.5 letter diameter for a contour interaction that is approximately 80% of maximum (McGraw & Winn, 1993). See figure 5.2.3 for an example of a test card.

Figure 5.2.3 An example of a Crowded Logarithmic Acuity Test card.

5.2.4 Single Letter Acuity Test with a Logarithmic Progression of Letter Size (SO)

This test employs the same six optotypes and size progression as the CLAT but 4 separate unflanked single letters are presented at each acuity level.

5.2.5 Pelli-Robson Chart (PR)

The Pelli-Robson chart consists of letters of the same size but of decreasing contrast. Letters of the same contrast are grouped in threes, with 2 groups in each line and a total of seven lines. The contrast decreases from 89% in the top left corner to 0.5% in the bottom right-hand corner of the chart in steps of 0.15 log units. Each letter correctedly identified is scored as 0.05 log units (Elliott et al, 1990).

5.3 Scoring Systems

The scoring method is based on the logarithm of the minimum angle of resolution (logMAR) originally designed for the Bailey-Lovie chart. For example, a 6/6 letter limb

width subtends 1 min arc at a distance of 6m. As the log of 1 is 0, 6/6 is given the score of 0. Similarly since a 6/60 letter limb width subtends 10 min arc, the score is 1. The letters change by a constant amount (0.1 log unit) from one line to the next in the charts used so interpolation of acuity scores between lines on the chart is possible. The scoring system used throughout this thesis designates 6/6 a score of 1 and 6/60 a score of 0 (CLAT score) (McGraw & Winn, 1993). This allows for an increase in acuity to be reflected by an increase in score. Conversion from the conventional Bailey-Lovie LogMAR units to these units can be calculated using

CLAT score = 1 - logMAR(Bailey-Lovie). Eqn.1

logMAR score used in this thesis CLAT	Bailey-Lovie LogMAR	Snellen
0	1	6/60
0.2	0.8	6/38
0.4	0.6	6/24
0.6	0.4	6/15
0.8	0.2	6/9.5
1.0	0	6/6

Table 5.3 Comparison of CLAT and Bailey-Lovie logMAR scores with Snellen scores.

A change of 0.1 is one line of a chart. Five letters are presented at each acuity level on the Bailey-Lovie chart and four at each level on the other charts. Since a letter size change is measured by 0.1 log units each letter correctly identified is ascribed a score of 0.02 log units on the Bailey-Lovie charts and 0.025 log units on the other 3 high contrast charts.

5.4 Measuring Change Using Charts

When visual acuity or any other continuous variable is graded there exists a statistical probability that values will differ despite the fact that no real change has occurred. To decide, therefore, whether a real change has occurred confidence limits for the test need to be established. When a re-test value falls outside these limits then it can be said that a change has taken place. A summary of these designated changes is shown in table 5.5.

chart	95% confidence limit for change	No of letters this represents	source
High Contrast Bailey-Lovie	0.16	8	Lovie-Kitchin, 1988
Low contrast Bailey-Lovie	0.16	8	Lovie-Kitchin, 1988
Crowded logarithmic acuity chart	0.125	5	McGraw, 1995
single optotypes on a logarithmic scale	0.2	8	McGraw, 1995
Regan Repeat letter chart	0.16	6	Simmers, 1997
Pelli-Robson chart	0.2	4	Elliott, 1992

Table 5.4 Repeatibility measures for the charts used.

5.5 What Affects Chart Performance?

Three factors which affect chart performance in the absence of ocular disease or amblyopia are retinal blur, decision criteria and chart design.

5.5.1 *Retinal Blur*

Retinal blur caused by a refractive error will impair the ability to read letters on a chart. It has been shown that VA will decrease by one log unit with 2-2.5D of blur (Bradley et al, 1991). The severity of this impairment will be related to the degree of the refractive error although the relationship is not straight forward and knowing the refractive error does not neccessarily mean that chart performance can be accurately predicted. See figure 5.5.1 and results in chapter 6.

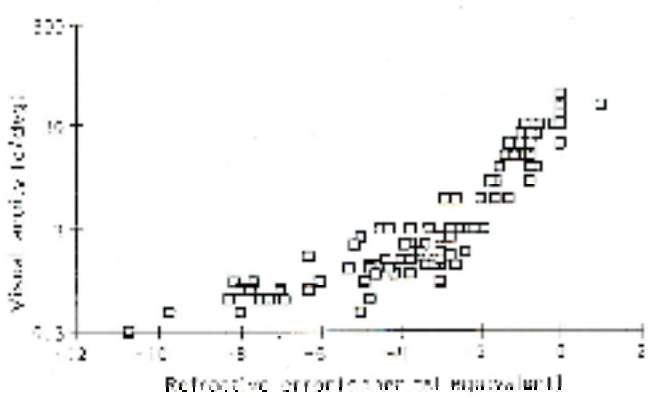

Figure 5.5.1 Visual acuity is plotted as a function of the spherical equivalent refractive error for 140 eyes without their appropriate refraction in place (Bradley et al, 1991). 30 c/deg, 3 c/deg and 0.3 c/deg are the equivalents of converted LogMAR scores 1.0 (6/6), 0 (6/60) and -1.0 (6/600).

5.5.2 Crowding Effect

The crowding effect is the name given to the phenomenon of single letter acuity generally being higher than that measured using letters surrounded by other letters on a chart. The crowding effect has been shown to include: 1) contour interaction (measured acuity depends on the proximity of the surrounding edges), 2) attentional factors and 3) fixational eye movements (Flom, 1991). The CLAT, RRL and the Bailey-Lovie chart are all designed to make crowding consistent for each letter size. The crowding ratio for high contrast letters is significantly higher than that for low contrast letters (Simmers, 1999).

5.5.3 Testing Distance and Illumination

There are variations in visual acuity with testing distance. These variations are, however, small and mostly associated with small testing distances (Heron et al, 1995). For the purposes of data analysis it is assumed that testing distance has no effect on chart acuity and so measurements taken at different testing distances can be compared. The distances that were used in this study were as follows:1m for PR, 3m for CLAT, SO and RRL, and 6m for B-L high and low contrast with the exception of the lower vision situations when it was necessary to reduce the test distance and the fully corrected situation in which 6m was used for CLAT, SO and RRL to reach threshold more easily.

The charts were evenly lit with a luminance of 80-90 cd/m2 which is within the photoopic range.

5.6 Procedures

5.6.1 Recruitment and Measurement

Twenty-one pre-presbyopic myopes (10 women and 11 men aged 19-45) were recruited into the study by means of posters displayed around the campus of Glasgow Caledonian University (see appendix 1 for a copy of the poster). The purpose of the study was explained and informed consent obtained. The refractive error range of the group was restricted to a spherical component of less than -7D and a cylindrical component of less than -1.5D.

For each participant the following measures were taken at the initial visit: A-scan ultrasonography, autokeratometry, autorefraction and cycloplegic autorefraction. Binocular and monocular corrected VA and unaided vision were also measured with all of the charts detailed above in a random order. Monocular measures were always taken before binocular and uncorrected vision before corrected VA.

All chart measurements were made in the GCU eye clinic in the same room. There was full knowledge of which group each participant was in during all testing (except the first visit in which testing took place before group allocation).

5.6.2 Group Allocation and Therapy Sessions

After the initial set of data collection the participants were assigned to one of three groups. The allocation was done (by someone who had never met the participants) with the aim of creating groups as evenly matched as possible for refractive error, age and sex. The participants in groups A and B were introduced to vision therapy techniques and provided with a reduced prescription while those in group C were not.

Group A had sessions with a trained Bates Method vision therapist, Aileen Whiteford. She trained with the Bates College of Vision Education and approaches all the vision work she does from a holistic perspective. The nature of her sessions with the participants were therefore very individual with activities and discussions based on each person's particular needs. These may have included some of the exercises as detailed in chapter 3. A typical session could include some time palming, some time with vision movement exercises and some time talking about the experiences and difficulties of working with blur and how to find time for vision work. Her sessions with the participants took place in the Eye Clinic at GCU and her fees and expenses were paid with a grant received from the Visual Research Trust. There follows the details of her contact with the participants. Sessions were usually held at between 2 week and 2 month intervals.

Participant No.	No. of sessions	Date of first	Date of last
1	6	28/4/98	18/3/99
2	7	8/5/98	29/4/99
7	10	15/5/98	29/4/99
11	12	8/5/98	17/6/99
17	6	8/6/98	10/9/99
22	10	1/10/98	7/6/99
24	10	1/10/98	6/5/99

Table 5.6 Details of the vision therapy sessions.

The participants in group B were given a handout (see appendix 2) detailing the ideas of vision therapy and the exercises of palming, sunning, shifting and swinging. They were also shown these techniques during one session with a post-graduate student, thereafter being left to practise on their own.

Those in group C remained in their full prescriptions and were given no instructions.

5.6.3 Details of the Reduced Prescriptions

Each participant in groups A and B was provided with a reduced prescription. This was done with the aim of reducing the prescription as much as possible and equalising the prescription between the two eyes.

Subject	Autorefractor Reading	Initial Prescription	Reduced Prescription
A1 R	-1.00/-0.50x27	-1.25DS	-1.00DS
A1 L	-1.00/-0.25x168	-1.50DS	-1.00DS
A2 R	none	-2.25/-0.25x82	-2.00DS
A2 L	none	-2.55/-0.20x110	-2.00DS
A7 R	-2.75/-1.00x7	-2.25DS	-1.50DS
A7 L	-1.00/-1.25x172	-1.50DS	-0.50DS (-1.50DS)
A11 R	-3.25/-0.25x150	-3.75/-0.25x80	-3.25DS
A11 L	-3.75/-0.25x78	-3.50/-0.25x100	-3.25DS
A22 R	-0.75/-1.50x7	-1.00/-1.00x165	-1.00/-0.25x165
A22 L	-2.50/-1.75x180	-3.25/-1.25x175	-2.00/-0.25x175
A24 R	-6.00/-2.00x12	-5.75/-1.25x5	-2.75/-1.25x5
A24 L	-5.25/-2.50x178	-5.25/-1.5x175	-3.00/-1.50x175
B8 R	-1.50/-0.25x30	-1.50/-0.25x65	-1.25DS
B8 L	-2.00/-0.50x15	-2.00/-0.25 x90	-1.25DS
B9 R	-3.25/-1.50x65	-2.75/-1.25x72	-1.00/-1.00x72
B9 L	-2.00/-0.75x150	-1.75/-0.75x140	-1.25/-0.50x140
B20 R	-5.25/-1.50x11	-4.75/-0.75x15	-3.75/-0.75x15
B20 L	-6.75/-1.25x177	-6.25/-0.50x150	-5.25/-0.50x150
B21 R	-0.50/-0.75x90	-0.75/-0.75x90	none
B21 L	-0.75/-0.75x8	-1.00/-0.25x25	none

Table 5.6.3 The autorefractor reading, the prescription of the spectacles the participant was wearing at the start of the study and the reduced prescription given. Participant A7 had her prescription adjusted to the value in brackets.

5.6.4 Repeat Data Collection

Ten to fifteen months after the initial data collection repeat measures were taken. 1 subject from group A, one from group B and 2 from C withdrew leaving a total of 17 (2 women and 4 men in group A, 2 women and 3 men in group B and 4 women and 2 men in group C). The uncorrected vision, autokeratometry and autorefraction measures were taken. Limited repeat a-scan measures were taken.

The VA measures were not repeated because the therapy groups were being encouraged to spend no time in their full prescription. The cycloplegic autorefraction measures were not repeated because there was no significant difference between the cycloplegic and non-cycloplegic autorefractions (see section 6.1.2).

5.6.5 Participant Interviews and Questionnaires

Each participant in group A was interviewed at the end of the project. These interviews were recorded and full transcripts are provided in appendix 3. The interviews were semi-structured with questions leading the participants to particular topics, however, they were left conversational is style to maintain as relaxed an approach as possible and to allow for the possibility of extra information not directly covered in the given topics. Questions outlining the themes covered in the interviews are shown below.

1. Did you experience a vision improvement through palming?
2. How much home practice of palming did you do?
3. How much do you wear your reduced prescription?
4. Did specific exercises improve your vision?
5. Did other people take an interest in what you were doing?
6. What was your overall impression of vision therapy?

At the start of the project and then again 6 to 12 months later questionnaires (see appendix 2) were given to the participants. The aim of these questionnaires was to monitor the levels of visual and physical comfort. The questions which were answered by marking on a sliding scale an answer between 2 possible extremes were:

1. In the last 7 days have you felt comfortable with your vision?
2. In the last 7 days have you felt frustrated with your vision?
3. Has this week been a typical week for you?
4. In the last 7 days have your eyes felt tingly?
5. In the last 7 days have your eyes been stinging?
6. How are you feeling today?
7. In the last 7 days have your eyes been watering?
8. Approximately how much time have you spent without your spectacles these past 7 days?
9. Approximately how much time have you spent palming these past 7 days?
10. Approximately how much time have you spent wearing your reduced prescription in the past 7 days?
11. Approximately how much time have you spent doing other vision activities in the last 7 days? e.g. going for a walk without spectacles, swinging, shifting.

5.7 Statistical Analysis

All the data was analysed using the StatView package. Linear regressions, t-tests and factorial ANOVAs were the tests applied where appropriate (see text in results chapters 6,7 and 8). The cut off for significance was chosen as 5%.

Chapter 6
Vision and Visual Acuity Data

6.1 Baseline Chart Scores

6.1.1 Unaided Vision

The initial chart scores for unaided vision are shown in table 6.1.1. All charts except Pelli-Robson are scored using CLAT converted logMAR units (see section 5.3 for an explanation of the scoring systems). The PR is scored in log units of contrast.

chart	*mean ± stdev (n=25)*	*range*
HCBL R	0.36 ± 0.31	-0.24 to 0.76
HCBL L	0.35 ± 0.32	-0.38 to 0.8
HCBL B	0.48 ± 0.33	-0.22 to 0.96
CLAT R	0.46 ± 0.30	-0.027 to 0.975
CLAT L	0.43 ± 0.46	-1.12 to 0.975
CLAT B	0.59 ± 0.33	-0.05 to 1.05
SO R	0.47 ± 0.39	-0.28 to 1.05
SO L	0.48 ± 0.29	-0.4 to 1.125
SO B	0.63 ± 0.36	-0.155 to 1.2
RRL R	0.58 ± 0.27	-0.13 to 0.975
RRL L	0.56 ± 0.28	-0.08 to 0.975
RRL B	0.68 ± 0.30	-0.13 to 1.15
LCBL R	0.10 ± 0.32	-0.43 to 0.7
LCBL L	0.13 ± 0.36	-0.65 to 0.68
LCBL B	0.23 ± 0.38	-0.35 to 0.84
PR R	1.59 ± 0.23	1.05 to 1.9
PR L	1.58 ± 0.31	0.6 to 2.05
PR B	1.81 ± 0.2	1.2 to 2.1

Table 6.1.1 Mean unaided vision scores.

The right eye and binocular results for all charts except PR are plotted on figure 6.1.1. It can be seen that the high contrast Bailey-Lovie chart scored the lowest and the Regan repeat letter chart the highest of the high contrast charts for unaided vision. This difference is not significant (ANOVA, p=0.07). The difference between the LCBL

scores and those of all the high contrast charts was significant (p=0.05). The standard deviation across the group for all charts is about 3 lines indicating the spread of refractive errors present in the group. The mean scores for right do not differ from that for the left eyes by more than 0.03 units (1.5 letters on Bailey Lovie chart). The binocular scores were 0.1 to 0.15 log units (1 to 1.5 lines) higher than the monocular scores.

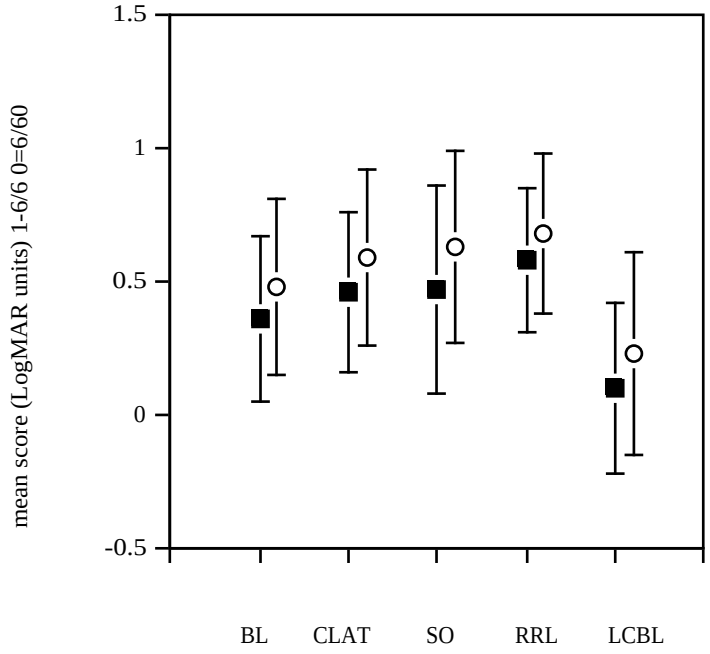

Figure 6.1.1 Mean unaided vision scores for the right eyes (filled squares) and binocular viewing (unfilled circles). Results for BL, CLAT, SO, RRL and LCBL are shown.

6.1.2 Corrected Acuity

The chart scores for corrected visual acuity are shown in table 6.1.2.

chart	*mean ± stdev*	*range*
HCBL R	1.10 ± 0.08	0.9 to 1.24
HCBL L	1.08 ± 0.11	0.72 to 1.24
HCBL B	1.15 ± 0.06	1.04 to 1.24
CLAT R	1.19 ± 0.07	1.025 to 1.3
CLAT L	1.17 ± 0.09	0.9 to 1.3
CLAT B	1.22 ± 0.08	1.1 to 1.325
SO R	1.23 ± 0.10	0.95 to 1.325
SO L	1.23 ± 0.11	0.95 to 1.4

SO B	1.29 ± 0.08	1.025 to 1.425
RRL R	1.20 ± 0.09	0.95 to 1.35
RRL L	1.18 ± 0.11	0.925 to 1.375
RRL B	1.24 ± 0.09	0.925 to 1.375
LCBL R	0.96 ± 0.10	0.72 to 1.14
LCBL L	0.92 ± 0.12	0.64 to 1.2
LCBL B	1.0 ± 0.10	0.8 to 1.18
PR R	1.82 ± 0.25	0.75 to 2.1
PR L	1.87 ± 0.15	1.55 to 2.1
PR B	2.02 ± 0.11	1.7 to 2.1

Table 6.1.2 Mean corrected acuity scores.

The right eye and binocular results for all charts except PR are plotted on figure 6.1.2. The standard deviations are about 0.1 log unit (about one line) across the group and the biggest difference between the mean score for right and left eyes was 0.04 units (low contrast Bailey-Lovie chart). For all charts the mean binocular score was about 0.06 better than the mean monocular score (approx. half a line). See section 6.4 for a comparison of monocular and binocular scores. The differences in mean scores between LCBL and the other charts are significant (p=0.05). The High Contrast Bailey Lovie chart scored significantly lower than the other high contrast charts by the following amounts: RRL 0.1 (p=0.05), CLAT 0.09 (p=0.05), SO 0.14 (p=0.05).

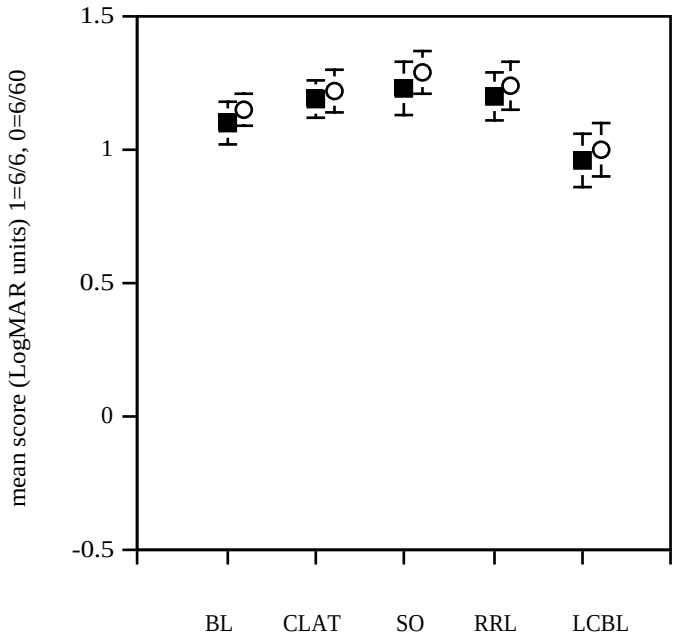

Figure 6.1.2 Mean corrected acuity scores for the right eyes (unfilled) and binocular viewing (filled). Results for BL, CLAT, SO, RRL and LCBL are shown.

6.1.3 Discussion

Comparing figure 6.1.1 and figure 6.1.2 it can be seen that the standard deviations for the mean scores are much larger for unaided vision than for corrected acuity. This reflects the range of refractive errors and hence the spread of vision in the sample. Refractive correction reduced this spread.

From observing these figures there also appears to be a greater difference between binocular and monocular scores for unaided vision. This difference, however is not significant. See section 6.4.

The low contrast chart scored significantly lower than the high contrast charts in each viewing situation. This would be expected due to the greater difficulty of the low contrast task.

Since all the charts do not give the same scores the angular size of letters is not the only factor in determining chart acuity. Among the other factors are contrast and the proximity of other letters. For both corrected and uncorrected scores the HCBL gives the lowest values of the high contrast charts although this result is only significant for the corrected scores.

6.2 Comparing Charts

In order to investigate the effect of crowding the difference between the high contrast Bailey-Lovie and the single optotypes was calculated. The Bailey-Lovie chart (see section 5.2.1) is designed to have constant crowding over all letter sizes and single optotypes have no crowding effect as there are no surrounding letters or contours.

In order to assess the role of unsteady fixation the difference between the high contrast Bailey-Lovie chart and the Regan repeat letter chart was calculated (see section 5.2.2 for a description of RRL chart).

In order to investigate the contrast dependency of the scores the difference between the low and high contrast Bailey-Lovie charts was calculated. In all cases this was done for monocular and binocular scores in both the corrected and uncorrected situations.

6.2.1 Chart Comparisons for Unaided Vision Scores

Table 6.2.1 shows the difference in unaided vision scores for the selected chart pairs.

	mean difference ± stdev R&L n=50	*mean difference ± stdev B n=25*
BL-RRL	-0.21 ± 0.13	-0.2 ± 0.14
BL-SO	-0.11 ± 0.16	-0.15 ± 0.15
BL-LCBL	0.34 ± 0.48	0.36 ± 0.54

Table 6.2.1 Mean chart comparisons for unaided vision scores.

The large standard deviation for the comparison including the low contrast chart is due to the effect of blur on low contrast scores introducing more variability.

6.2.2 Chart Comparisons for Corrected Acuity

Table 6.2.2 shows the difference in corrected acuity scores for selected chart pairs.

	mean difference ± stdev R&L n=50	*mean difference ± stdev B n=25*
BL-RRL	-0.07 ± 0.17	-0.07 ± 0.16
BL-SO	-0.12 ± 0.18	-0.11 ± 0.15
BL-LCBL	0.19 ± 0.17	0.16 ± 0.16

Table 6.2.2 Mean chart comparisons for corrected acuity scores.

In order to determine if there was any difference between the corrected and uncorrected situations with respect to crowding, eye movements and the ability to perceive low contrast the differences tabled above were compared in the two situations. The results for the corrected and uncorrected situations are shown on figure 6.2.3.

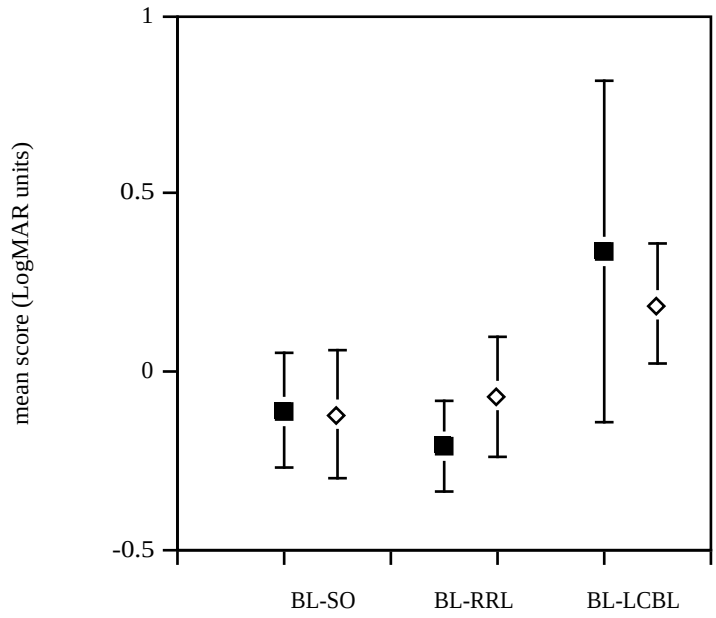

Figure 6.2.3 The mean difference across all subjects between chart pairs as labelled. The filled squares show the scores for unaided vision and the open diamonds those for corrected VA.

The difference between the corrected and uncorrected situation with regard to eye movements (that is the difference between the RRL and BL) was significant (p=0.0001). The difference between crowding on the Bailey-Lovie chart (BL-SO) in the situations of corrected acuity and uncorrected vision was not significant. The difference between groups in the change of score when reading a low contrast chart (BL-LCBL) was (although marginal) significant (p=0.044).

6.2.3 Discussion

i) The binocular differences were of a similar magnitude to the monocular differences for both corrected and uncorrected comparisons. In both situations (with and without correction) the SO scored on average about one line better than the BL chart. The difference in task difficulty between the SO and the BL chart (postulated to be due to the crowding effect) was not altered by the removal of the correcting lenses.This suggests that the effect of crowding is the same in the corrected and uncorrected situations.

ii)The RRL chart scored about 2 lines better than the BL chart for the uncorrected situation and only 2-3 letters more for the corrected situation. This difference is significant (p=0.0001). This result means that the relative difficulty of the two charts is different when correcting lenses are removed with the RRL chart becoming relatively

easier. The RRL chart was designed to measure acuity independent of abnormal eye movements i.e. if fixation is unsteady a high score can still be achieved. This result suggests a difference in the quality of fixation between the corrected and the uncorrected myope.

Possible explanations for this result are: (1) that corrected chart acuity is limited by cone spacing and so any differences brought about by subtleties in visual style will be masked i.e. the eye movements in the corrected and uncorrected situations are the same but there is not an increase in score for the RRL in the corrected case because the acuity is already limited by other factors. (2) that eye movements are different with a minus refractive correction and contain less fixational movements than uncorrected myopic vision.

If the image minification of minus lenses is taken into account then the eye movements needed to move from fixating one point to another will be smaller. This may have an effect on fixational eye movements and points to the 2nd explanation as being correct.

During one study it was noted that subjects often reported scanning the edges or perimeter of the letters to help in recognition (Bradley et al, 1991). This also suggests a link between eye movements and acuity and can be compared to the shifting exercise (see section 3.2.1).

iii) The BL chart scored about 3.5 lines higher than the LCBL for uncorrected vision as compared with nearly 2 lines better for the corrected situation. This difference is significant ($p=0.044$). This suggests that the ability to perceive low contrast targets is relatively easier in the corrected situation, that is, the presence of blur lowers the threshold for low contrast acuity.

It is also of note that there is a large standard deviation for the uncorrected situation. This suggests that knowing someone's high contrast acuity does not mean that the low contrast acuity can be easily predicted.

6.3 Range of Chart Scores for a Refractive Error Range

6.3.1 Score Ranges

To establish the range of scores found for a given refractive error, the mean vision scores for refractive error groupings were found. The ranges were defined as shown in table 6.3.1.

range (D)	0 -1	-1 -2	-2 -3	-3 -4	-4 -5	-5 -6	-6 -7	-7 -8
n	2	17	7	5	4	3	6	2

Table 6.3.1 Refractive error ranges used and the number of subjects (n) in each grouping.

The results for all charts except the PR are shown on figure 6.3.1.

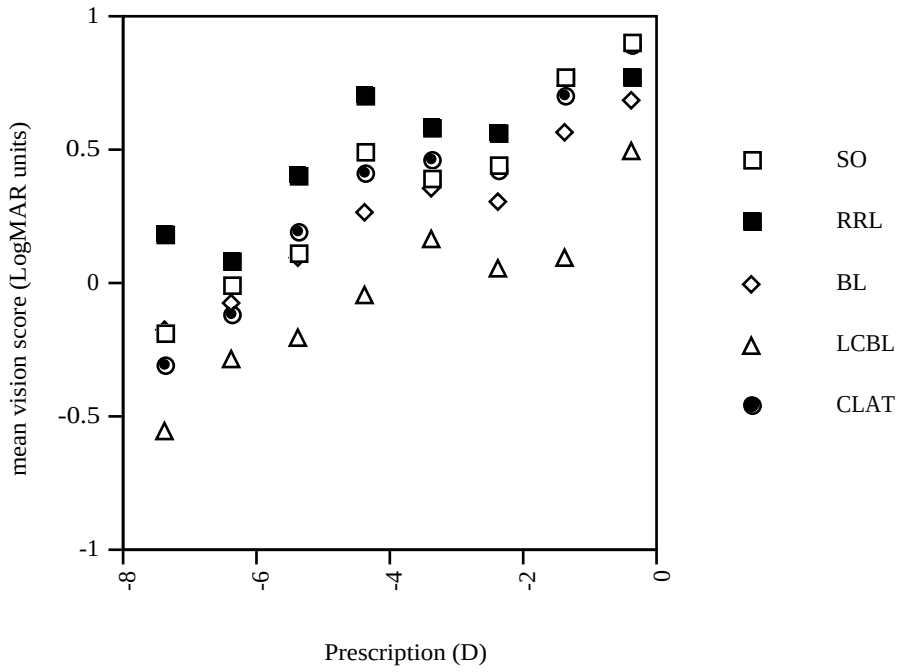

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Figure 6.3.1 The mean vision scores for a range of refractive errors is shown.

The results for each chart separately with error bars showing the standard deviations and a linear fit are plotted on figures 6.3.2-7. In figure 6.3.2 is shown the relationship between the BL vision score as a function of the non-cycloplegic refractive status of the subjects. A linear regression analysis (see line) shows that the vision score decreases with increasing refractive error (p=0.0001, r=0.98). Figures 6.3.3-7 show

the same for the other charts. The results of the regression analysis for each were as follows:

chart	slope (chart dif. for 1D change)	y-intercept (predicted emmetropic score)	p	r
BL	0.12	0.73	0.0001	0.98
CLAT	0.14	0.93	0.0001	0.97
SO	0.16	0.98	0.0001	0.98
RRL	0.09	0.88	0.0040	0.88
LCBL	0.12	0.46	0.0005	0.94
PR	0.10	1.87	0.0025	0.90

Table 6.3.2 Slopes, y-intercepts p and r values from graphs 6.32-6.37.

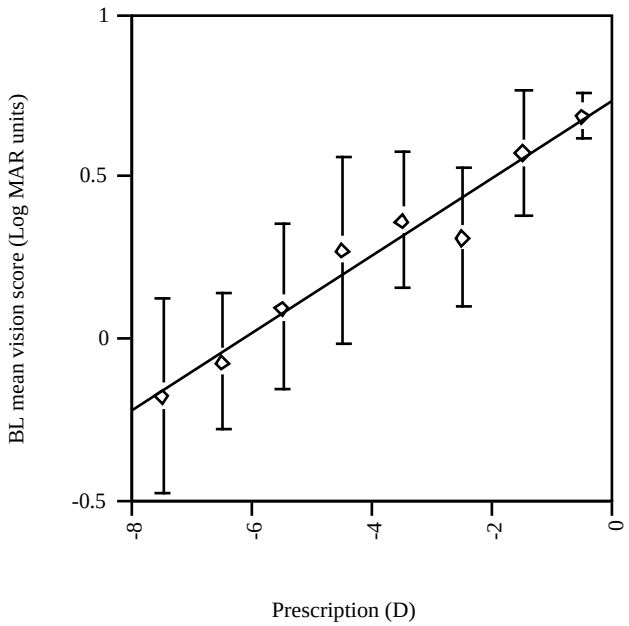

Figure 6.3.2 Mean scores for the BL chart for refractive error groupings (see table 6.3.1). The equation of the line is y=0.12x + 0.73, R=0.98, p=0.0001.

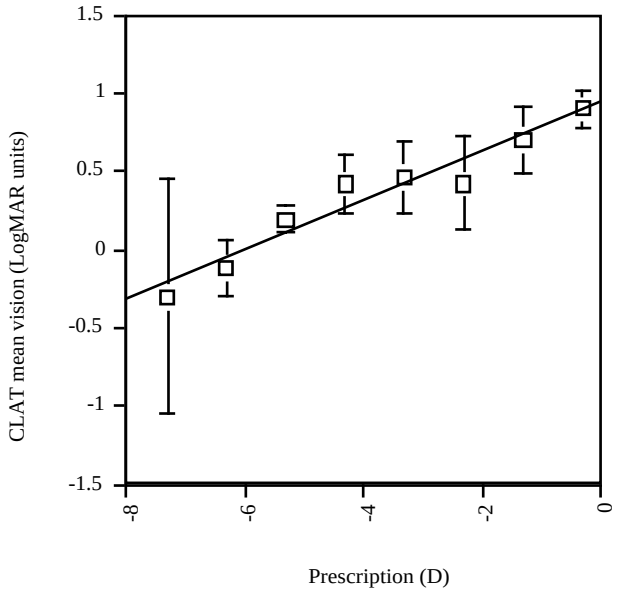

Figure 6.3.3 Mean scores for the CLAT chart for refractive error groupings (see table 6.3.1). The equation of the straight line is y=0.143x + 0.933, R=0.968, p=0.0001.

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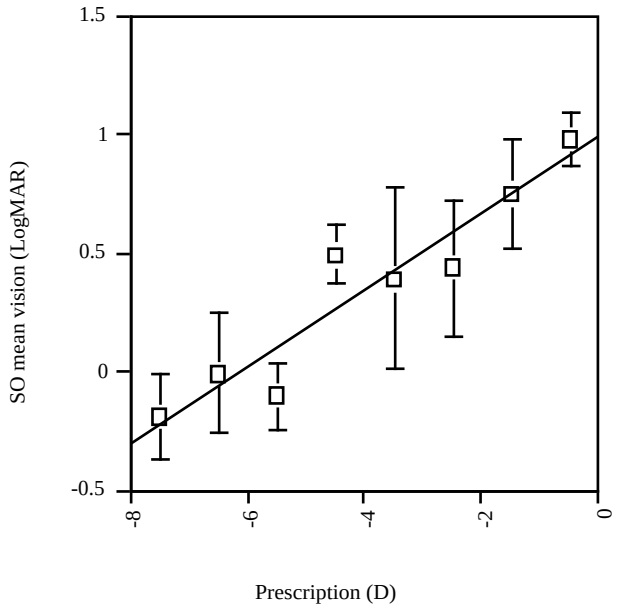

Figure 6.3.4 Mean scores for the SO chart for refractive error groupings (see table 6.3.1). The equation of the straight line is y=0.16x + 0.98, R=0.984, p=0.0001.

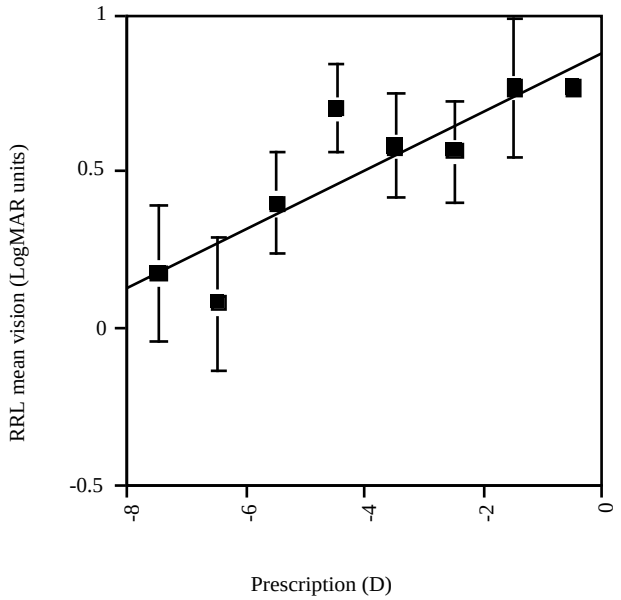

Figure 6.3.5 Mean scores for the RRL chart for refractive error groupings (see table 6.3.1). The equation of the straight line is y=0.094x + 0.88, R=0.878, p=0.004.

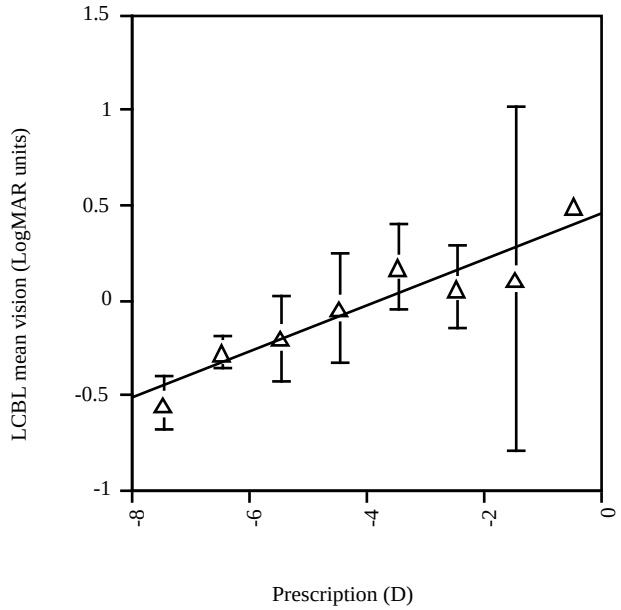

Figure 6.3.6 Mean scores for the LCBL chart for refractive error groupings (see table 6.3.1). The equation of the straight line is y=0.122x + 0.46, R=0.941, p=0.0005.

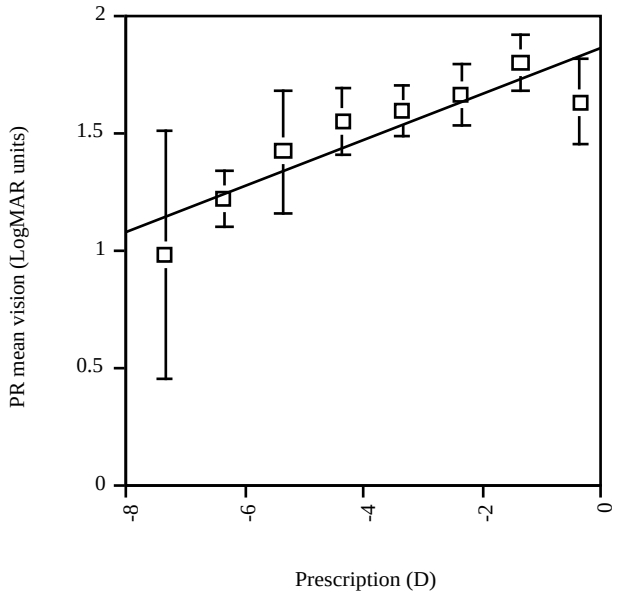

Figure 6.3.7 Mean scores for the PR chart for refractive error groupings (see table 6.3.1). The equation of the straight line is y=0.10x + 1.87, R=0.898, p=0.0025.

6.3.2 Discussion

The linear correlations on figures 6.3.2 to 6.3.7 can be used to calculate how much of a change in chart performance would be expected for a 1D change in refractive error. These can be seen on table 6.3.2. There are, however, standard deviations associated with these values which will mean that although a good guide, an individual's score will not be accurately predictable from the refractive error.

If the linear extrapolations of these graphs are used to predict the score for a refractive error of 0, that is emmetropic vision, the results shown on table 6.3.2 are found. These are not accurate since emmetropic scores on the high contrast charts would be expected to be at least 1.0 and the low contrast score 0.8. The BL and RRL scores seem particularly low when analysed in this way suggesting that something more than straightforward blur is limiting myopic vision for these charts.

6.4 Comparing Binocular with Monocular Scores

6.4.1 Binocular and Monocular Scores

For all charts and for the corrected and uncorrected conditions the means of the best monocular and binocular scores were compared. For each subject the best monocular score was subtracted from the binocular score. The mean across all subjects was then found.

chart	*binoc score mean±stdev*	*best monoc score mean±stdev*	*binoc-monoc mean±stdev*
Vis SO	0.63±0.36	0.56±0.36	0.07±0.14
Vis CLAT	0.59±0.33	0.54±0.31	0.05±0.11
Vis RRL	0.68±0.3	0.62±0.28	0.06±0.1
Vis BL	0.48±0.33	0.41±0.32	0.07±0.18
Vis LCBL	0.12±0.62	0.10±0.57	0.02±0.17
Vis PR	1.81±0.21	1.66±0.24	0.15±0.08

Table 6.4.1 Comparison of binocular and monocular unaided vision scores.

chart	*binoc score mean±stdev*	*best monoc score mean±stdev*	*binoc-monoc mean±stdev*
VA SO	1.29±0.08	1.26±0.10	0.02±0.05
VA CLAT	1.22±0.08	1.21±0.07	0.01±0.05
VA RRL	1.24±0.09	1.22±0.10	0.03±0.04
VA BL	1.18±0.14	1.15±0.16	0.03±0.06
VA LCBL	1.04±0.15	0.95±0.25	0.04±0.09
VA PR	2.02±0.11	1.9±0.11	0.13±0.11

Table 6.4.2 Comparison of binocular and monocular corrected acuity scores.

The binocular scores show relatively more improvement for the uncorrected condition with the exception of the low contrast Bailey-Lovie chart. This result is not significant (ANOVA, p=6). The biggest difference was for the single optotype and Bailey-Lovie uncorrected, the difference being 0.07. See section 9.1.2 for a discussion of these results.

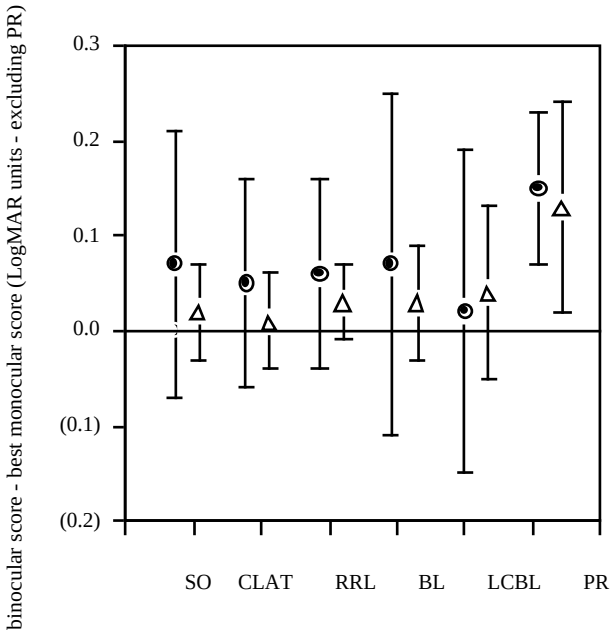

Figure 6.4.1 Mean over all subjects of binocular score minus the best monocular score for each chart. The filled circles represent unaided vision and the open triangles corrected acuity.

6.4.2 Discussion

These results show there to be a trend for binocular viewing to be a greater advantage in the uncorrected situation. This result is not significant, but this is possibly due to the large standard deviations in the uncorrected situation. Two possible explanations for a possible difference are: 1) in the corrected situation monocular acuity is already at threshold and so binocular viewing can not greatly increase the score, 2) in the uncorrected situation binocular viewing allows a greater freedom of neural interpretation and coordination of eye movements which can increase the score. This would also account for the larger standard deviation in the uncorrected case.

6.5 Pre and Post Therapy Chart Scores

chart	*Group A (n=6)* *mean±stdev*	*Group B (n=5)* *mean±stdev*	*Group C (n=6)* *mean±stdev*
HCBL R	0.07±0.13	0.04±0.26	0.06±0.16
HCBL L	0.02±0.09	-0.08±0.15	-0.04±0.14
CLAT R	0.10±0.17	0.02±0.17	0.02±0.22
CLAT L	0.07±0.15	-0.05±0.17	0.06±0.18
SO R	0.1±0.1	0.12±0.16	0.01±0.22

SO L	-0.04±0.06	0.05±0.14	0.09±0.13
RRL R	0.03±0.36	0.04±0.19	0.16±0.40
RRL L	0.09±0.11	0.13±0.18	0.17±0.33
LCBL R	0.05±0.13	-0.03±0.13	-0.06±0.08
LCBL L	-0.08±0.27	-0.12±0.24	-0.02±0.15
PR R	0.09±0.20	-0.07±0.30	0.04±0.15
PR L	0.13±0.15	-0.09±0.15	0.01±0.17

Table 6.5.1 Mean difference between monocular chart scores at t1 and t2.

For each chart there is no significant difference between the groups A, B and C at t1 and t2. (E.g a t-test on goup A for the before and after result on the BL chart gave p=0.8.) This indicates that the therapy groups did not score significantly higher than the control group on any of the charts after the therapy period.

The results for each chart are plotted in figures 6.5.1-6 showing the difference against the mean. These graphs show no obvious trends.

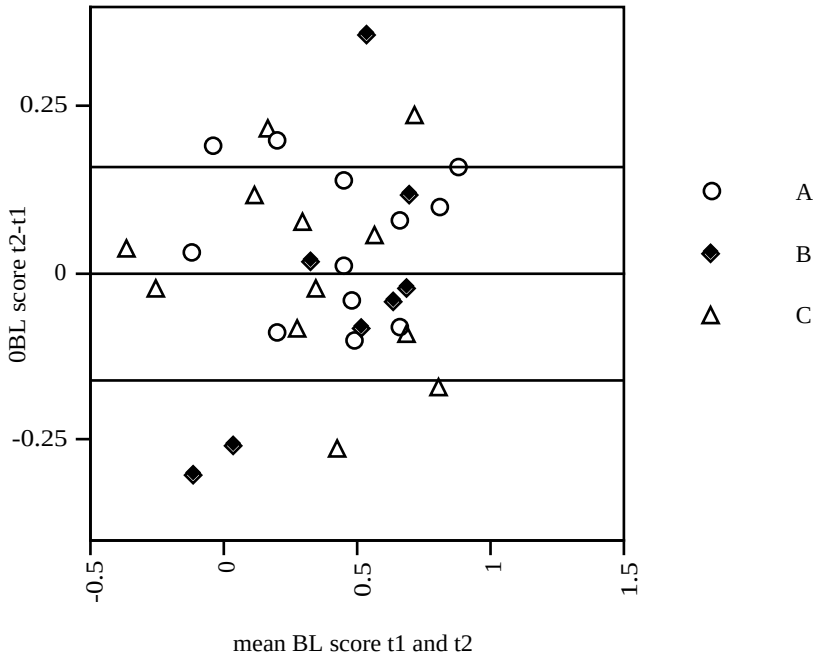

Figure 6.5.1 Difference of scores for BL chart at t1 and t2 plotted against the mean of the same for all groups.

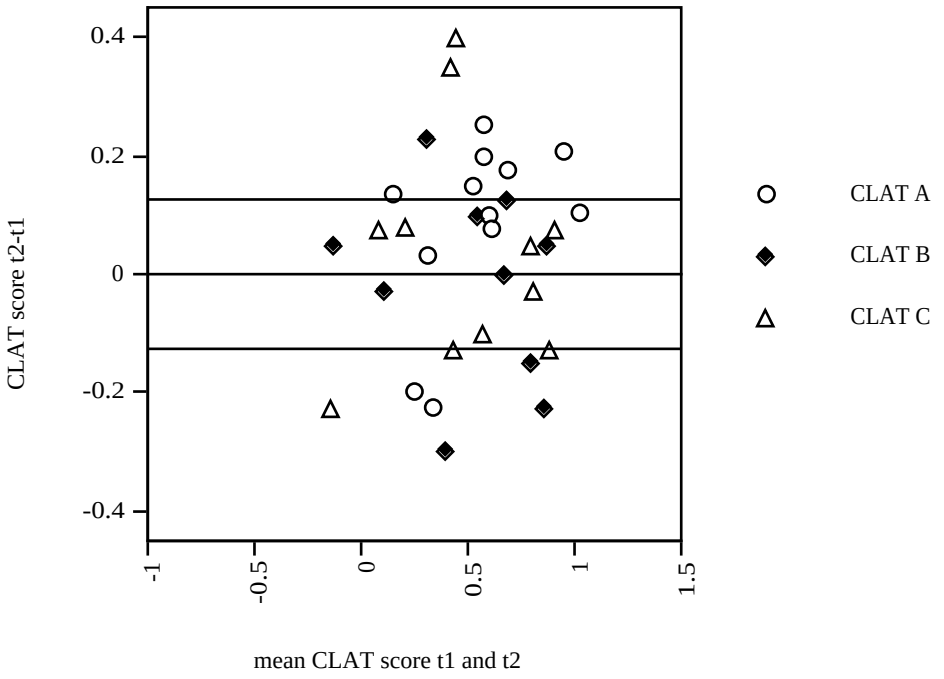

Figure 6.5.2 Difference of scores for CLAT chart at t1 and t2 plotted against the mean of the same for all groups.

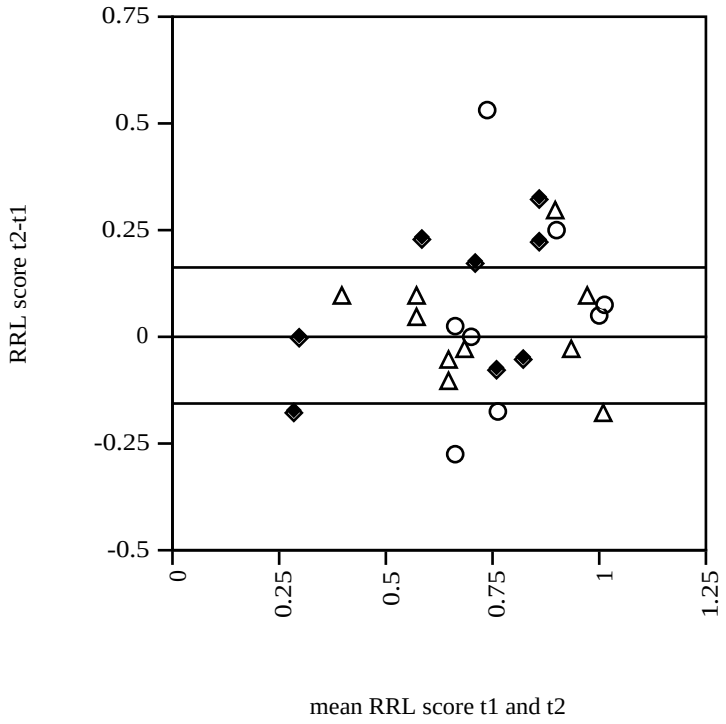

Figure 6.5.3 Difference of scores for RRL chart at t1 and t2 plotted against the mean of the same for all groups.

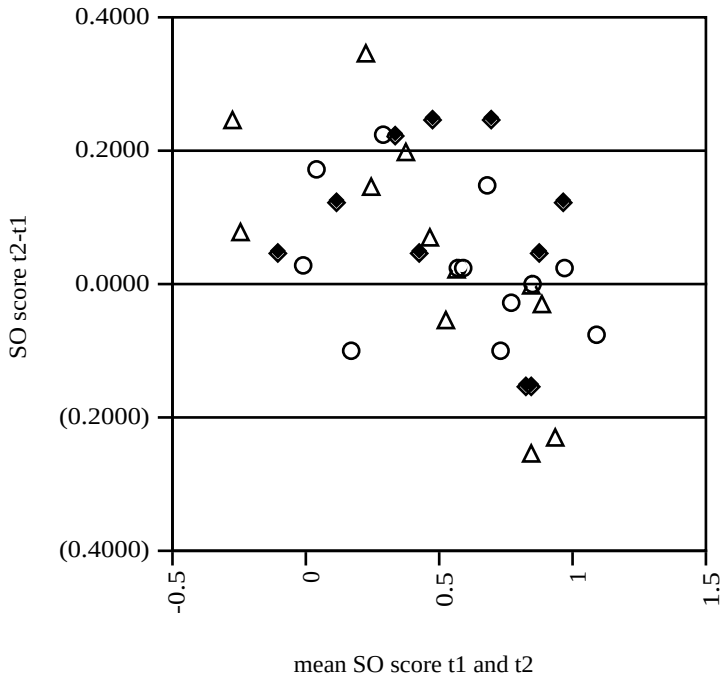

Figure 6.5.4 Difference of scores for SO chart at t1 and t2 plotted against the mean of the same for all groups.

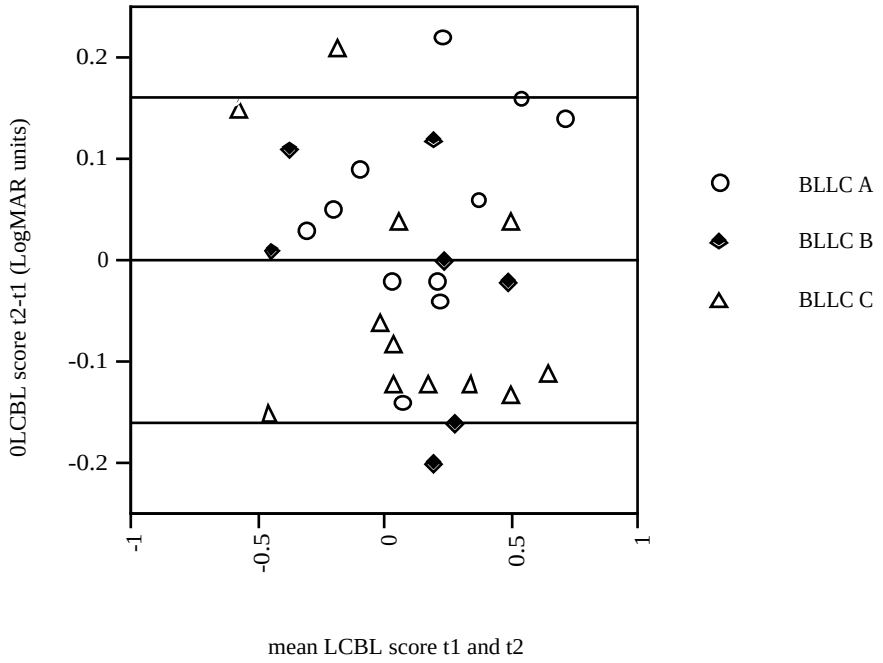

Figure 6.5.5 Difference of scores for LCBL chart at t1 and t2 plotted against the mean of the same for all groups.

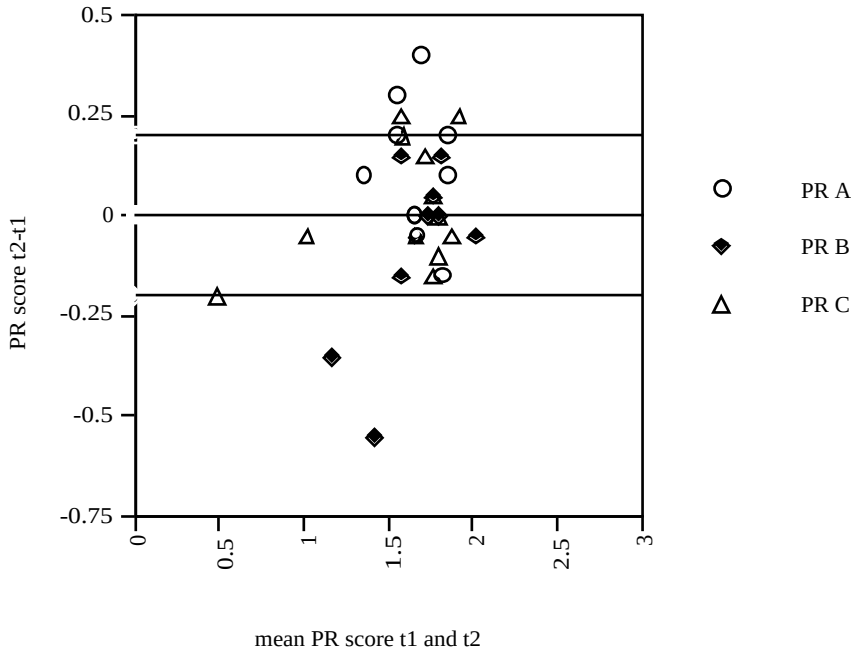

Figure 6.5.6 Difference of scores for PR chart at t1 and t2 plotted against the mean of the same for all groups.

6.5.2 Binocular Results

	Group A(n=6) mean±stdev t2-t1	*Group B (n=5)*	*Group C (n=6)*
HCBL B	-0.01±0.07	0.04±0.10	0.03±0.14
CLAT B	0.16±0.14	0.05±0.07	0.01±0.22
SO B	0.05±0.18	0.11±0.12	0.01±0.11
RRL B	0.02±0.17	0.05±0.05	0.07±0.16
LCBL B	0.02±0.11	-0.04±0.11	0.09±0.15
PR B	0.04±0.11	-0.03±0.22	0.07±0.10

Table 6.5.2 Mean difference between binocular chart scores at t1 and t2.

With the exception of HCBL (Group A) there was an improvement in the binocular score of all groups on all high contrast charts.

There was no change or a decrease in score for all the groups on the low contrast charts except for the PR for group A and the LCBL for group C.

These results are plotted on figure 6.5.7-12.

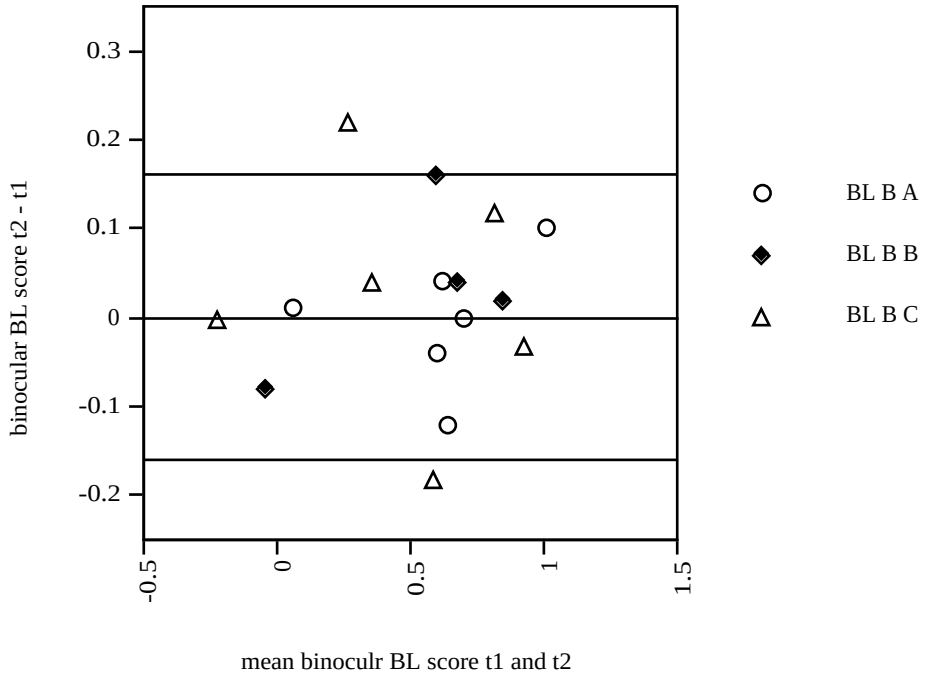

Figure 6.5.7 Difference of binocular scores for BL chart at t1 and t2 plotted against the mean of the same for all groups.

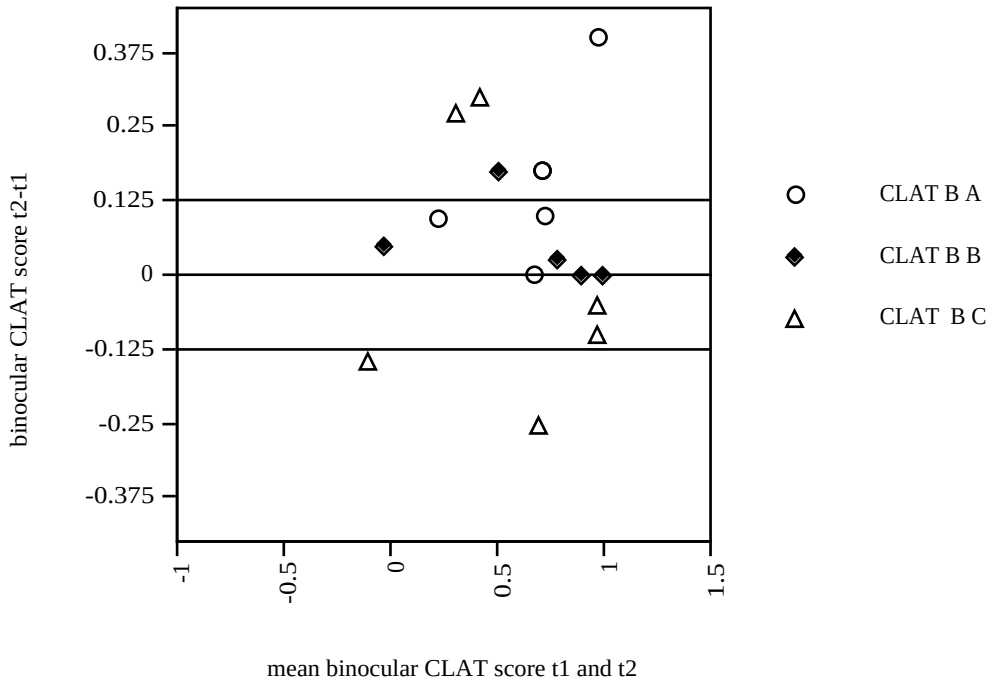

Figure 6.5.8 Difference of binocular scores for CLAT chart at t1 and t2 plotted against the mean of the same for all groups.

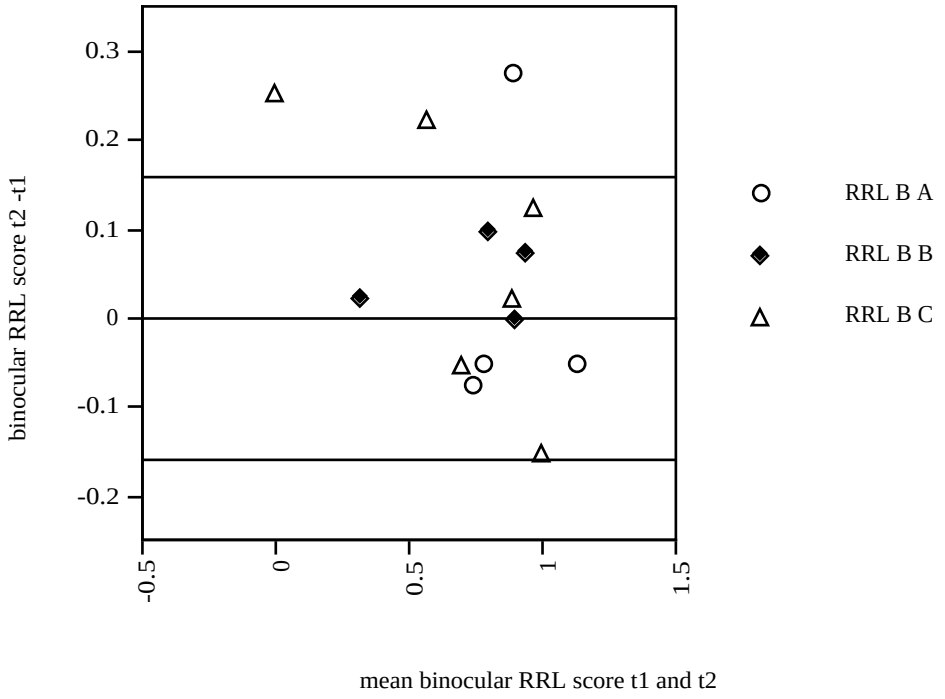

Figure 6.5.9 Difference of binocular scores for RRL chart at t1 and t2 plotted against the mean of the same for all groups.

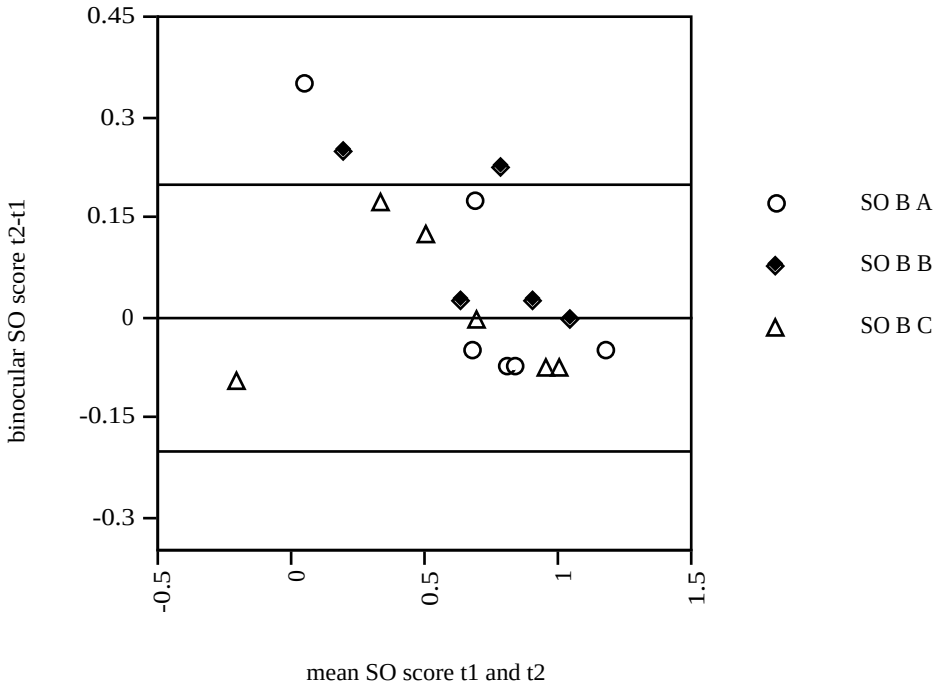

Figure 6.5.10 Difference of binocular scores for SO chart at t1 and t2 plotted against the mean of the same for all groups.

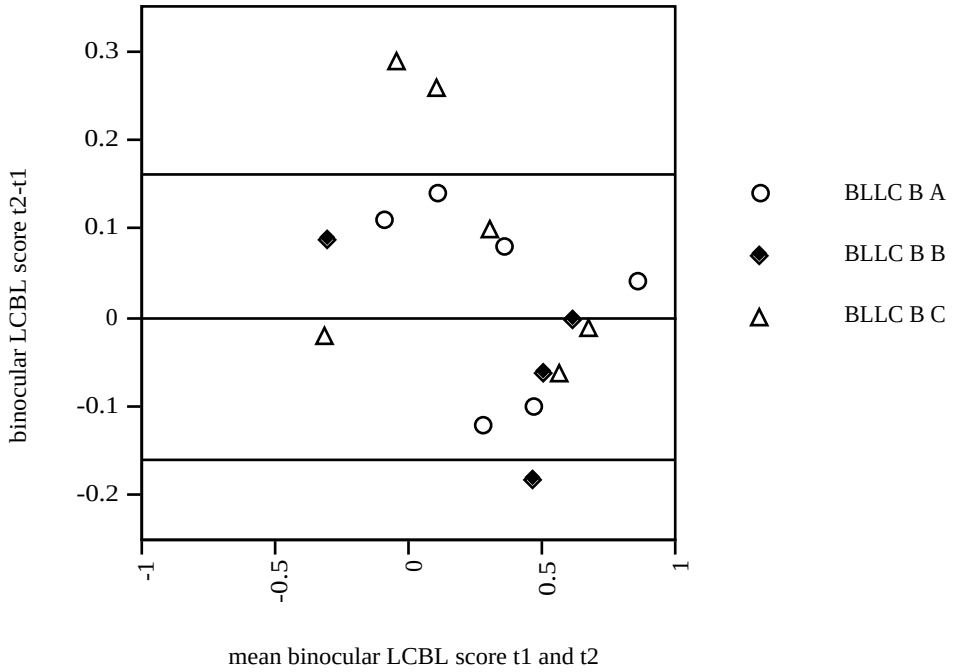

Figure 6.5.11 Difference of binocular scores for LCBL chart at t1 and t2 plotted against the mean of the same for all groups.

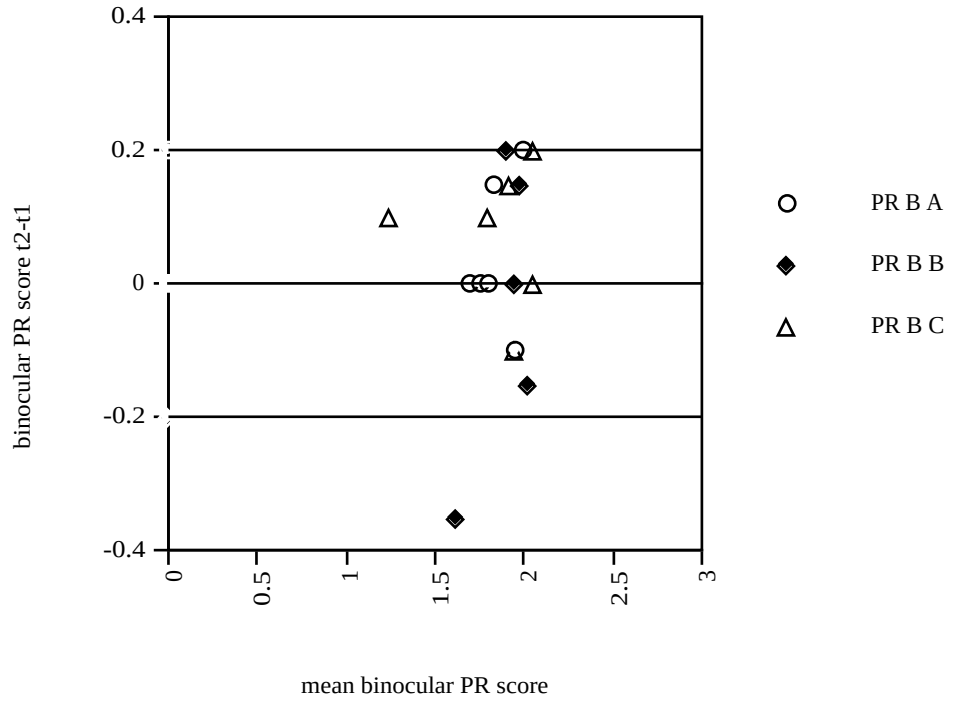

Figure 6.5.12 Difference of binocular scores for PR chart at t1 and t2 plotted against the mean of the same for all groups.

6.5.3 Discussion

On each graph there are points which lie outside the limits for a significant change both for increases and decreases in vision. Possible explanations for this are that one of the measurements for the point in question did not reach threshold creating a greater difference in results than would have been obtained if both measurements were at threshold. Other anomalies such as tearing and squinting which may always be present despite experimental vigilance could also account for these differences.

In both the monocular and binocular cases there appears to be a trend for improvement in score for lower vision (see figures 6.5.4 and 6.5.10). This trend suggests a learning effect for the single optotype chart.

The graphs of change in charts score between the two testing times show no clear trends in the data. Also there were no significant changes in any of the groups for any of the chart measures taken. These results suggest that either vision therapy produces no effect on vision as measured by the charts used or the changes were too small and variable to show on the size of data sample presented.

Chapter 7
Physical Data

7.1 Baseline Data

7.1.1 *Initial Data*

The baseline physical data collected from all participants is shown in table 7.1.1.

	mean ± sd	*range*
non-cycloplegic autorefraction R (D)	-3.38 ± 2.06	-0.9 to -6.725
non-cycloplegic autorefraction L (D)	-3.49 ± 2.22	-1.075 to -6.8
cycloplegic autorefraction R (D)	-3.63 ± 2.33	-0.3 to -7.65
cycloplegic autorefraction L (D)	-3.89 ± 2.45	-0.525 to -7.45
radius of corneal curvature R (mm)	7.82 ± 0.24	7.41 to 8.28
radius of corneal curvature L (mm)	7.79 ± 0.24	7.42 to 8.22
axial length R (mm)	24.80 ± 0.88	23.48 to 26.09
axial length L (mm)	24.69 ± 0.97	22.91 to 26.48

Table 7.1.1 Baseline optometric data.

7.1.2.Cycloplegic versus Non-cycloplegic Autorefractions

The difference between the cycloplegic autorefraction and the non-cycloplegic autorefraction is plotted in figure 7.1.2. The difference between the two values is not significant (ANOVA p=0.62) although 3 values fall outside of ±2sd of the mean. Since there was no difference between the two results only the non-cycloplegic autorefraction was repeated for post-therapy data collection.

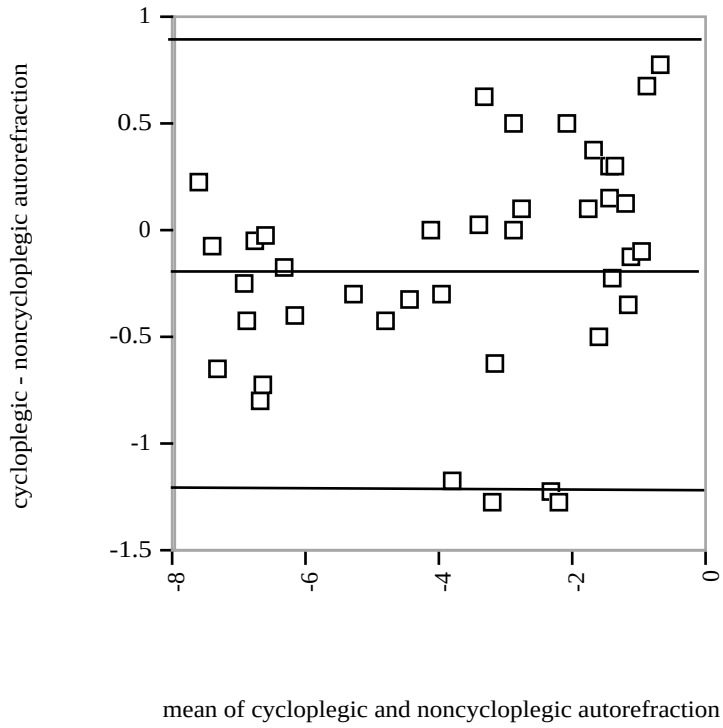

Figure 7.1.2 The difference between the cycloplegic and the non-cycloplegic autorefractor readings (mean sphere) plotted against the mean of the same for each subject. The solid lines represent the mean difference for all subjects and ±2stdev of the differences.

7.1.3 Corneal Curvature and Axial Length

The Gullstrand-Emsley schematic eye values (calculated from average population values) are 7.8mm for corneal curvature, 23.89mm for axial length and a refractive state of 0 (Bennett and Rabbetts, 1989). The mean corneal curvature found here (7.8mm) is therefore the same as those found previously for a normal population. The mean refractive error is different being more minus than the emmetropic value of zero. This result shows the myopic nature of the population chosen. The mean axial lengths found (RE = 24.80mm and LE = 24.69mm) are longer than that proposed for the schematic eye and this suggests that the myopia is due to the longer axial lengths.

7.1.4 Axial Length versus Prescription

The axial length versus the autorefractor readings are given in figure 7.1.4. This graph shows a relationship for which longer axial lengths are associated with larger negative refractive errors. The linear regression line shows that a change in axial length of 0.5mm will give a 1D change in the state of refraction. This gives a slightly lower

prediction of the refractive change induced by a change in axial length than the calculated value of 1.4D for a 0.5mm change (Bennett & Rabbetts, 1989). Extrapolating the results predicts an axial length of 22.6mm for a refractive state of 0 (compared with 23.89mm for the schematic eye.) These results agree with those found previously in that there is a linear correlation between axial length and the refractive status (Carroll, 1982), the gradient of the slope of this correlation, however, was found to be -2.7mm/D as compared with -1.87mm/D here. This difference could be because of the restricted range of refractive errors presented here, (Carroll's data ranged from -15D to +10D).

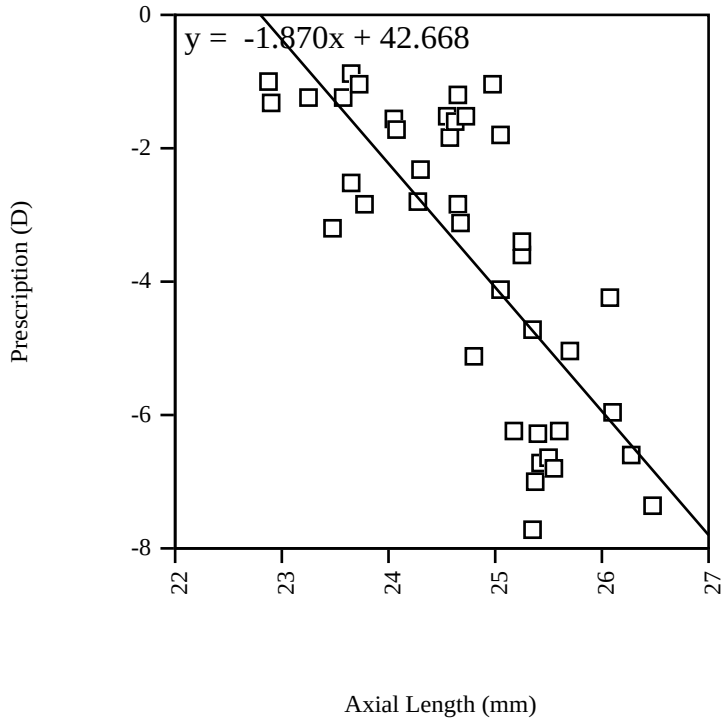

Figure 7.1.4 Prescription (mean sphere of noncycloplegic autorefraction for right and left eyes) plotted against axial length. R=0.767, p=0.0001.

7.1.5 Prescription versus Corneal Curvature

The mean sphere refractive error is plotted against corneal curvature in figure 7.1.5 and shows no obvious relationship. This suggests that the prescription is not determined by corneal curvature. When comparing myopes with emmetropes Grosvenor and Scott (1991) found significantly greater corneal power in the myopes. This suggests that although the results here show no relationship this is perhaps because the differences

are small and the spread of refractive errors of the subjects was not great enough to show any differences.

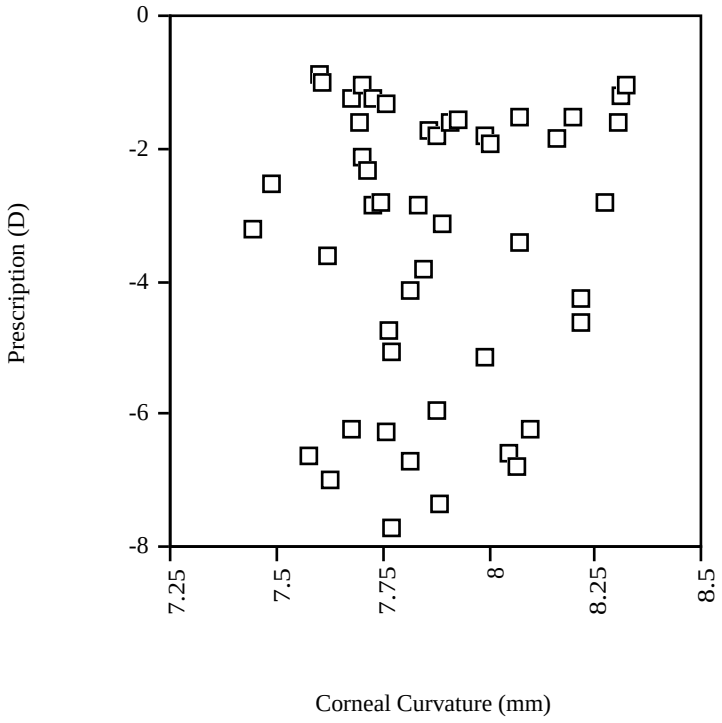

Figure 7.1.5 Prescription (mean sphere of noncycloplegic autorefraction for right and left eyes) plotted against the autokeratometry reading of corneal curvature. No relationship is observed.

7.1.6 Axial Length versus Corneal Radius Ratio

It has been reported that axial length/corneal radius ratio is highly correlated with refractive error with a value of 2.79 for emmetropia, 3.09 for early adult onset myopia and 3.21 for youth onset myopia (with the standard deviations not stated) being found (Grosvenor & Scott, 1991). The ratio for the data under discussion was calculated and the mean found to be 3.18 ± 0.11. This concurs with Grosvenor and Scott's findings and suggests that the subject group is a mixture of early adult and youth onset myopes weighted with more youth onset myopes.

7.1.7 Discussion

The physical data shows that there was no significant difference between the cycloplegic and non-cycloplegic refractions (see section 7.1.2). The mean corneal curvatures measured is the same as that which has been previously measured for a normal emmetropic population (see section 7.1.3). The mean axial length found was larger than that found for a normal emmetropic population suggesting that the myopia corresponds to the larger axial length (see section 7.1.3). A linear relationship between

prescription and axial length was found for which a change in axial length of 0.5mm would give a 1D change in the state of refraction. No relationship between refractive error and corneal curvature was observed and the axial length/corneal radius ratio that was found agreed with previously found values (see section 7.1.6).

7.2 Pre and Post Therapy Optometric Data

Between 9 and 12 months after the initial data collection repeat measures were taken of the non-cycloplegic autorefraction and the autokeratometry reading. Repeat cycloplegic autorefraction measures were not taken since there was no significant difference between the initial cycloplegic and non-cycloplegic measures (see section 7.1.2). Any changes that would show up under cycloplegic autorefraction would, therefore, not be revealed. The initial data (t1) and the repeat data (t2) are compared for all three groups. The difference between the readings (t2-t1) is also shown. Where a subject withdrew the equivalent data entry in the initial group has been dropped for the purposes of comparison. The mean results and standard deviations from the autorefractor and the keratometer for each group are given in table 7.2.

	mean±stdev t2-t1 Group A(n=5)	*mean±stdev t2-t1 Group B(n=5)*	*mean±stdev t2-t1 Group C(n=6)*
autorefractor R	0.06±0.18	-0.09±0.23	0.16±0.21
autorefractor L	-0.02±0.21	-0.18±0.15	0.03±0.30
keratometry R	0±0.01	0.03±0.04	0.01±0.02
keratometry L	-0.01±0.03	-0.01±0.01	0.02±0.02

Table 7.2 Mean difference of values of optometric measures at t1 and t2 for all groups.

From the table it can be seen that the results for the corneal curvature were very stable with almost no change in the readings at t1 and t2 for any of the groups. The results of the autorefractor readings are not stable although none of the group means changed by more than 0.18D. These results show no significant changes in the group means of these parameters and are plotted in figures 7.2.1 and 7.2.2.

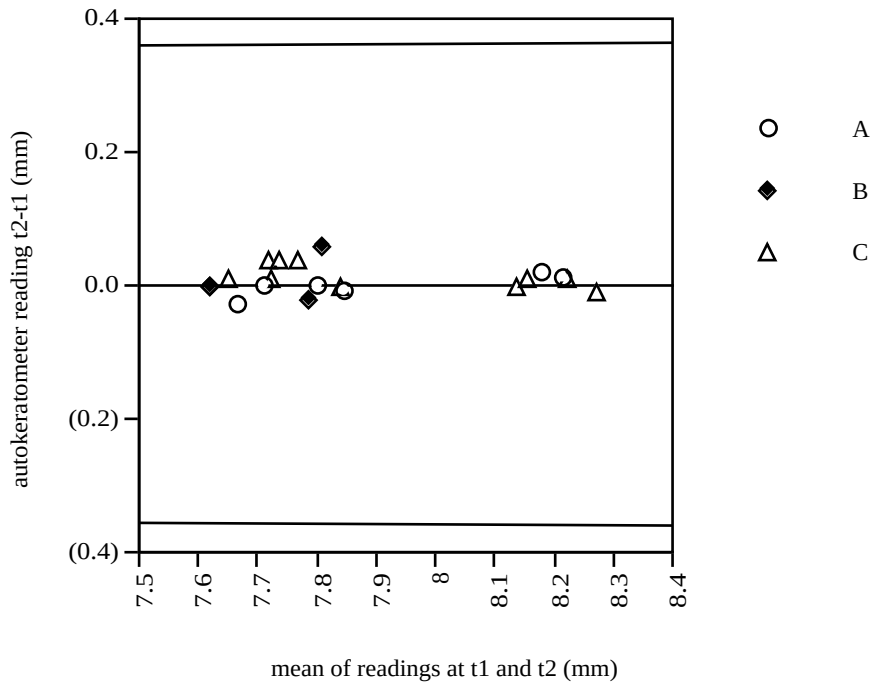

Figure 7.2.1 The final keratometry reading minus the initial reading for subjects in each group against their mean. The solid line shows zero change and the dashed lines show the confidence limit for change.

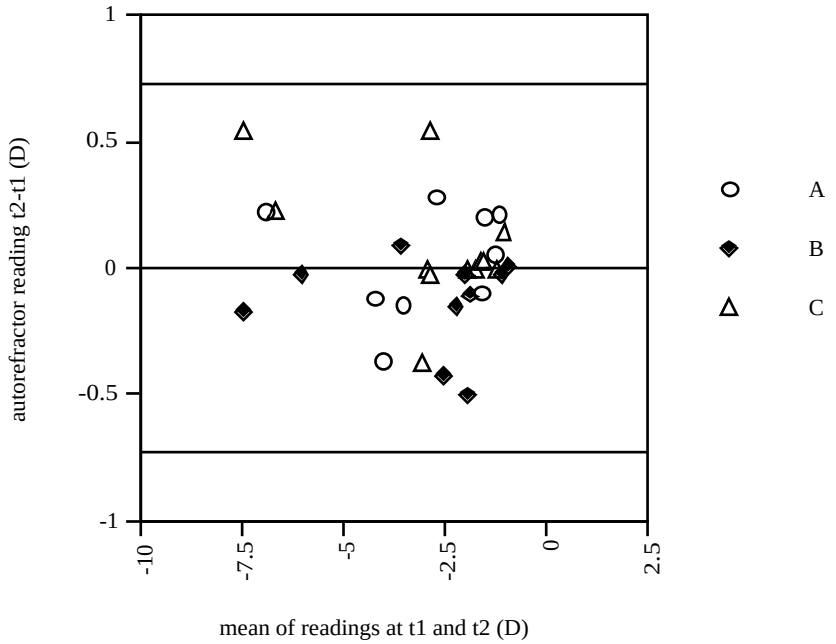

Figure 7.2.2 The final (non-cycloplegic) autorefractor reading minus the initial reading for subjects in each group against their mean. The solid line shows zero change and the dashed lines show the confidence limit for change of ±0.73D.

7.2.2 Axial Length

10 repeat axial length measures were taken, 8 from group C and 2 from group A. The mean of the results from group C were for the right eyes (n=4) 24.81±0.43mm at t1 and 24.68±0.51mm at t2. The left eyes (n=4) gave 24.59±0.50 at t1 and 24.95±0.53 at t2. For the subject in group A who had the axial length measurement repeated the results were as follows; right eye, t1, 23.58±0.07 and t2, 23.22±0.16, left eye, t1, 23.26±0.24, t2, 22.92±0.10.

7.2.3 Discussion

The results show no significant change in the parameters of corneal curvature or refractive status. Any change in prescription that would bring about changes in acuity as claimed by vision therapy would be small long term changes with possible large short-term fluctuations. The data collected for this study is all within the autorefractor's limits for a certainty of change and therefore it is concluded that no changes were observed in the state of refraction.

The axial length for the one subject in therapy group A that was collected reduced by 0.36±0.23mm in the right eye and 0.34±0.34 in the left. These changes would correspond to about 0.7D or about 4 letters (one short of one line) on the Bailey-Lovie chart. This compares with a decrease of 0.13mm and an increase of 0.36mm in the means for the group C axial length data.The confidence limit for change for the axial length measurements is ±0.35mm (see table 5.1.4) and so the changes observed are well under or borderline with this amount. The data numbers are too small, however, to make any conclusions as to the changes in axial length.

Chapter 8
Experiential Data

8.1 Experiential Data

8.1.1 Interview Texts

There are claims made about vision therapy (in particular the effects of the practises of shifting, palming and peripheral vision stimulation) which have not been monitored in this study. In order to try and gain some information about these techniques and their effects the participants who had sessions with the vision therapist (group A) were interviewed about their experiences. These interviews were used to see if there were any signs of things that are not measured by the optometric techniques used (e.g. fluctuating vision, expanded peripheral awareness, greater visual comfort) and to examine possible routes for further study.

Among the observations that were made in the interview texts the participants commented on noticing differences in their vision during the vision therapy sessions. This, however, was not experienced by everybody who took part. There follows some quotations from the interview texts to illustrate instances in which improvements were experienced after palming, peripheral vision stimulation and eye movement work.

No. 1: I started palming again and I do generally notice that it does help.....The main thing I find is my vision. I find it just sharper again.

No.7: I was doing the stuff with the peripheral vision which I'd never noticed before either.
A. What did you notice with your peripheral vision?
No. 7: I noticed that...I became more aware of it, that things were starting to become clearer, which I'd never, never seen before...But, yeah, it was really weird how the chart did become so much clearer...it wasn't like all of a sudden the letters all became clear, it was very much they came into focus and out of focus a lot more, whereas before it was all just out of focus.

No. 11: I could actually see things in the room which I couldn't see before...when the chart was stuck up at first I was like "oh no, I can't get it" but then later on it's like, well, I mean it was still blurred but I can make it out as opposed to not being able to make it out.

A: What activities make a difference?

No. 11: Following coloured balls, (see section 3.2.1) *that was the kind of thing that made me do it.*

Insert Table 8.1.1 here

See appendix 3 for the full interview texts. In addition to this one participant in group B who was particularly aware of her stereoscopic vision because of her work researching this area commented on noticing that without her glasses her vision was more three dimensional in nature and that with her glasses things appeared more flat. These instances of the experience of changing vision are presented as observations not immediately accessible to the research methods used in this work. No conclusions as to the efficacy or mechanisms of the techniques are drawn from these observations but they are presented because the experiences concur with the observations and claims made in chapter 3 and may be useful in determining future research (see chapter 9).

Table 8.1.1 was constructed by picking out themes from the interview texts (appendix II). 5 out of the 6 participants said that they experienced some sort of vision improvement, 4 people palmed regularly, 3 wore their reduced prescription regularly, 2 partially and one wore no prescription most of the time. 4 of the 6 said that they experienced improvements from some sort of vision exercises and 4 of the 6 also said that they would recommend vision therapy to other people.

Looking across the table there is a similarity in quality and tone of the responses to the different questions. For example no. 22 replies in the negative to most of the points whereas no. 1 is positive about each theme. Generalising this tendency means that those who experienced an improvement through palming and did home palming practise were generally positive about the experience. It is also of note that no. 22 who was the only participant to definitely experience no visual changes said that people close to him were dismissive of vision therapy techniques.

8.1.2 Vision Therapist's Reports

After the final therapy sessions the vision therapist was asked to give a brief synopsis of each participant.These are shown below with the initial and final chart scores for each participant on the Crowded Logmar Acuity Test, and the high and low contrast Bailey-Lovie charts.

Participant No. 1

No. 1 is minimally shortsighted. She is tight, controlled and intense. Glasses probably first prescribed because of exam stress. Work addressed her need to relax and let things be. She probably studies too hard with effort. "Soft focus" was encouraged. (Soft focus is the term used when equal attention is paid to every area of the visual field as compared with concentrated localised attention on a detail).

She was more or less without her glasses from the first time. She was frustrated by it but determined. She became used to it and it felt okay to go without her glasses. She palmed every day for extended periods. She has good days and bad days and is now noticing the fluctuations in her vision. She can not tolerate the reduced perscription although she was reading better with this at the last session.

With solid work could be out of her glasses with good vision. I would work more with right and left integration and do right handed work for balancing.

Chart	*Score t1*	*score t2*	*t2-t1*
CLR	0.845	1.05	0.205
CLL	0.97	1.075	0.105
CLB	0.775	1	0.225
BLR	0.76	0.8	0.04
BLL	0.8	0.92	0.12
BLB	0.96	1.0	0.04
LCR	0.46	0.62	0.16
LCL	0.64	0.74	0.1
LCB	0.84	0.88	0.04

Table 8.3.2a Vision scores on CLAT, BL and LCBL for each eye and binocular viewing for subject number 1.

Participant No. 2

The sessions were difficult and flat. He was probably bored at school and frustrated with his work. He was uptight and tense and described himself as easy going but I would dispute that. He reported that he had high blood pressure. He stayed tight and I don't think that he did any work at home.

Initially he said his glasses were too strong and he wasn't happy with them. He settled well into the reduced prescription but he probably appreciated the support more than anything else. He is trapped in a difficult position and not motivated to change his vision.

He got enormous benefit from palming and could get fluctuations from 6/30(0.3) to 6/15(0.6) during the sessions.

His vision could be better but it is unlikely that circumstances will allow for it.

Chart	*Score t1*	*score t2*	*t2-t1*
CLR	0.45	0.7	0.25
CLL	0.45	0.6	0.15
CLB	0.625	0.8	0.175
BLR	0.54	0.44	-0.1
BLL	0.5	0.46	-0.04
BLB	0.7	0.58	-0.12
LCR	0.24	0.2	-0.04
LCL	0.22	0.2	-0.02
LCB	0.34	0.22	-0.12

Table 8.3.2b Vision scores on CLAT, BL and LCBL for each eye and binocular viewing for subject number 2.

Participant No. 7

No. 7 didn't wear her glasses all the time anyway and didn't ever wear them for studying. She puts a huge effort into everything she does. There is quite a difference between right and left for her. Her binocular vision tests slightly worse than the left eye alone yet was preferable to her showing that the eyes worked together comfortably.

She palmed from the beginning and went around without her glasses. She didn't mind the blur. She probably had a lot better vision than was tested. She did well with her reduced prescription but we had to change it again to get stereoscopic vision back. The gap between the eyes narrowed giving greater balance.

She experienced big changes in vision during the sessions 6/21(0.5) to 6/9(0.8).

She has the potential for averagely good vision without glasses. Quite a lot more work is needed especially with right/left balance. She is still palming and it is now part of her routine.

Chart	*Score t1*	*score t2*	*t2-t1*
CLR	0.295	0.325	0.03
CLL	0.6	0.775	0.175
CLB	0.625	0.8	0.175
BLR	0.1	0.3	0.2
BLL	0.62	0.7	0.08
BLB	0.7	0.7	0
LCR	-0.15	-0.06	0.09
LCL	0.34	0.4	0.06
LCB	0.52	0.42	-0.1

Table 8.3.2c Vision scores on CLAT, BL and LCBL for each eye and binocular viewing for subject number 7.

Participant No.11

No. 11 got improvement from palming from the start. He talked about having low self-esteem and not being confident. He was strained about everything. He could go from 6/60(0) to 6/15(0.6) during a session. He adjusted well to the reduced prescription and would wait for the blur to clear. He wears it all the time.

We did lots of postural work and work with peripheral vision went well. I think he enjoyed the process and he made steady progress. He would arrive stressed from work and then palm and see better. Tension is a problem for him. Both eyes were similar and worked well together. His vision with the reduced prescription went from 6/12(0.7) to 6/6(1.0).

With more work he will get better vision. He did the work and was reliable.

Chart	*Score t1*	*score t2*	*t2-t1*
CLR	0.55	0.525	-0.025
CLL	0.575	0.6	-0.025
CLB	0.675	0.675	0
BLR	0.7	0.62	-0.08
BLL	0.46	0.46	0

BLB	0.62	0.58	-0.04
LCR	0.14	0	-0.14
LCL	0.04	-0.06	-1
LCB	0.04	0.12	0.08

Table 8.3.2d Vision scores on CLAT, BL and LCBL for each eye and binocular viewing for subject number 11.

Participant No. 22

No. 22 had very unbalanced vision with a big difference between the eyes. He was uptight and precise and not aware of eyestrain. Now he may be more aware of it.

He never did any work outside the sessions and didn't palm. He had a low frustration tolerance and wouldn't be without his glasses.

If he was interested in doing more work I would work with the left eye, but I don't think that he is motivated.

Chart	*Score t1*	*score t2*	*t2-t1*
CLR	0.475	0.675	0.2
CLL	0.45	0.225	-0.225
CLB	0.675	0.775	0.1
BLR	0.38	0.52	0.14
BLL	0.25	0.16	-0.09
BLB	0.6	0.64	0.04
LCR	0.12	0.34	0.22
LCL	0.495	-0.1	-0.595
LCB	0.32	0.4	0.08

Table 8.3.2e Vision scores on CLAT, BL and LCBL for each eye and binocular viewing for subject number 22.

Participant No. 24

No. 24 is highly myopic and he likes his glasses. He likes seeing easily, has no reason to change and is happy to stay in his prescription. Very low motivation. He probably would have lasted no more than 2 sessions privately.

Chart	*Score t1*	*score t2*	*t2-t1*
CLR	0.35	0.3	-0.05
CLL	0.075	0.01	0.025
CLB	0.18	0.175	-0.005
BLR	-0.13	0.06	0.19
BLL	-0.13	-0.1	0.03
BLB	0.05	0.06	0.01
LCR	-0.33	-0.3	0.03
LCL	-0.23	-0.18	0.05
LCB	-0.15	-0.04	0.11

Table 8.3.2f Vision scores on CLAT, BL and LCBL for each eye and binocular viewing for subject number 24.

The comments illustrate the holistic approach to vision work and also highlight the fact that although they are grouped together for the purposes of numerical analysis the participants who attended the vision therapy sessions each had a different experience of the work.The chart scores show how the individuals scored in an optometric testing situation before (t1) and after (t2) vision therapy.

8.1.3 Questionnaires

16 pre-therapy (t1) questionnaires were returned (6 from group A, 4 from group B and 6 from group C). After 1-6 months (t2) the same questionnaire was sent to the participants and 13 returned (5 from group A, 3 from group B and 5 from group C). 20 questionnaires were used for analysis, those from groups A and C at t2 and the corresponding questionnaires at t1.

Group A were significantly less comfortable with their vision after they started working with their vision (question 1, t-test p= 0.0004). There were no significant differences to the answers to the other questions. The following shows the question number followed by the p-value for the other questions (see section 5.7.5 for the questions). 1(.0004) 2(.914) 3(.0569) 4(.0477) 5(.91) 6(.159) 7(.47) 8(.9).

8.2 Discussion

Those participating reported changes in their vision - short term fluctuations which could be quite large. This suggests a flexibility in the visual system which could be due to
1) more efficient processing of blurred images
2) change in the state of refraction produced by a relaxation of accommodation by the ciliary muscle or changes in axial length
Whatever the local mechanisms these changes have only been observed when vision work is approached holistically.

Questionnaire data show that those taking part in the vision therapy sessions found their vision less comfortable. If a situation of reduced vision is indicative of strain it may well be the case that the person will be unaware of that strain. Any attempt to change this situation of strain will only be possible if he or she first of all becomes aware of it. This in itself can be an uncomfortable process and could account for this finding.

The vision therapist's reports illustrate the holistic nature of the work. The comments involve a discussion of how much work each person put in but also their own personal circumstances which may have prevented them dedicating a lot of time to the work. It also shows the emphasis placed on balancing the right and left sides of the body.

The approach that was taken with each participant was different and addressed their own particular needs, strengths and weaknesses.

There is a lack of consistency between the vision therapist's reports and the chart testing scores i.e. those that improved in the sessions did not neccessarily score well in controlled conditions. Also, however, of note is No. 22 who did score higher on the charts after the therapy period but did not report any improvement during the sessions.

The experience of vision therapy and the vision therapist's reports suggest a variability in vision that is faster (over seconds, minutes or hours) that can be recorded using conventional chart testing techniques, or which can not be produced on demand. It also suggests a great range in this variability (up to 3-6 lines of a test chart).

Chapter 9
Discussion and Conclusions

9.1 Vision and Visual Acuity Data

9.1.1 Differences Between the Charts

How a vision chart is designed alters the angular size of the smallest recognisable letter. This indicates that the results of a vision test in cases of ametropia is dependent on more than the degree of refractive blur.

The contrast of a chart is a major factor in chart scores obtainable and it was found that scores for the low contrast chart were lower than for the high contrast charts. This difference was found to be significantly greater for uncorrected vision than for corrected visual acuity. Exploring this difference further the slopes of the fall in chart score with refractive error can be considered (see figures 6.3.2 and 6.3.6). These graphs show that the rate of decline in chart score with refractive error is the same for both high and low contrast Bailey-Lovie charts. This result suggests that there is not a relative difference between the chart scores for different degrees of myopic blur when there is a difference between the corrected and uncorrected situation. Extrapolating these graphs predicts a difference between the two charts of 0.27 for a refractive state of 0. The mean observed difference for the corrected scores was 0.19 (see table 6.22). This result suggests a difference in the quality of corrected myopic vision, that is, the chart results do not extrapolate linearly from myopic blur to corrected clarity. Emmetropic data could be collected to find out if emmetropes conform to the uncorrected myopic trends, those of the corrected vision or neither.

The proximity of the other letters on a testing chart also affects performance. Single optotypes scored about one line more than the high contrast Bailey-Lovie chart for both the corrected and uncorrected situations. Assuming that this difference is due to the crowding effect of the surrounding letters on the BL chart suggests that crowding affects corrected and uncorrected myopia by the same amount.

The quality of fixational eye movements also play a role in vision. The Regan Repeat Letter chart has repeated letters in the centre and was designed to measure acuity independent of abnormal fixational eye movements (see section 5.2.2). It was observed (see section 6.2) that the relative difference between the scores of the RRL chart and that for the BL chart were significantly different in the case of corrected acuity as compared with uncorrected vision. This result indicates a need for an

investigation into the role of fixational eye movements and myopia as it suggests a difference in the quality of these movements when refractive correction is worn. Again, emmetropic data would determine whether or not the difference was simply due to the level of acuity or whether it was only true in the presence of negative refractive correction.

9.1.2 Differences between Binocular and Monocular Viewing

The difference in score between monocular and binocular viewing in the corrected situation as compared with the uncorrected situation was analysed (see section 6.4.1). The standard deviations were much larger in the uncorrected situation suggesting that different refractive errors have a greater variability in the benefit gained by binocular viewing. Any difference between the uncorrected and corrected situation was found, however, not to be significant.

9.1.3 Pre and Post Therapy Data

There were no significant differences found between the data before therapy and the data after therapy. It is therefore concluded that vision therapy had no effect on the chart scores of the participants.

9.2 Physical Data

The physical data was collected in order to try to establish physical links to any changes in vision which may have been observed during vision therapy. It also allows relationships between the state of refraction and physical parameters to be made. There was no difference between the cycloplegic and non-cycloplegic autorefractions observed. A linear relationship between axial length and the state of refraction was found with longer axial lengths corresponding with larger negative refractive errors. No relationship between refractive error and corneal curvature was found. This result suggests that all the myopia of the participants was axial.

After the vision therapy no change was observed in the parameters of corneal curvature or refractive status. There was not enough data to establish whether or not a change in axial length was observed, however, since no significant change in vision or refractive status both of which are highly correlated with axial length, was recorded it seems unlikely that this parameter would have shown a change.

9.3 Experiential Data

Those participating reported changes in their vision - short term fluctuations which could be quite large. This suggests a flexibility in the visual system which could be caused by:
1) more efficient processing of blurred images
2) change in the state of refraction produced by a relaxation of accommodation by the ciliary muscle or changes in axial length
Whatever the local mechanisms these changes have only been observed when vision work is approached holistically.

Questionnaire data show that those taking part in the vision therapy sessions found their vision less comfortable. If a situation of reduced vision is indicative of strain it may well be the case that the person will be unaware of that strain. Any attempt to change this situation of strain will only be possible if he or she first of all becomes aware of it. This in itself can be an uncomfortable process and could account for this finding.

The vision therapist's reports illustrate the holistic nature of the work. The comments involve a discussion of how much work each person put in but also their own personal circumstances which may have prevented them dedicating a lot of time to the work. It also shows the emphasis placed on balancing, especially the right and left sides.

The approach that was taken with each participant was different and addressed their own particular needs, strengths and weaknesses.

There is a lack of consistency between the vision therapist's reports and the chart testing scores i.e. those that improved in the sessions did not neccessarily score well in controlled conditions. Also, however, of note is No. 22 who did score higher on the charts after the therapy period but did not report any improvement during the sessions.

The experience of vision therapy and the vision therapist's reports suggest a variability in vision that is faster (over seconds, minutes or hours) that can be recorded using conventional chart testing techniques. It is also suggest a great range in this variability (up to 3-6 lines of a test chart).

9.4 General Experimental Points

Changes in decision making criteria will also affect chart performance. Jogging and cycling can improve chart measures and it has been argued that this is due to the change in decision criteria brought about by the positive mood changes that occur after exercise (Woods & Thomson, 1995). Improved acuity was also observed in one trial after muscle relaxation and postural training (Konno, 1997).

The amount of encouragement given during measurement can also have an effect. Two different styles of taking chart measurement are 1) readily accepting the point where the patient or subject states that they cannot see any more or 2) taking unhurried measurements giving plenty of encouragement and 'forcing' guesses. Ideally to reach a point of threshold the latter method which is in effect a forced choice procedure should be used. This is especially true of the low contrast charts for which the letters often become visible only after prolonged inspection and scores tend to be 0.15 log units lower if a patient is not given sufficient time to look at the chart near threshold (Elliott & Whitaker, 1992). In this study the participants were given positive reinforcement irrespective of their accuracy and asked to continue reading until a point where mistakes were being made was reached, that is, "good" was said after every attempt.

Measurements taken in the blurred condition have a greater variability because: 1) there is a greater margin for guesswork and hence a flexibility in decision criteria and 2) if the holistic perspective is adopted there is a variability in vision which will be greater when uncorrected.While measuing the acuity of patients with uncorrected myopia one study observed that "subjects often reported scanning the edges or perimeter of the letters to help in recognition" (Bradley et al, 1991). This can be compared to the *shifting* exercise described in chapter 3 (see chapter 6 for a discussion of this point). People with poorer vision also tend to improve on retest by a few letters (see figure 9.4). When viewing the charts without glasses participants often reported seeing 2 or more images. This was most noticeable for the case of single letters. This phenomenon of monocular diplopia in the presence of defocus has been successfully modelled (Woods et al, 1996).

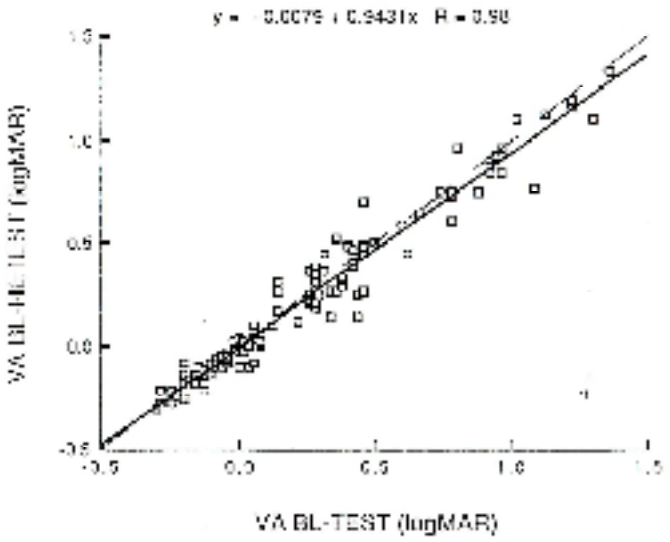

Figure 9.4 Test-retest relationship for vision measured with the Bailey-Lovie chart (solid line is regression line; dashed line is 1:1 line) (Lovie-Kitchin, 1988). The scoring used in this figure is the Bailey-Lovie LogMAR (0 is equivalent to 6/6) See table 5.3.

Even if a holistic method of analysis is not adopted in order to try to explain vision therapy understanding the process is not simple. Visual behaviour is a complex process dependent upon multiple factors. These may include: attention to task, motivation to perform, ability to discriminate stimuli, clarity of the image on the retina and neural processing of the retinal stimulation. There is no reason to expect that only one of these factors will be impacted by training (Collins & Gil, 1984). With this sort of framework a full discussion of myopia becomes unwieldy and impossible. If the factors of posture and environment etc. are also included the situation becomes even worse. There is at present a compartmentalisation of the various symptoms associated with myopia which needs the synthesis of a coherent theory.

9.5 Researching Holistic Vision Therapy

Holistic vision therapy claims to increase spatial, colour, movement and depth awareness. It also claims to improve the fluidity of eye movements, improve body posture and to decrease levels of anxiety and muscle tension. Although it is also claimed that vision can improve it is all the above elements which precede and are involved in the improvement. None of these elements were investigated in the experimental work. This was due, not only to a lack of expertise in researching these areas but also because of the nature of the experimental methodology.

Contemporary research in optometry, as with all research, is based on certain assumptions and principles which stand in place to make sense of the research. In optometry which is the study of the biological system of vision, the aim of the scientific study is to understand vision as far as possible. Alongside this is the practical application of this understanding in the form of medical intervention (e.g. spectacles prescribed for myopia). The assumption is that the best way to do this is to examine the intricacies of the system in as much detail as possible. "The argument for this detailed research (here the topic is nearwork, accommodation and myopia) is that only once the details of the mechanisms have been fully investigated and understood can any attempt at preventing and treating myopia be made" (Jiang & Morse, 1999). This as a philosophy of investigation runs counter to the premises of holistic healing.

Vision therapy is holistic and, as such, the more approaches that are being tackled at once, the more likely success is. There are many things that can be done and many outcomes expected e.g. a change in diet, exercise and motivation alongside vision exercises and a change of vision habits altogether are more likely to bring about changes in muscle tension, anxiety, posture, spatial awareness and visual quality as well as visual acuity.

In order to analyse this process breaking it up and compartmentalising it into component factors and dependent outcomes loses the essence and nature of the phenomenon. To try and find out which of the factors is more important and which outcome more likely although possible would be a difficult task. The only way to proceed using this technique is to eliminate as many variables as possible i.e. only change one thing at a time so that what causes any outcomes is clearly established. The problem with this approach to holistic vision therapy is that the more things that are being changed at once the more likely a change in vision is. Reducing the variables, therefore, reduces the chance of getting measureable results. As the field is examined more closely the number of variables keeps increasing. In order, therefore, for intelligible research in the field to proceed a theoretical approach which is not dependent on a reductionist model will be neccessary.

The holistic perspective also means that any direct link between a symptom, its cause and the treatment is impossible because there are no 1:1 relationships.

Chapter 10
Future Work

10.1 Postural Factors in Myopia

The main question to arise from this thesis is "Is myopia a holistic problem?" One possible approach to this would be to test the postural correlates speculated in chapter 3. This could be done by taking a postural expert e.g. an Alexander technique teacher and getting them to make an assessment of a group of myopes and a group of non-myopes. If any trends can be established, i.e. tension in the forehead, jaw, neck, shoulders, upper arms and lower back (Schneider et al, 1994), then the topic could be further investigated.

10.2 Peripheral Retinal Function and Peripheral Awareness

Within the natural vision literature it is reported that with myopia comes a reduction in peripheral awareness (Schneider et al, 1994; Goodrich, 1985) for which exercises stimulating the peripheral visual field is given. Also significant differences in the peripheral refraction of myopes, hyperopes and emmetropes have been found (Millodot, 1981) suggesting that peripheral refraction is related to the overall refraction in some way (McBrien & Barnes, 1984). It is hypothesised that emmetropia is a situation in which there is healthy functioning of all parts of the retina. In order to explore this topic experiments comparing visual fields and movement detection in people with different refractive states, both corrected and uncorrected could be done.

10.3 Imagery

The use of visual imagination has been shown to make a difference to experimental perception. In one experiment the observation that target detection can be facilitated with flanking visual masks was used to test the role of visual imagery in perception. It was found that imagining the flanking masks produced a similar enhancement of target detection (Ishai & Sagi, 1995). One of the natural vision techniques not discussed in this thesis is visual imagery. This can take the form of looking at an object, closing the eyes and sketching the object in the imagination and then opening the eyes and shifting around the object again observing as many details as possible. Another way that is suggested for doing this is the expansion of peripheral awareness and the use of visual imagery techniques emphasising distance vision to allow the experience of feelings associated with accommodative relaxation. (Birnbaum, 1981; Friedman, 1981). More

experiments in the style of those by Ishai and Sagi could be done to explore this topic more fully.

10.4 Perceptual Metrics

In chapter 3 there is a passage in which someone who has undergone vision therapy describes her changing visual perception and describes it as "space expanding". In order to analyse this type of perceptual experience a framework can be devised to describe spatial concepts.

A metric is the set of rules defining distances between points in any space, for example, in 3-D Euclidean space the metric is described by the rule that the distance between two points (x_1, y_1, z_1) and (x_2, y_2, z_2) is given by $\sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}$. This expression would not apply in a different metric, for example on the surface of a sphere. This concept of a metric can be used to aid description of perceptual awareness and there have been attempts to describe vision, kinesthetic awareness and an awareness of the location of sounds in terms of metrics (Andrews, 1964). As a description of individual experience these metrics are necessarily subjective phemonena and can be flexible. It has been shown that with the application of lenses which severely distort the incoming visual information the visual system will adapt and recoordinate the visual information to agree with other sensory clues (e.g. balance). A less extreme example of this is the reported experience of difficulty walking down stairs for an initial period after receiving a new spectacle prescription.

This adaptation is not just a static effect and similar adaptation is possible in response to an environment moving at different speeds as well as those differing spatially. This is demonstrated in the waterfall illusion in which an observer watching a waterfall for a time and then altering the gaze to a static scene will observe the scene rushing upwards (Sekuler & Blake,1994). In this context the practises of shifting and swinging could be seen as exercises in motion adaptation teaching the perceptual system the metric needed for the physical motion of the body and the eyes.

A more detailed analysis using metrics could allow for quantification of three dimensional perceptual phenomena and with careful experimentation an analysis of the effect of refractive lenses and vision therapy on these personal perceptions may be possible.

10.5 Changing Awareness

When participating in vision therapy for myopia reduction there has been a reported increase in the perception of colour intensity. This phenomenon could be investigated.

The relationship of details to context is also reported to change. Myopia can be described as an increased attention to detail. Therapy work encourages peripheral awareness to expand a narrowed visual function to a global way of working. Metaphors for emotional work can be found in this with the relationship of context to details being out of balance. Myopia in this sense can be described as a lack of context.

10.6 Clinical Vision Therapy

In order to further explore what happens to people and their vision when natural vision techniques are used then the resource of natural vision teachers should be used in order to collect case study data and increase knowledge of the area. In order to achieve this documentation, however, there are real issues of communication which need to be addressed. The aims of optometric analysis and the aims of therapeutic work are quite different (therapy being about balance and integration of the person to a position of general health, optometric analysis the taking of specific measurements) and there exists at present suspicion and distrust between the fields. This means a general status quo in which the information on developing techniques and novel case studies are not being collected and used for furthering the understanding of how vision works in the more widespread scientific community. In order to reverse this situation and assimilate these new situations into current knowledge a sensitive approach to information gathering needs to be adopted. At best a long term collection of case studies will provide data on the efficacy of the techniques.

References

Abbot, M., Schmid, K. and Strang, N. (1998) Differences in the accommodation stimulus response curves of adult myopes and emmetropes *Ophthalmic and. Physiological Optics* **18**, 13-20

Adams, D., McBrien, N. (1992) Prevalence of Myopia and Myopia Progression in a Population of Clinical Microscopists *Optometry and Vision Science* **69,** 467-473

Alsbirk, P. (1979) Refraction in Adult West Greenland Eskimos *Acta Ophthalmologica* **57,** 84-93

Andrews, D.P. (1964) Error-correcting perceptual mechanisms *Quarterly Journal of Experimental Psychology* XVI Part 2, May 1964

Angi, M., Caucci, S., Pilotto, E., Racano, E., Rupolo, G. and Sabbadin, E. (1996) Changes in Myopia, Visual Acuity, and Psychological Distress after Biofeedback Visual Training *Optometry and Vision Science* **73,** 35-42

Bailey, I. L. and Lovie, J. E. (1976) New Design Principles for Visual Acuity Letter Charts *American Journal of Optometry and Physiological Optics* **53,** 740-745

Bates, W.H. (1920) The Cure of Imperfect Sight by Treatment without Glasses *Central Fixation Publishing Co.*

Berne, S.A. (1995) Creating Your Personal Vision *Color Stone Press*

Benjamin, H. (1929) Better Sight without Glasses *Health For All Publishing Company*

Bennett, A. and Rabbetts, R. (1989) Clinical Visual Optics *Butterworth*

Berens, C., Girard, L., Fonda, G. and Sells, S. (1957) Effects of tachistoscopic training on visual function in myopic patients *American Journal of Ophthalmology* **44,** 25-48

Birnbaum, M. (1978) Holistic aspects of visual style: a hemispheric model with implications for vision therapy *Journal of the American Optometric Association* **49,** 1133-1141

Birnbaum, M. (1981) Clinical Management of Myopia *American Journal of Optometry and Physiological Optics* **58,** 554-559

Birnbaum, M. (1984) Nearpoint visual stress: A physiological model *Journal of the American Optometric Association* **55,** 825-835

Blackie, C. and Howland, H. (1999) An extension of an accommodation and convergence model of emmetropization to include the effects of illumination intensity *Ophthalmic and Physiological Optics* **19,** 112-115

Bradley, A. Hook, J. and Haeseker, J. (1991) A comparison of clinical acuity and contrast sensitivity charts: effect of uncorrected myopia *Ophthalmic and Physiological Optics* **11,** 218-226

Brown, B. and Lovie-Kitchin, J. (1989) High and Low Contrast Acuity and Clinical Contrast Sensitivity Tested in a Normal Population *Optometry and Vision Science* **66,** 467-473

Brown, B. and Lovie-Kitchin, J. (1993) Repeated Visual Acuity Measurement: Establishing the Patient's Own Criterion for Change *Optometry and Vision Science* **70,** 45-53

Bullimore, M. and Gilmartin, B. (1988) The accommodative response, refractive error and mental effort: 1. The sympathetic nervous system *Documenta Ophthalmologica* **69,** 385-397

Carroll, J.P. (1982) Component and Correlation Ametropia *American Journal of Physiological Optics* **59,** 28-33

Chen, C.J., Cohen, B. H. and Diamond, E. L. (1985) Genetic and environmental effects on the development of myopia in Chinese twin children *Ophthalmol. Pediat. Genet.* **6,** 113-119

Ciuffreda, K. and Ordonez, X. (1998) Vision therapy to reduce abnormal nearwork-induced transient myopia *Optometry and Vision Science* **75,** 311-315

Collins, F. and Gil, K. (1984) Critical issues in the evaluation of behavioural training for myopia: a reply to Matson, Helsel and LaGrow *Behavior Research andTherapy* **22,** 195-196

Corbett, M. (1949) Help Yourself to Better Sight *Melvin Powers Wilshire Book Company, Hollywood CA*

Cottriall, C. and McBrien, N. (1996) The M1 Muscarine Amtagonist Pirenzepine Reduces Myopia and Eye Enlargement in the Tree Shrew *Investigative Ophthalmology and Visual Science* **37,** 1368-1379

Curry, T.A., Sivak, J.G., Callender, M.G. and Irving, E.L. (1999) Afocal Magnification Does Not Influence Chick's Eye Development *Optometry and Vision Science* **76,** 316-319

Curtin, B. (1985) The Myopias *Harper and Row*

Donders, F. (1864) On the Anomalies of Accommodation and Refraction of the Eye *London, The New Sydenham Society*

Ebenholtz, S. (1983) Accommodative Hysteresis: A Precursor for Induced Myopia? *Investigative Ophthalmology and Visual Science* **24,** 513-515

Edwards, M. (1999) The development of myopia in Hong Kong children between the ages of 7 and 12 years: a five year longitudinal study *Opthalmic and Physiological Optics* **19,** 286-294

Ehrlich, D. (1987) Near Vision Stress: Vergence Adaptation and Accommodative Fatigue *Ophthalmic and Physiological Optics* **7,** 353-357

Ehrlich, D., Atkinson, J., Braddick, O., Bobier, W. and Durden, K. (1995) Reduction of Infant myopia: a Longitudinal Cycloplegic Study *Vision Research* **35,** 1313-1324

Elliott, D.B. Sanderson, K. and Conkey, A. (1990) The reliability of the Pelli-Robson contrast sensitivity chart *Ophthalmic and Physiological Optics* **10,** 21-24

Elliott, D.B. and Whitaker, D. (1992) Clinical contrast sensitivity chart evaluation *Ophthalmic and Physiological Optics* **12,** 275-280

Flitcroft, D. (1998) A model of the contributions of oculomotor and optical factors to emmetropization and myopia *Vision Research* **38,** 2869-2879

Flitcroft, D. (1999) The lens paradigm in experimental myopia: oculomotor, optical and neurophysiological considerations *Ophthalmic and Physiological Optics* **19,** 103-111

Flom, M. (1991) Contour Interaction and the Crowding Effect *Problems in Optometry* **3,** 237-257

Friedman, E. (1981) Vision Training Program for Myopia Management *American Journal of Optometry and Physiological Optics* **58,** 546-553

Friedman, N., Mutti, D. and Zadnik, K. (1996) Corneal Changes in Schoolchildren *Optometry and Vision Science* **73,** 552-557

Fulk, G.W., Cyert, L.A. and Parker, D.E. (2000) A Randomized Trial of the Effect of Single Vision vs Bifocal Lenses on Myopia Progression in Children with Esophoria *Optometry and Vision Science* **77,** 395-401

Gallop, S. (1994) Myopia Reduction: A View from the Inside *Journal of Behavioural Optometry* **5,** 115-120

Garner, L., Tap, M., Kinnear, R. and Frith, M. (1995) Ocular dimensions and refraction in Tibetan children *Optometry and Visual Science* **72,** 266-271

Garner, L., Owens, H., Kinnear, R. and Frith, M. (1999) Prevalence of myopia in Sherpa and Tibetan children in Nepal *Optometry and Vision Science* **76,** 282-285

Gawron, V. (1983) Ocular Accommodation, Personality and Autonomic Balance *American Journal of Optometry and Physiological Optics* **60,** 630-639

Giddings, J. and Lanyon, R. (1974) Effect of Reinforcement of Visual Acuity in Myopic Adults *American Journal of Optometry and Physiological Optics* **March,** 181-187

Gil, K. and Collins, F. (1983) Behavioral Training for myopia: Generalization of Effects *Behavior Research and Therapy* **21,** 269-273

Gilmartin, B. (1986) A review of the role of sympathetic innervation of the ciliary muscle in ocular accommodation *Ophthalmic and Physiological Optics* **6,** 23-27

Gilmartin, B., Gray, L. and Winn, B. (1991) The amelioration of myopia using biofeedback of accommodation: a review *Ophthalmic and Physiological Optics* **11,** 304-313

Gilmartin, B. and Winfield, N. R. (1995) The Effect of b-adrenoceptor antagonists on accommodation in emmetropia and myopia *Vision Research* **35,** 1305-1312

Goodrich, J. (1985) Natural Vision Improvement *Penguin*

Goss, D. (1982) Attempts to Reduce the Rate of Increase of Myopia in Young People - A Critical Literature Review *American Journal of Optometry and Physiological Optics* **59,** 828-841

Goss, D. (1986) Effect of Bifocal Lenses on the Rate of Childhood Myopia Progression *American Journal of Optometry and Physiological Optics* **63,** 135-141

Goss, D. and Rainey, B. (1999) Relationship of Accommodative Response and Nearpoint Phoria in a Sample of Myopic Children *Optometry and Vision Science* **76,** 292-294

Graham, C. and Leibowitz, H. (1978) The Effect of Suggestion on Visual Acuity *The International Journal of Clinical and Experimental Hypnosis* **20,** 169-186

Greene, P. (1980) Mechanical Considerations in Myopia; Relative Effects of Accommodation, Convergence, Intraocular Pressure, and the Extraocular Muscles *American Journal of Optometry and Physiological Optics* **57,** 902-914

Greenspan, S. (1981) Research Studies of Bifocals for Myopia *American Journal of Optometry and Physiological Optics* **58,** 536-540

Grosvenor, T. (1993) The Results of Myopia Control Studies Have Not Been Encouraging *Journal of Behavioural Optometry* **4,** 17-19

Grosvenor, T., Perrigin, D., Perrigin, J. and Maslovitz, B. (1987) Houston Myopia Control Study: A Randomized Clinical Trial. Part II. Final Report by the Patient Care Team *American Journal of Optometry and Physiological Optics* **64,** 482-298

Grosvenor, T. and Scott, R. (1991) Comparison of Refractive Components in Youth-Onset and Early Adult-Onset Myopia *Optometry and Vision Science* **68,** 204-209

Grosvenor, T. and Goss, D. (1999) Clinical Management of Myopia *Butterworth Heineman*

Gwiazda, J., Bauer, J., Thorn, F. and Held, R. (1995) A Dynamic Relationship between Myopia and Blur-driven Accommodation in School-aged Children *Vision Research* **35,** 1299-1304

Hamilton, J. (1976) Vision anomalies in Indian school children: the Lame Deer study *Journal of the American Optometric Association* **47,** 479-486

Helmholtz, H. (1871) Helmholtz's Treatise on Physiological Optics *New York Dover Publications*

Hemminki, E. and Parssinen, O. (1987) Prevention of Myopic Progress by Glasses. Study Design and the First-Year Results of a Randomized Trial among Schoolchildren *American Journal of Optometry and Physiological Optics* **64,** 611-616

Henson, D.B. (1996) Optometric Instrumentation *Butterworth Heinemann, London*

Heron, G., Furby, H., Walker, R., Lane, C. and Judge, O. (1995) Relationship between visual acuity and observation distance *Ophthalmic and Physiological Optics* **15,** 23-30

Holland, K. (1996) Will behavioural optometry come in from the cold? *Optician* **211,** 16-21

Horner, D., Soni, S., Salmon, T. and Swartz, T.S. (1999) Myopia Progression in Adolescent Wearers of Soft Contact Lenses and Spectacles *Optometry and Vision Science* **76,** 474-479

Huxley, A. (1943) The Art of Seeing *FlamingoHarperCollins*

Hui, J., Peck, L. and Howland, H. (1995) Correlations Between Familial Refractive Error and Children's Non-cycloplegic Refractions *Vision Research* **35,** 1353-1358

Ingram, R. and Barr, A. (1979) Changes in refraction between the ages of 1 and 3.5 years *British Journal of Ophthalmology* **63,** 339-343

Ishai, A. and Sagi, D. (1995) Common Mechanisms of Visual Imagery and Perception *Science* **268,** 1772-1774

Jennings, J.A.M. (2000) Behavioural Optometry: A Critical Review *Optometry in Practice* **1,** 67-78

Jiang, B. Morse, S. (1999) Oculomotor functions and late onset myopia *Ophthalmic and Physiological Optics* **19,** 165-172

Jones, R. (1990) Physiological Pseudomyopia *Optometry and Vision Science* **67,** 610-616

Kaplan, R. (1987) Seeing Without Glasses *Beyond Words Publishing*

Kaplan, R. (1995) The Power Behind Your Eyes *Healing Arts Press*

Kaufmann, P. L. (1992) Accommodation and Presbyopia: Neuromuscular and Biophysical Aspects in Adler's Physiology of the Eye ed. Hart, W. M. *Mosby, St. Louis, Missouri*

Kavner, R. (1978) Total Vision *Kavner Books, New York*

Kerns, R. (1981) Contact Lens Control of Myopia *American Journal of Optometry and Physiological Optics* **58,** 541-546

Konno, Y. (1997) The effects of relaxation and postural training on external perception: Improvement of visual acuity, visual field and hearing acuity *Japanese Psychological Research* **39,** 119-123

Koslowe, K., Spierer, A., Rosner, M. and Belkin, M. (1991) Evaluation of Accommotrac Biofeedback Training for Myopia Control *Optometry and Vision Science* **68,** 338-343

Kothe, A. and Regan, D. (1990) The Component of Gaze Selection /Control in the Development of Visual Acuity in Children *Optometry and Vision Science* **67,** 770-778

Kruger, P. (1980) The Effect of Cognitive Demand on Accommodation *American Journal of Ophthalmic and Physiological Optics* **57,** 440-445

Kushner, B. (1999) Does overcorrecting lens therapy for intermittent exotropia cause myopia? *Archives of Ophthalmology* **117,** 638-642

Lam, C., Edwards, M., Millodot, M. and Goh, W. (1999) A 2-year longitudinal study of myopia progression and optical component changes among Hong Kong schoolchildren *Optometry and Vision Science* **76,** 370-380

Lanyon, R. and Giddings, J. (1974) Psychological Approaches to Myopia: a Review *American Journal of Ophthalmic and Physiological Optics* **51,** 271-281

Leech, E., Cottriall, C. and McBrien, N. (1995) Pirenxepine prevents form deprivation myopia in a dose dependent *Ophthalmic and Physiological Optics* **13,** 351-356

Leung, J. and Brown, B. (1999) Progression of myopia in Hong Kong schoolchildren is slowed by wearing progressive lenses *Optometry and Vision Science* **76,** 346-354

Li, T., Glasser, A. and Howland, H. (1995) Constant Light Produces Severe corneal Flattening and Hyperopia in Chickens *Vision Research* **35,** 1203-1209

Liberman, J. (1995) Take Off Your Glasses and See *Thorsons: HarperCollins*

Liang, H., Crewther, D., Crewther, S. and Barila, A. (1995) A Role for Photoreceptor Outer Segments in the Induction of Deprivation Myopia *Vision Research* **35,** 1217-1225

Lithander, J. (1999) Prevalence of myopia in school children in the Sultanate of Oman: A nation-wide study of 6292 randomly selected children *Acta Ophthalmologica Scandinavica* **77,** 306-309

Lovie-Kitchin, J. (1988) Validity and reliability of visual acuity measurements *Ophthalmic and Physiological Optics* **8,** 363-370

Malmstrom, F. and Randle, R. (1976) Effects of visual imagery on the accommodation response *Perception and Psychophysics* **19**, 450-453

Mansfield, P. (1992) The Bates Method *Vermilion*

McBrien, N.A. and Barnes, D.A. (1984) A review and evaluation of theories of refractive error development *Ophthalmic and Physiological Optics* **4,** 201-213

McBrien, N., Gentle, A. and Cottriall, C. (1999) Optical Correction of Induced Axial Myopia in the Tree Shrew: Implications for Emmetropization *Optometry and Vision Science* **76,** 419-427

McBrien, N. and Millodot, M. (1986) Amplitude of accommodation and Refractive Error *Investigative Ophthalmology and Visual Science* **27,** 1187-1190

McBrien, N. and Millodot, M. (1987) The Relationship Between Tonic Accommodation and Refractive Error *Investigative Ophthalmology and Visual Science* **28,** 997-1004

McBrien, N., Moghaddam, H., Cottriall, C., Leech, E. and Cornell, L. (1995) The Effects of Blockade of Retinal Cell Action Potentials on Ocular Growth, Emmetropizaton and form Deprivation Myopia in Young Chicks *Vision Research* **35,** 1141-1152

McBrien, N., Moghaddam, H. and Reeder, A. (1993) Atropine Reduces Experimental Myopia and Eye Enlargement Via a Nonaccommodative Mechanism *Investigative Ophthalmology and Visual Science* **34,** 205-215

McCarty, C., Livingston, P. and Taylor, H. (1999) Prevalence of myopia in adults: implications for refractive surgeons *Journal of Refractive Surgery* **13,** 229-234

McGraw, P. (1995) Studies of Human Macular Function: Developmental Anomalies *PhD thesis* Glasgow Caledonian University

McGraw, P. and Winn, B. (1993) Glasgow Acuity Cards: a new test for the measurement of letter acuity in children *Ophthalmic and Physiological Optics* **13,** 400-404

McGraw, P. and Winn, B. (1995) Measurement of letter acuity in preschool children *Ophthalmic and Physiological Optics* **15,** S11-S17

McLinn, L. Schor, C. (1988) Voluntary Effort as a Stimulus to Accommodation and Vergence *Investigative Ophthalmology and Visual Science* **29,** 1739-1746

Miller, N. (1969) Learning of Visceral and Glandular Responses *Science* **163**, 434-445

Millodot, M. (1981) Effect of ametropia on peripheral refraction. *American Journal of Optometry and Physiological Optics* **58,** 691-695

Mohan, M., Pakrasi, S. and Zutshi, R. (1988) Myopia in India *Acta Ophthalmologica* **185**, 19-23

Mon-Williams, M., Tresilian, J., Strang, N., Kochhar, P. and Wann, J. (1998) Improving vision: neural compensation for optical defocus *Proceedings of the Royal Society of London* **265**, 71-77

Mutti, D., Zadnik, K. and Adams, A. (1996) Myopia: The Nature Versus Nurture Debate Goes On *Investigative Ophthalmology and Visual Science* **37,** 952-956

Neetans, A. and Evans, P. (1985) The use of bifocals as an alternative in the management of low grade myopia *Bull. Soc. Belge Ophthalmol.* **214,** 79-85

Oakley, K. H. and Young, F. A. (1975) Bifocal Control of Myopia *American Journal of Optometry* **52,** 758-64

Obstfeld, H. (1978) Optics in Vision *Butterworths* pp.120-123

Obstfield, H. (1991) The Multiple Image Phenomenon *Optometry and Vision Science* **68,** 79

Ong, E. and Ciuffreda, K.J. (1997) Accommodation, nearwork and myopia *Santa Ana CA: Optometric Extension Program* pp.76-93

Ong, E., Grice, K., Held, R., Thorn, F. and Gwiazda, J. (1999) Effects of spectacle intervention on the progression of myopia in children *Optometry and Vision Science* **76,** 363-369

Orfield, A. (1994) Seeing Space: Undergoing brain re-programming to reduce myopia *Journal of Behavioural Optometry* **5,** 123-131

Owens, D. and Wolf-Kelly, K. (1987) Near Work, Visual Fatigue and Variations of Oculomotor Tonus *Investigative Ophthalmology and Visual Science* **28,** 743-749

Paritsis, N., Sarafidou, E., Koliopoulos, J. and Trichopoulos, D. (1983) Epidemiologic research in the role of studying and urban environment in the development of myopia during school age years. *Annals of Ophthalmology* **15,** 1061-1065

Perrigin, J., Perrigin, D., Quintero, S. and Grosvenor, T. (1990) Silicone acrylate contact lenses for myopia control: 3 year results. *Optometry and Vision Science* **67,** 765-769

Pesudovs, K. and Brennan, N. (1993) Decreased Uncorrected Vision After a Period of Distance Fixation with Spectacle Wear *Optometry and Vision Science* **70,** 528-531

Phillips, J. and McBrien, N. (1995) Form deprivation myopia: elastic properties of sclera *Ophthalmic and Physiological Optics* **15,** 357-362

Qiang, M. and Zhao, R. (1994) Early Signs of Myopia in Chinese Schoolchildren *Optometry and Vision Science* **71,** 14-16

Quackenbush, T. (1997) Relearning to See *North Atlantic Books*

Quinn, G.E., Shin, C.H., Maguire, M.G. and Stone, R.A. (1999) Myopia and ambient lighting at night *Nature* **399,** 113

Rabbets, R.B. (1998) Clinical Visula Optics *Butterworth Heineman Kent*

Rabin, J., Van Sluyters, R. and Malach, R. (1981) Emmetropization: a vision-dependent phenomenon. *Investigative Ophthalmology and Visual Science* **April,** 561-564

Randle, R. (1988) Responses of myopes to volitional control training of accommodation *Ophthalmic and Physiological Optics* **8,** 333-340

Raviola, E. and Wiesel, T. (1990) Neural control of eye growth and experimental myopia in primates. *Ciba Found Symp* **155,** 22-38. Wiley pp. 22-44.

Reeves, B., Wood, J. and Hill, A. (1993) Reliability of high- and low-contrast letter *Ophthalmic and Physiological Optics* **13,** 17-26

Remole, A. (1980) The Perception of Blur *Australian Journal of Optometry* **63,** 280-283

Remole, A. (1991) Multiple Images Produced by Retinal Image Defocus *Optometry and Vision Science* **68,** 477-478

Richter, H. and Franzen, O. (1994) Velocity percepts of apparent laser speckle motion modulated by voluntary changes of visual accommodation: real-time, in-vivo measurements of the accommodative response *Behavioural Brain Research* **62,** 93-102

Roberts, W. L. and Banford, R. D. (1967) Evaluation of Bifocal Correction Techniquein Juvenile Myopia *Optometry Weekly* **58**(38), 25-31; (39), 21-30; (40), 23-28; (41), 27-34; (43), 19-26

Rosanes-Berrett, M. (1983) Do You Really Need Eyeglasses? *Instant Improvement Inc., New York*

Rosen, R. C. Schiffman, H. R. and Meyers, H. (1984) Behavioural treatment of myopia: refractive error and acuity changes in relation to axial length and intraocular pressure *American Journal of Optometry and Physiological Optics* **61,** 100-105

Rosenfield, M. and Gilmartin, B. (1997) Myopia and Nearwork *Butterworth Heinemann Oxford*

Rosenfield, M. and Gilmartin, B. (1999) Accommodative error, adaptation and myopia *Ophthalmic and Physiological Optics* **19,** 159-164

Rosenfield, M. and Abraham-Cohen, J. (1999) Blur Sensitivity in Myopes *Optometry and Vision Science* **76,** 303-307

Rupolo, G., Angi, M., Sabbadin, E., Caucci, S., Pilotto, E., Racano, E and de Bertolini, C. (1997) Treating Myopia with Acoustic Biofeedback: A Prospective Study on the Evolution of Visual Acuity and Psychological Distress *Psychosomatic Medicine* **59,** 313-317

Schaeffel, F. and Howland, H. (1991) Properties of the feedback loop controlling eye growth and refractive state in the chicken. *Vision Research* **1,** 717-734

Schmid, K.L., Strang, N.C. and Wildsoet, C.F. (1999) Imposed Retinal Image Size Changes - Do they Provide a Cue to the Sign of Lens-Induced Defocus in Chick? *Optometry and Vision Science* **76,** 320-325

Schneider, M., Larkin, M. and Schneider, D. (1994) The Handbook of Self-Healing *Penguin Arkana*

Schor, C. (1999) The influence of interactions between accommodation and convergence on the lag of accommodation *Ophthalmic and Physiological Optics* **19,** 134-150

Sekuler, R and Blake, R. (1994) Perception *McGraw-Hill International* p. 278

Sheehan, E., Smith, H. and Forrest, D. (1982) A Signal Detection Study of the effects of suggested improvement on the monocular visual acuity of myopes. *The International Journal of Clinical and Experimental Hypnosis* **30,** 138-146

Sherman, A. (1993) Myopia can often be prevented, controlled or eliminated *Journal of Behavioural Optometry* **4,** 16-22

Simmers, A.J. (1997) Clinical Evaluation of Visual Dysfunction in Human Amblyopia and the Effect of Occlusion Therapy *PhD Thesis* Glasgow Caledonian University

Simmers, A.J., Gray, L.S., McGraw, P.V. and Winn, B. (1999) Contour interaction for high and low contrast optotypes in normal and amblyopic observers *Ophthalmic and Physiological Optics* **19,** 253-260

Smith, E.L., Bradley, D.V., Fernandes, A. and Boothe, R.G. (1999) Form Deprivation Myopia in Adolescent Monkeys *Optometry and Vision Science* **76,** 428-432

Steele, C.F., Crabb, D.P. and Edgar, D.F. (1992) Effects of different ocular fixation conditions on A-scan ultrasound biometry measurements *Ophthalmic and Physiological Optics* **12,** 491-495

Stone, R., Lin, T., Desai, D. and Capehart, C. (1995) Photoperiod, Early Post-natal Eye Growth and Visual Deprivation *Vision Research* **35,** 1195-1202

Strang, N., Gilmartin, B., Gray, L., Winfield, N. and Winn, B. (2000) Open-loop accommodation in emmetropia and myopia *Current Eye Research* **20,** 190-194

Strang, N., Schmid, K. and Carney, L. (1998) Hyperopia is predominantly axial in nature *Current Eye Research* **17,** 380-383

Strang, N. Winn, B. and Bradley, A. (1998) The role of neural and optical factors in limiting visual resolution in myopia *Vision Research* **38,** 1713-1721

To'mey, K., Faris, B., Jalkh, A. and Nasr, A. (1981) Ocular Pulse in High Myopia: A Study of 40 Eyes *Annals of Ophthalmology,* **May,** 569-571

Trachtman, J. N. (1987) Biofeedback of accommodation to reduce myopia: a review *American Journal of Optometry and Physiological Optics* **64,** 639-643

Van Alphen, G.W. (1961) On emmetropia and ametropia *Ophthalmologica* **142,** S1-S92

Vingrys, A. Skurrie, M. and Smith, G. (1980) The Anomalous (or Induced) Myopias and the Intermediate Resting Point of Accommodation *Australian Journal of Optometry* **63,** 284-287

Wallman, J. and Turkel, J. (1978) Extreme Myopia Produced by Modest Change in Early Visual Experience *Science* **201,** 557-560

Wallman, J. and Adams, J. (1987) Developmental Aspects of Experimental Myopia in Chicks: Susceptibility, Recovery and Relation to Emmetropization. *Vision Research* **27,** 1139-1163

Wallman, J., Adams, J. and Trachtman, J. (1981) The eyes of young chickens grow toward emmetropia. *Investigative Ophthalmology and Visual Science* **20,** 557-561

Wenssor, M., McCart, C. and Taylor, H. (1999) Prevalence and risk factors of myopia in Victoria, Australia *Archives of Ophthalmology* **117,** 658-663

Wildsoet, C. (1997) Active emmetropization - evidence for its existence and ramifications for clinical practice *Ophthalmic and Physiological Optics* **17,** 279-290

Wildsoet, C. and Wallman, J. (1995) Choroidal and Scleral Mechanisms of Compensation for Spectacle Lenses in Chicks *Vision Research* **35,** 1175-1194

Winn, B., Gilmartin, B., Mortimer, L. and Edwards, N. (1991) The effect of mental effort on open- and closed-loop accommodation *Ophthalmic and Physiological Optics* **11**, 335-339

Winn, B., Pugh, J., Strang, N. and Gray, L. (1998) Report to the Medical Devices Agency on the Evaluation of Autorefractors *Crown copyright*

Wood, J. and Bullimore, M. (1996) Interocular differences in visual function in normal subjects *Ophthalmic and Physiological Optics* **16,** 507-512

Woods, A. (1946) Report from the Wilmer Institute on the Results Obtained in the Treatment of Myopia by Visual Training *American Journal of Ophthalmology* **29,** 28-57

Woods, R. and Thomson, D. (1995) Effects of exercise on aspects of visual function *Ophthalmic and Physiological Optics* **15,** 5-12

Woods, R., Bradley, R. and Atchison, D. (1996) Consequences of Monocular Diplopia for the Contrast Sensitivity Function *Vision Research* **36,** 3587-3596

Woods, R., Bradley, R. and Atchison, D. (1996) Monocular Diplopia Caused by Ocular Aberrations and Hyperopic Defocus *Vision Research* **36,** 3597-3606

Young, F. (1961) The Effect of Restricted Visual Space on the Primate Eye *American. Journal of Ophthalmology* **52,** 799-806

Young, F. (1981) Primate myopia *American Journal of Optometry and Physiological Optics* **58,** 560-566

Young, F., Leary, G., Baldwin, W. and West, D. (1969) The Transmission of Refractive Errors within Eskimo Families *American Journal of Optometry and Archives of the American Academy of Optometry* **49,** 676-85

Zadnik, K. and Mutti, D. (1995) How Applicable are Animal Myopia Models to Human Juvenile Onset Myopia? *Vision Research* **35,** 1283-1288

Zadnik, K. Mutti, D. and Adams, A. (1992) The Repeatability of Measurement of the Ocular Components *Investigative Ophthalmology and Visual Science* **33,** 2325-2333

Appendix 1
Recruitment Poster

Shortsighted?
Are you interested in trying to get your sight back to how it used to be?

We are running a vision training project in the Vision Sciences department and are looking for participants aged 18-45.

For more information please contact
Anna Bambridge. Room M625.
Tel. 331-3382 or 334-6607
Email:A.Bambridge@gcal.ac.uk

or Dr Eve Pascal MCOptom
Room M518 Tel. 331-3385

Appendix 2
Questionnaires

There follows the questionnaires as were given to those in group A. Group C were given a similar questionnaire but with the questions referring to therapy techniques omitted.

As part of the vision therapy project I would like to collect some information about some of your experiences participating in the project. There is nothing compulsory about sharing this information. If you want to that is great but if not that is fine too. You can still continue working with your vision and attending sessions at the eye clinic.

There follows some questions with a line underneath. The ends of the line represent the two possible extremes of an answer to the question. To answer you should place a mark on the line which indicates where your answer lies in relation to the two extremes.

For example:

In the last 7 days have you been having fun?

No, Ive been in bed with flu

Yes, it's been a non-stop party

I have put my mark in the middle because it has been a quiet week but more to the right because my flatmate finished her exams and we had a celebration for that which was fun.

Today's date _____

In the last 7 days have you felt comfortable with your vision?

No, very uncomfortable — Yes, very comfortable

In the last 7 days have you felt frustrated with your vision?

None of the time — All of the time

Has this week been a typical week for you?

most unusual — very typical

In the last 7 days have your eyes felt tingly?

Not that I've noticed — Yes, they tingle all the time

In the last 7 days have your eyes been stinging?

No, they have felt fine	Yes, they have been really stingy

How are you feeling today?

feeling horrible	feeling fantastic

In the last 7 days have your eyes been watering?

Not at all I've been totally dry eyed	Yes, my eyes have been watering a lot

Approximately how much time have you spent without your glasses these past 7 days? (Awake time only)

None of the time	All the time

Approximately how much time have you spent palming these past 7 days?

0 hours 20hours

Approximately how much time have you spent wearing your reduced prescription in the last 7 days? (If applicable)

None of the time All of the time

Approximately how much time have you spent doing other vision activities in the last 7 days? e.g. going for a walk without glasses, swinging, shifting

0 hours 15 hours

There follows a couple of empty pages. These are for you to fill if you want to. There may be some points that the questions above raised that you want to express more fully or you may just want to say a few things about working on your vision that haven't been covered. These can be difficulties you have encountered with the project, good things you have discovered or just some vision anecdotes. Some people find the experience of writing about what they are doing useful so use this space for this if you feel like it. Any information you offer is appreciated and these pages will be returned to you to keep.

Appendix 3

Transcripts of the Interviews

19/5/99

A: If you can remember back to when you first had a session, what was that like?
No. 7: I thought it was really interesting, just generally learning, I thought it was interesting the whole psychology aspect of it - about actually why psychologically I could be myopic, and how I got bored, which fascinated me because an awful lot of it was true. And being a vision science student I just found it generally interesting. Just actually being able to see an improvement in my vision from doing the palming because I *was* able to see better. So, I came away really encouraged.
A: So that was in the first session you saw an improvement?
No. 7: Yes
A: And did that last?
No. 7: Hmm....No, it seemed to be temporary, but ..if I kept palming....generally after palming for a while there is an improvement in vision.
A:Were you asked to do any home exercises?
No. 7: Basically at the start it was just palming and I was to try and do that as much as I could.
A:How often was that?
No. 7: I try to do at least 10 minutes every day. When I was studying I would take a break and just put the music on and palm. I did one half hour stint but I never reached half hourly, I wouldn't do half an hour regularly. So I don't know whether that would have had an effect. But I couldn't have the time for the rest of it, I was just trying to get as much work done as possible, and the rest of it.
And then I was trying to do Shifting exercises to see which plane I could see more clearly in whether it was the horizontal or the vertical. Just to keep running my eye up and down it to see if I could make it clearer and later on...
A: How was that?
No. 7: That was actually interesting because I'd never noticed it before, that one line was actually clearer.
A: So what was clearer?
No. 7: The horizontal was clearer and I tried to get the vertical as clear which worked sometimes and it didn't sometimes, I don't know whether that was when I was tired or not. And then later on I was doing the stuff with the peripheral vision which I'd never noticed before either.
A: So what did you notice with your peripheral vision?
No. 7: I noticed that....I became more aware of it, that things were actually starting to become clearer, which I'd never, never seen before.
A: So are you saying that becoming aware of your peripheral vision made all of your vision clearer?
No. 7:Yes, but it was a lot harder to do because if you put something in your peripheral vision you just want to look at it straight away and it was hard to keep the awareness on the peripheral vision and look straight ahead and keep that in focus, and to get that in focus. But yeah it was really weird how the chart did become so much clearer.
A:So when you became aware of the periphery you could actually read further down the chart?

No. 7: Yes, well, it didn't like, all of a sudden the letters all became clear, it was very much they came into focus and out of focus a lot more, whereas before it was just all out of focus.
A: So there was more variability?
No. 7: Yes
A:So you've talked about palming, shifting...are there any other exercises that you have done?
No. 7: Well I was a bit worried about the binocular vision and I was encouraged to do the magic eye pictures to try and get them and I found dthey were so much harder to do with the reduced prescription at first. And it was harder without my glasses too and I hadn't noticed this before either and I was getting scared. "Oh no I've noticed so little about my eyes" But whenever I had my full prescription and I had full binocularity I could do them no problem but it was really difficult, but it was really challenging and my eyes felt really worked after trying to do them for a while.
A: So when you say your eyes felt worked, can you describe that more?
No. 7:It's like whenever you do any exercise with any muscle, your muscle feels really stretched and almost toned. So it was like the muscles in my eyeball were getting worked out and it was really bizarre.It wasn't the same feeling like after you've been studying for a while, it was different, because your eyes get tired after studying but it was very much as though my muscles felt like they had been pulled in every direction which was strange.
A:would you say it was a nice feeling or not a nice feeling?
No. 7: Well.....I just thought it was like another exercise except it was my eyes because at the start exercise can be a real annoyance, yes it's sore to start but it fels more natural as it goes on and you feel like your eyes are actually doing something.
A:So did you tell anybody about what you were doing?
No. 7:Oh yeah.
A:What was the reaction?
No. 7:Well, 3 of my flatmates wear glasses anyway and so they were actually quite interested. The whole psychology thing had me completely fascinated. I was like, wow, because I got bored in secondary school I had to get glasses. And just talking to them and when they started wearing glasses, oh yes, the same hypothesis...very bizarre. And yes just telling them about the palming. A couple of them thought it was really bizarre though, they thought it was really funny that I was doing it. I was a called a guinea pig for scientific research. A couple of the lecturers knew about it as well.
A:You mentioned that you have experienced changes in your vision. Can you describe those? First of all when do they happen?
No. 7: Whenever I'm not tired. They occur more frequently whenever I'm not tired. Definitely. I would have said that with the exams at the minute I wouldn't have noticed that much change in my vision because I have been studying so hard. So my vision hasn't been experiencing anything new.
A: What about during the vision therapy sessions?
No. 7: Those were really good. It was amazing. Putting what looked like a screen with lots of pinholes in it in front of the eye. That was really interesting because at the start I was like "why am I doing this?" because, honestly at the start I saw no improvement. I thought, there's nothing, the chart's still all blurred, but within about 10 minutes the chart, well I was reading almost to the 6/6 line and it was really weird to see such a change, to have it happen so fast. And doing things with the dominance of my eyes. I was throwing a bean bag with my left hand and I kept on dropping it and it was really bizarre to see how if I did that, how it affected the chart, and how it became clear, and unclear, clear and unclear whenever I threw it up. And I was like, "woah, what is this bean bag doing." So I was doing that and that was really interesting and I hadn't noticed just how little one of my eyes worked. Whenever I was seeing things...I did this thing with a thread to see how far...it was so obvious, one of the lines was hardly there.
A:The beads on the string?

No. 7: Yes, it crosses and one of the lines was just so faint and it really struck me how little one of my eyes worked. So then its was encouraging whenever I worked the other eye by throwing this beanbag. The chart started to have more variability and like the session with the peripheral vision. There was a pink spot put on the wall and because it was so bright your eyes couldn't fail to notice it.
A:So that's some of the changes you have noticed during the sessions. What about by yourself?
No. 7: Well I tried not to wear my glasses as much (the full prescription) and I generally wore the reduced prescription all the time. When I first got the reduced prescription, when I put them on I felt physically sick. I really did, it was such a change. I honestly felt really ill. I had to put the other glasses back on because I really did not feel like I could do anything at all. But I increased the time that I put them on and within a couple of days I'd got used to them and that really struck me as well how quickly I got used to them. At first I thought "oh no what have I let myself in for " because I really could not believe how ill I felt and I really didn't think my eyes could affect me that much, I was like "what's going on?" I walk into uni, and I walk down Great Western Road and there's so much to look at that I hadn't noticed before, especially things like the spires and chimneys and stuff and because I had done the things with vertical lines I was tryinng to shift up and down them as I was walking. That was really interesting to see how it did actually become clearer. I don't know if it was because I had had my glasses on and I knew what it was meant to look like or if in my brain I knew it was meant to be a straight line or whether it was actually becoming clearer.
A:So, you're wearing your reduced prescription and walking around. Do you see things changing, moving from blur to clear as you are moving around?Or is it a steady blur? How would you describe it?
No. 7: Some things I could see in focus and some things I could see not in focus. When I'm walking I'm not staring at something for a particularly long length of time. Various things at different distances were coming in and out of focus. I was looking at something, a chimney which would be a certain distance away and it would be in focus and then I'd walk further down and it would be the same distance away but it wouldn't be in focus. So things like that were really bizarre. I know that whenever I started wearing my reduced prescription I really thought that one of my eyes wasn't working as well as the other one.
A:So which perscription do you prefer wearing now?
No. 7: It depends. If my eyes are tired then I probably wear my full prescription. When you're tired you don't want to do any exercise and it's the same philosophy. When I study I don't wear my glasses at all because I find that I get a really bad headache if I do wear my glasses.
A:Is that a change from before?
No. 7: No I've always had really bad headaches when I study and wear my glasses. But if it was just for general use I would prefer to wear my reduced prescription because ..well it's interesting.
A:What does it feel like when you have been wearing your reduced prescription and then you put your full prescription on?
No. 7: Sometimes it feels like giving my eyes a big rest, and other times I don't really feel much of a change, it just depends how much work my eyes have actually done.
A:Would you recommend vision therapy to people?
No. 7: Yes, it has been interesting and it has made me a lot more aware of things I hadn't even thought about, things with my eyes. The whole periphery thing really got me, and the horizontal /vertical and the psychology aspect, because a lot of it did ring true, so yes I would.
A: Do you plan to carry on working with your vision? Now that the study is up what's your plan for your eyes?
No. 7:I think I'll try and keep palming, I'll carry on with it because I think it has been beneficial for myself.I think because when I wear my glasses, I know when I drive with

glasses you're not so much aware of your periphery. When you wear glasses you have to turn your whole head around. whereas with contacts you're much more aware of your periphery. Because I've never worn contacts, maybe that's had an affect on my peripheral vision. To actually become more aware of that has been really interesting and yeah, just to see things in a different light. It's turned things on it's head a wee bit.

20/5/99

A: It's a year ago you first had a vision therapy session. What were your impressions of it then? How did the first session go?
No. 1: I was a wee bit sceptical in the beginning, Not quite sure what to make of it all. I thought I was going to be more active, physically doing things. But as the time progressed ....(I haven't actually seen Aileen that many times.) The first time I really wasn't sure but I thought "well I'll give it a go anyway" I think I only really settled into it the second time I saw Aileen. I felt a lot more comfortable and I started to believe that you know I was noticing changes with my eyesight.
A:Were you asked to do anything at home?
No. 1: I was. ..My palming..which I thought was.. I took it to be a wee bit..."what's all this about" but again I was willing to give it a go and I have to admit that I was good in the beginning but laterly...
A:When you say you were good what do you mean?
No. 1: Well She would say to me if you can do it x amount of time.
A: How much time?
No. 1:Right, She was saying to me, I think, it was about half an hour every day.
A:And did you do that?
No. 1: Yes I was doing that, I was actually doing a bit more. And then when it would come up to the period of exams and stuff it completely went out the window and laterly I have not been doing it as much although when I did speak to you that time I was actually starting to do it again. I've actually been noticing I've been getting really bad eyestrain in the last four or five weeks so it's the first time I've really noticed that so I started doing it again {palming} and I do generally notice that it does help.
A: When you say it helps what do you mean? It helps with eyestrain, or vision?
No. 1: The main thing I find is my vision. I find that it's just sharper again. That's one thing I have noticed over the last year. ...I find that I go through periods...I mean that's one thing that I have noticed over the last year..when you or Aileen said..."you would notice" I really ..the first day that I noticed that my eyesight was really sharp... I noticed...I mean I continued to do the palming.
A: Is there anything else you were asked to do?
No. 1:The last time I saw Ailenn...which to be absolutely honest I have done nothing about. I had to do...it was to do with my dominant eye. I had to cover my dominant eye and learn to use the other eye and I found it so uncomfortable. And I've just not been doing it at all. I found it very hard to tolerate the spheres that I was given, the change in prescription so this was her saying that I should try to wear them a wee bit more and she gave me these little exercises to do but I really didn't enjoy doing them at all. That I really did not stick to.
A:Did you tell people about what you were doing?
No. 1: I did yeah.
A: What sort of reactions did you get?
No. 1: Some people just laughed at it. Other people actually wanted to know more about it and the biggest thing for a lot of people was the fact that people who knew me to wear my glasses al the time. I wasn't wearing my glasses anymore. I went to a wedding in January

and that was a big shock, I didn't have my glasses on. So those people that saw....and then there were some people who said there is no way that something like that could improve your vision.
A: You were saying that you experienced changes in your vision. Can you describe that?
No. 1: Well I'd go through periods of..mm..sometimes I.. I remember the first time that I actually really recognised it. My vision was really really really sharp but then maybe sometime later it was like totally blurred and I noticed going through these sort of stages of being, you know, everything was really reallly sharp and at other times it was just totally, mmm...
A: Did you ever experience something like that during the sessions with Aileen?
No. 1: She would make me palm. "Make me" That sound terrible. I would be palming and then I would notice. She would then give me an exercise to do, whether it was to read letters or whatever and I would know. I would notice at the time that there was a difference. I didn't in the beginning but certainly half way through, over the summer last year thats when I really really noticed a difference.
A: You were given a reduced prescription. Have you ever worn that?
No. 1: No not really
A: So what do you generally wear?
No. 1:Generallly I don't wear my glasses but I still need my glasses for driving and during lectures. So for that I have gone back to my old prescription.
A: And how has that changed from before you started with the project?
No. 1:Before I was wearing my glasses the whole time. They would go on in the morning and come off at night. Whereas now as I said I only wear them when I absolutely feel that I have to.
A: And how do you feel about that change?
No. 1:: Good. Although the thing is now I actually don't like wearing my glasses because it feels like this big heavy weight on my face and I don't actually like wearing them now.
A: Would you recommend vision therapy to people?
No. 1: I definitely would. In the beginning I was really sceptical but because it has definitely helped me. But it's saying to people that they've actually got to work with it if you know what I mean. It's up to them. It's very much up to them how much they do. But there's some people who I don't think would be suited to it at all. But definitely for some people it would be of benefit.
A: What are you planning to do now that the project is over?
No. 1: Well I'm actually a wee bit confused about it all. At the end of the day I still don't know... I believe that I should have a prescription. I don't know what to do, you know, I don't know where I am. Not because, hmm. that I'll have to wear my glasses every day or anything but I feel for driving. I'm not really sure how much it has actually changed from that point of view but I have got no intentions of going back to wearing my glasses. I wouldn't feel comfortable going back to wearing them full time but I'm just not sure.
A: How does it feel when you first put your glasses on?
No. 1: It just feels really really strong. So I don't know whether...
A: When you say really strong..?
No. 1: It's like putting on the glasses of someone who is double the prescription that you are it just... Not that it's that much but it just.. It's just really so sharp and so small.
A: If given the opportunity for more vision therapy sessions would you take them?
No. 1: Yes I would , I'd never go back to wearing my specs full time. But in the last few weeks I was getting really bad eyestrain and doing the palming really helped a lot.

27/5/99

A: If you can remember back to your first session. What was that like?

No. 2: The first session she asked me to not wear my spectacles most of the time, I started to do that. You know on a good day you could see better, on a bad day it would be as if...sometimes it would be better in the morning and worse at night time. So you have good days and bad days
A: What were your first impressions of actually working with your vision?
No. 2: I was quite keen to start with, I wanted to make it work, see what would happen.
A:Had you heard about it before?
No. 1: I'd heard about it before. Some of the lecturers here thought it was pretty bad.
A:Were you asked to do anything at home?
No. 2:Yes, palming
A: And did you do that?
No. 2: Yes to start with.
A: How much were you asked to do?
No. 2: As much as possible, it started off quite well.
A: About how long?
No. 2: Every day if possible
A: For how long each day?
No. 2: It wasn't specific
A: Just as much as you wanted?
No. 2 Yes. Originally it was good going but after a while it got boring.
A: And what did you do then?
No. 2: I stopped doing it.
A: Did you explain to people what you were doing?
No. 2: No, nobody asked. They're not interested really.
A: Have you experienced any changes in your vision?
No. 2:Well I am wearing the lenses that you gave me and my vision is fine now. Initially when I put them on ..the vision you know was...quite comfortable. The only thing I noticed was when I went for the bus. In the distance I couldn't make out what the buses were. Now I don't have a problem with the buses. I don't know if it is because my vision has improved or if I am just learning to distinguish which bus. I don't have a problem with buses now.
A: So do you ever see blur and clear? Or something like that?
No. 2: With or without my specs?
A: Anytime either during some of the sessions or by yourself ouside.
No. 2: In the sessions there was an instant improvement. You'd sith there with Aileen and you know she would ask you to do things and all of a sudden it would be clear. You notice the difference between before you've done the exercise and after you have done the exercise. Outside as well on a sunny day my vision is a lot better. I notice the difference. On a cloudy day, you know, it's not as good. Before I didn't notice things like that because I used to wear my spectacles all the time anyway.
A: So there's changes now that you notice that you didn't before?
No. 2: Yes, that's right.
A: What activities make a difference to your vision? When you say that it goes clear, what are the things that makes it go clear if there is anything specific?
No. 2: If I relax it tends to go clear. Apart from that...
A: What about the palming?
No. 2: Palming makes a difference as well.
A: You've got a reduced prescription.
No. 2: Yes and I wear it all the time. I don't wear my other spectacles now. When I do wear them when I can't find these ones what happens is the vision is too sharp, it's sore on the eyes.
A: So you prefer your reduced prescription glasses?
No. 2: I prefer these ones yes.
A: How do these feel compared to the other ones?

No. 2: The objects seem to be better defined slightly although there is not much of a difference but it really doesn't feel right.
A: So which ones don't feel right?
No. 2: The old ones.
A: So what is better about these ones.
No. 2:Everything looks normal.
A: But how do they feel?
No. 2: They feel comfortable.
A: Now you know what is involved in something like this would you do it again?
No. 2: Yes I'd do it again but I'm one of these people who loses interest fairly quickly.
A: And would you recommend it to family and friends? Would you recommend working like this?
No. 2: To reduce the prescription?
A: Yes
No. 2: To me it seems to have worked. My prescriptions gone down about 0.75 of a dioptre. My eyesight's not that bad but for somebody with thick spectacles they might want to reduce them to make the spectacles thinner. It seems like a good idea.
A: Do you plan to carry on trying to work with your vision?
No. 2: I don't know to be honest with you.
A: If you were offerred more time with Aileen would you take it?
No. 2: If I was offereed more time, yes I probably would take it because it is interesting to see what's happenning.

2/6/99

A: If you can remember back to your first vision therapy session. What was that like?
No. 24: Well, it was all very informative and I didn't expect there to be any radical change in my eyesight but from start to finish I felt as though what I was doing was worthwhile and I felt that there was, if not a measureable, tangible improvement, I felt that what I learned, if I stick with it will, I think improve my eyesight. It made me think about my eyes in a different way. It made me regard them as a set of muscles that I had woefully underutilised tfor 30 odd years.
A: And so initially going into the first session what was that like?
No. 24: Well I had no idea what to expect but...I actually can't remember too many details of the first session with Aileen, I can't remember. It was all instructive, informative.
A: Where you asked to do anything at home?
No. 24: Yes I was asked not to wear my glasses at home and do palming, and do one or two exercises. At one point relatively early on I began to do some exercises but thereafter they never came back again. I don't know what happened to them.
A: What do you mean by never came back?
No. 24: Well I was never told to do them again - the exercise sort of allowing your eye to wander along the edge of the ceiling. That happenned really briefly in one session and then never came back again.
A: So did you do any of the other things??
No. 24: I did the palming but not enough. I walked around outside wallking the dog without my glasses on and I've got the half strength glasses of course which I've worn at work but not as often as I should have done.
A: How much palming do you do?
No. 24: I've never really done more than probably on average about 1 5 or 10 minute session a week because I just found it difficult to establish a routine. My life's got certain routines but perhaps not as many as there should be.
A: Did you explain to people what you were doing?

No. 24: Yeah.
A: And what was the reaction?
No. 24: Generally positive. You saw a light bulb go over peoples' heads when you say "the eyes are a set of muscles so therefore you can exercise them".
A: Have you experienced any changes in your vision?
No. 24: No, none that are really measurable. I experienced the temporary change that you get through palming.
A: That's what I mean, I just mean any changes at all.
No. 24: The temporary palming change.
A: Can you describe that?
No. 24: It just became clearer for a brief spell, not momentary but a spell.
A: So was that during some of the sessions or was that by yourself?
No. 24: It was during the sessions beccause I spent longer palming during sessions than I did on my own.
A: And what did that look like?
No. 24: Well it was closer to what my vision is like with glasses.
A: So were there any other activities apart from palming which made a difference?
No. 24: I enjoyed walking about outside without my glasses on. I walk the dog at night and as I was doing it through the winter, I don't know if it was because there were cold winds at night but it tended to make my eyes stream which I felt improved them.
A: And you've got a reduced prescription. Which prescription do you prefer wearing?
No. 24: I suppose to be honest I prefer the full strength prescription. The half strength one, I feel that it is a beneficial thing to do, I am convinced of that.
A: What does it feel like with the reduced prescription?
No. 24: It feels blurry but I feel that doing those makes my eyes do more work as a set of muscles within the body.
A: How is your vision in the reduced prescription?
No. 24: Blurry but acceptable for what I use it for which is sitting in front of a computer monitor.
A: Have there been any changes with your vision when you are wearing your reduced prescription?
No. 24: No
A: Now that you know what is involved in the project would you do it again?
No. 24: Yeah
A:And would you recommend working with vision?
No. 24: To other people? Oh yeah, I'd recommend it to anybody.
A: Do you plan to continue working with your vision.
No. 24: I do and I have been.
A: So what is it that's making you come back?
No. 24: I don't know. The belief that I have I don't know how many years of life left in my eyes and for a very long period I've not really thought about my eyes as being a kind of organic part of me, of my body. I've just regarded them as my eyes unconnected to everything else. And just by doing a few simple things I can rest them, if not actually improve them or I can certainly not contribute to their steady decline.

2/6/99

A: Can you remember the first time you saw Aileen?

No. 11: Vaguely, it's so long ago now.
A: Can you tell me a bit about it?
No. 11: No, I can't remember anything about it. I remember a big rectangular bit of foam and I remember her telling me when we did the palming that I wasn't doing it right. She moved me all about getting me up, putting my feet on the floor, getting the weight going right through the back of my back, stretching my neck up and allsorts of things like that. It's all a haze, I couldn't put it in any order.
A: Were you asked to do anything at home?
No. 11: Yes
A: What?
No. 11: I was asked to do the palming. I was asked to get a big bit of foam and I duly went down and got a big bit of foam, it was about £3.84 which seemingly is quite cheap I was asked to do palming for up to an hour which I tried to do. Sometimes finding an hour's a wee bit hard. I can't remember if it was the first one or the second one when we did also another exercise which I have. It involves standing and moving about from side to side following colours. I only did that..and then dropped it by the wayside due to..well we did it over the next couple but over Christmas I sort of stopped doing it.
A: Did you do it at home?
No. 11: I did do it at home up until Christmas.
A: So how often were you palming?
No. 11: Well at the start I was trying to do it every day and not managing.
A: Did you do it every day?
No. 11: Oh God No.
A: So when you say you didn't do it every day..?
No. 11:I was probably doing a half hour five days. Leading up to Christmas I consciously did try to get it up to like an hour a day and I was making it an hour a day but Christmas. After Christmas I started it again. I've been quite good at it since Christmas and also I've probably been a bit more relaxed since Christmas personally, in some ways. Work is about to go hectic again but I think that I have been making the time more. I find it easier to make the time just through the fact that I have been doing it but it was hard finding the time.
A:Did you explain to people what you were doing?
No. 11: Not really, one or two. On the whole I just said that I was going to the eye clinic. After I explained it to the first couple, not embarassment or anything I just got bored telling them about it. The first couple I was really excited about it, "oh yeah listen to this, listen to this" and they went yeah, right okay so then I just said "eye clinic appointment."
A: Have you experienced any changes in your vison?
No. 11: I think so. I think I have noticed a slight improvement.
A: Can you describe that? When is it that you notice? What is it that you notice?
No. 11: I can get by without my glasses on...Not 100% but previously I would not have my glasses on and I would be totally blindwhereas now if I'm wallking along without my glasses on I sort of take my time and I look and I can sort of concentrate on things and focus in inverted commas. I just don't stumble about. It's like trying to see past that oh it's a bit blurred I can't see it, oh it's a bit blurred concentrate on it.
A: And what about during some of the sessions?
No. 11:Oh God I mean like in the actual sessions itself, I mean it was very noticable the fact that I would come in, I'd have rushed up the road, I'd be like "aw no, I can't see, I can't see, I can't see" and then come the end of it Aileen would be like " right so have a look at that does it look clear" and I would be like "good grief there's a computer there, I couldn't see it before" sort of thing. I could actually see things in the room which I couldn't see before. I don't think that it was due to just becoming adjusted to the room, I think it felt like I'd relaxed, I was concentrating,and I was actually....I just felt that I was..
A: Was that with the chart or objects?
No. 11: It was mainly objects. The times that we did charts, I mean yeah I could notice it more because. It's not because I knew what the letters on it were or anything but I really

didn't have to struggle to get the next line. When the chart was stuck up at first I was like "oh no I can't get it" but then later on it's like well I mean it was still blurred but I can make it out as opposed to not being able to make it out.
A: So what activities make a difference?
No. 11: Doing a lot of stuff with like....looking round the room...following coloured balls and stuff and that was the kind of thing that made me do it.
A: And you've got a reduced prescription?
No. 11: Yes
A: And which prescription do you prefer?
No. 11: Well it's a bit of a pain because these {the reduced ones} don't have astigmatism and that's quite difficult. But I think in terms of strength I prefer these. I can just see the same. I know these aren't as strong and I can see the same with these as I can with the other ones. So obviously there must be something "wrong". The other ones are possibly too strong. And I just feel that perhaps all along your just getting strong prescriptions and strong prescriptions and it's just making your eyes lazy.
A: So what do you where now?
No. 11: I'm wearing these
A: That's your reduced prescription. And do you wear those all the time?
No. 11: Yeah, well all the time that I am wearing glasses I wear them.
A: So what about your full prescription?
No. 11: I never wear them now. I mean I've not had them on since before Christmas.
A: Now you know what's involved in the project would you do it again?
No. 11: yeah
A: And would you recommend it?
No. 11: Oh yeah. I got the Bates method book, I would loan it out to friends.
A: Why would you do that?
No. 11: Because there's a big sort of bit of regret that I might not be as blind as i've been led to believe.over all the years and Aileen actually explained astigmatism to me and I knew what it meant but I'd never really known that when I was sitting down watching the chart in the optician that the I couldn't make out the letters because ..you were seeing more images. They were never really explaining the difference between the blur and the astigmatism and possibly to not need such coca cola type glasses. I just think I may never have needed glasses. My eyes have become used to them over the years. I don't remember having anything wrong with my vision and then I got told I needed glasses. Back at the turn of the century people got locked up for no reason maybe it's just progressed to something that's sor t of smaller and more insignificant as glasses
A: Do you plan to continue working with your vision?
No. 11: Yes I do want to follow it up and do someting, yes, I don't know what yet.

3/6/99
A: Can you remember your first session?
No. 22: Yes
A: What were your impressions of that?
No. 22: I went along with an open mind and I thought it was a bit weird. It wasn't what I expected. There was one thing that she said which was really weird. I was sitting with one leg crossed and she said "No, no, no you've got to put both feet on the floor to let the power in" or something and I was like "oh dear". I think that was the weirdest thing she said to me, I didn't wanted to get into why I need the power to come up my trouser legs to get me to see. I drew back at that point. But other that that there was nothing too untoward.
A: Were you asked to do anything at home?
No. 22: Yes, I was asked to not wear my glasses as often as I could. And also when I didn't have my glasses on to look rather than just glance and to do palming exercises.
A: And did you?

No. 22: Some of the time. I've got to admit doing it in the office was very difficult with my colleagues. The idea of them coming in and finding me with my hands over my eyes they'd be like ""what's wrong?" and I'd say "nothing go away". So it was difficult from a social standpoint and at home with a small baby is not a great environment for doing it. You need a desk as well, I mean I have a desk at home but it's always full of junk.
A: So about how much did you do?
No. 22: I started reasonably sort of keenly and it tapered off quite badly. I mean it's quite a nice thing to do. I didn't feel any immediate benefits so I suppose...I think you get this feeling that there's no immediate returns so you...
A: Did you explain to people what you were doing?
No. 22: Yes, yeah, they thought I was weird. One guy couldn't believe it, he was really funny, he said "why do you want to get rid of your myopia, you'll be thankful of it when you are a little bit older". Other people, yes they were quite dismissive.
A: Have you experienced any changes in your own vision?
No. 22: No I don't think I have.
A: Either at home or during some of the sessions?
No. 22: No, Not at all, I didn't, if I was to be honest. I suppose there is an element of wanting to please the therapist, and I tried my best not to fall into that. I think Aileen found it irritating when I would use fixed points. She'd put a vision chart up to illustrate some point and then got me to look around the room. I would have remembered to what line I could see on the chart so that after I had done something I could then use that as my reference point and she would be like "oh no no no don't look at that, just generally how do you see" and I suppose it's a difference. It might just be the analytical, you're looking for the right answer, rather than some nebulous general impression of what your vision is like.
A: You've got a reduced prescription.
No. 22: Yes, I have it with me.
A: Do you ever wear it?
No. 22: Yes, I actually wear it at the desk, that's the commonest place I wear it. I can see my computer through it. To begin with it was very unbalanced, but now they're quite balanced. The computer screen if I sit at normal reading distance I can manage it okay.
A: Which prescription do you prefer?
No. 22: I prefer the one I can see through. I could do this work quite easily now with the reduced prescription. The problem is if I look out of the window or decide to go along the corridor to get a printout and there is someone at the end of the corridor waving at me and I'm like "who is it, is it someone I know or someone I don't know". That was actually really one of the most embarassing things, not being able to read peoples' faces. I mean at home it's less of a problem. You can tell someone's upset with you because they're shouting at you but in a social setting, looking around the room it's like..well you really on your vision to decide what's going on and if you are going to speak to them or if you are Not going to speak to them. It was akward so I stopped doing it. Even if I had been wearing my reduced prescription at my desk I would put the other ones on if I was going out.
A: Do you feel a difference between the two prescriptions?
No. 22: Oh yeah, you can't see through these.
A: What about how they feel, is there a difference?
No. 22: Well for close work it's fine. Different in what way?
A: Anyway. It's an open question in case you had noticed any difference. I mean sensation or comfort or...
No. 22: I think that it is less stressful to wear glasses you can see through than the reduced prescription. I mean you end up screwing your eyes up.
A: Now you know what's involved in the project would you do it again?
No. 22: I suppose because I don't feel that my vision has improved. I really came to it quite excited. I knew absollutely nothing about vision therapy and I've never really wanted

anything like LASIK or PRK because I knew the disadvantages...I suppose in retrospect....
A: So is that a no?
No. 22: I suppose it is. Well maybe, I don't know. I'd maybe give it another crack.
A: Would you recommend it to anybody?
No. 22: Uh..that's a harder question I mean because I didn't feel any benefit then it's harder to recommend.
A: Do you plan to keep working with your vision?
No. 22: I more than likely will and I don't know why, it's illogical isn't it. I'll keep using these reduced prescription specs and I suppose rationally I couldn't say why.....and I suppose you do see your prescription getting stronger and stronger and stronger.

No	Did you experience an improvement through palming?	How much home practise of palming did you do?	How much do you wear your reduced prescription?	Did specific exercises improve your vision?	Did other people take an interest in what you were doing?	What was your overall impression?	Will you continue working with your vision?	Would you recommend vision therapy to people?
1	Yes.	1/2 hour per day	Not at all I went straight to wearing no glasses most of the time.	Yes, shifting.	Some laughed, some wanted to know more.	There has been a general improvement so that I don't wear my glasses most of the time now.	Yes, I will never go back to glasses full time.	Yes, to the right people if they know that it is up to them.
2	Yes.	A little at the beginnning and then I stopped	All the time	Yes. (but exercise unspecified)	I didn't tell anyone.	I can now read bus numbers with the reduced prescription.	I'm not sure, probably not.	Possibly.
7	Yes.	10 mins per day	Some of the time I wear the reduced some of the time the full prescription.	Yes, shifting and peripheral vision exercises.	Yes, there was general interest.	Things became clearer out of doors when I was walking without glasses.	Yes, I'll keep palming.	Yes.
11	No specific quote	1/2 hour 5 days a week	All the time.	Yes. (but exercises unspecified)	They were not that interested.	I've noticed a slight improvement.	Yes, but I'm not sure how.	Yes, I bought the book and would loan it to friends.
22	No.	Some at the very start and then I stopped	For computer wear only	No.	They were dismissive.	There have been no changes at all.	Yes, I'll keep using the reduced specs.	No.
24	Yes.	10 mins per week	Sometimes at the computer.	None specified.	There was a positive interest	There have been no obvious changes.	I plan to.	Yes.

Table 8.1.1 Themes from interview texts