SCIENTIFIC EVIDENCE TO SUPPORT THE ART OF PRESCRIBING SPECTACLES

Identification of the clinical scenarios in which optometrists apply partial prescribing techniques and the quantification of spectacle adaptation problems.

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Abstract

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***Keywords*:** Partial prescription, spectacle dissatisfaction, subjective refraction, maxim, evidence based optometry.

Although experiential prescribing maxims are quoted in some optometric textbooks their content varies significantly and no direct research evidence was available to support their use. Accordingly in chapters 2 and 3, the uses of several potential prescribing rules were investigated in the UK optometric profession. Our results indicated that the subjective refraction result exerted a strong hold on the prescribing outcome with 40-85% of optometrists prescribing the subjective result in a variety of scenarios. The finding that after 40 years qualified, experienced optometrists were three times more likely to suggest a partial prescription was an important discovery that provides significant support for the prescribing rules suggested by various authors. It would also appear from the results of the retrospective evaluation of the "if it ain't broke, don't fix it" clinical maxim in Chapter 4 that spectacle dissatisfaction rates could be reduced by between 22 to 42% depending on how strictly the maxim is interpreted by the practitioner. Certainly an "if it ain't broke, don't fix it much" maxim was suggested as being particularly appropriate. Chapter 5 included a re-analysis of previously published data that found no change in falls rate after cataract surgery to investigate any influence of refractive correction change and /or visual acuity change on falls rate. Unfortunately these data were not sufficiently powered to provide significant results. In chapter 6, a spectacle adaptation questionnaire (SAQ) was developed and validated using Rasch analysis. Initial studies found no differences in SAQ with gender or age.

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Chapter 1

Introduction

1.1 Spectacle prescribing

The prescribing of spectacles is probably the principal function of most UK community optometrists and accordingly, spectacles contribute the largest portion of the £2.7 billion UK optical industry (Mintel Retail Research, 2008). Given this information, it is somewhat surprising that there is very little direct research evidence regarding how practitioners make spectacle prescribing decisions. For instance, should the power of the spectacles prescribed be determined solely by the objective and/or subjective refractive process or is the prescribing of spectacles more complex than this? The process of refraction encompasses a myriad of complex sensory and motor functions, neurological, psychological and cultural factors (Safir, 1975), with Walsh (2009) stating that "although many practitioners may wish it to be a science, prescribing spectacles is essentially an art". This statement implies that there are other factors which must be considered when prescribing spectacles rather than simply considering the refractive result in isolation. The concept of practitioners adjusting the power of the spectacles (partial prescribing) to help patient adaptation and/or comfort is discussed in most of the standard optometric textbooks (Elliott, 2008). However the advice provided often varies considerably both in quantity and type depending on the source. Optometric textbooks such as Zadnik (1997) and Rosenfield and Logan (2009) cover most aspects of primary care optometry provision but make no mention of partial prescribing, whilst

Grosvenor (2002) only considers the issue of partial prescribing in the context of changing the spherical prescription to aid binocular vision problems. This prescription modification is not aimed at easing spectacle adaptation difficulties as generally experienced more by the older patient (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007) but conversely is more relevant to younger patients. In the context of partial prescribing to facilitate spectacle adaptation, other texts provide a section or chapter on when and how practitioners should make adjustments to the prescribed refractive correction (e.g., Wick, 1960; Giles, 1965; Ball, 1982; Obstfeld, 1988; Polasky, 1991; Fletcher, Still & Allen, 1998; Carlson & Kurtz, 2004; Newman, 2006; Elliott, 2007; Eperjesi, Bartlett & Dunne, 2007; Lee & Tahran, 2007). Furthermore, there are three textbooks that focus almost exclusively on this topic: *Clinical Pearls in Refractive Care* by US optometrists Werner and Press, *Refractive Management of Ametropia* edited by Brookman, another US optometrist and *The Fine Art of Prescribing Glasses Without Making a Fool of Yourself* by US Ophthalmologists Milder and Rubin. However it is interesting to note that as only the latter title has been updated and published as a third edition, these texts may not be widely used in optometric education. Thus in summary, it is difficult to quantify whether partial prescribing and its concomitant guidelines are merely esoteric advice given in some textbooks but not others, to what extent they are taught in undergraduate programmes throughout the UK and the rest of the world and to what

extent, if any, practitioners actually apply these guidelines in the course of their professional practice.

At this juncture, it should be noted that the principles of partial prescribing referred to throughout this thesis are only intended to apply to adult patients. The prescribing of spectacles for infants and children will not be discussed further, as other factors such as emmetropisation and the treatment or prevention of amblyopia and strabismus predominate in the prescribing decision (Farbrother, 2008).

1.2 Overview of spectacle dissatisfaction.

Historically the term “patient non-tolerance” has tended to be used by optometrists and dispensing opticians to describe spectacle problems that could not be rectified by addressing dispensing difficulties. However it could be argued that this label is somewhat of a misnomer as it subconsciously attributes blame to the patient for not being able to “tolerate” what was by implication a correct refractive correction. In most cases the problem lies not with the patient, but with a prescription error made by the prescribing clinician (Cockburn, 1987; Mwanza & Kabasele, 1998; Hrynchak, 2006; Freeman & Evans, 2010). Therefore perhaps it would be more appropriate to describe any patient who is unhappy with their new spectacles as exhibiting spectacle dissatisfaction.

There are many possible potential reasons to explain why a patient may be unhappy with their new spectacles and these are summarised in Table 1.1. When a patient returns to report problems with their new spectacles, it is mandatory to take a full history including onset, frequency, severity, duration of symptoms and whether these were present when wearing the habitual spectacles (Gordon & Amos, 1987). As can be seen from Table 1.2, poor adaptation and incorrect refractive error assessment represent only a small subset of the possible reasons for spectacle dissatisfaction. Other issues which could be termed “dispensing issues” should not be underestimated, as Brooks and Borish (1979) suggest that the majority of complaints in clinical practice are related to the physical fit of the spectacle frame. This may be simply due to poor frame adjustment or more complex psychological issues such as the patient reporting discomfort, but the underlying reason for dissatisfaction is that they have changed their mind regarding the cosmetic appearance of their chosen frame. Clearly, in this latter situation no amount of frame adjustment is likely to pacify the patient.

A further category of patients expressing problems with their new spectacles could be derived from “lens issues”. These problems stem from changes made to the lens design of the new spectacles when compared to the patient’s habitual spectacles and may, for example be relatively simple issues such as the placing of the bifocal segment. Other differences may include the positioning of optical centres, presence of an

anti-reflective coating or changes in lens base curve or lens form (Table 1.1).

Table 1.1 Summary of possible explanations for spectacle dissatisfaction (adapted from Gordon & Amos, 1987).

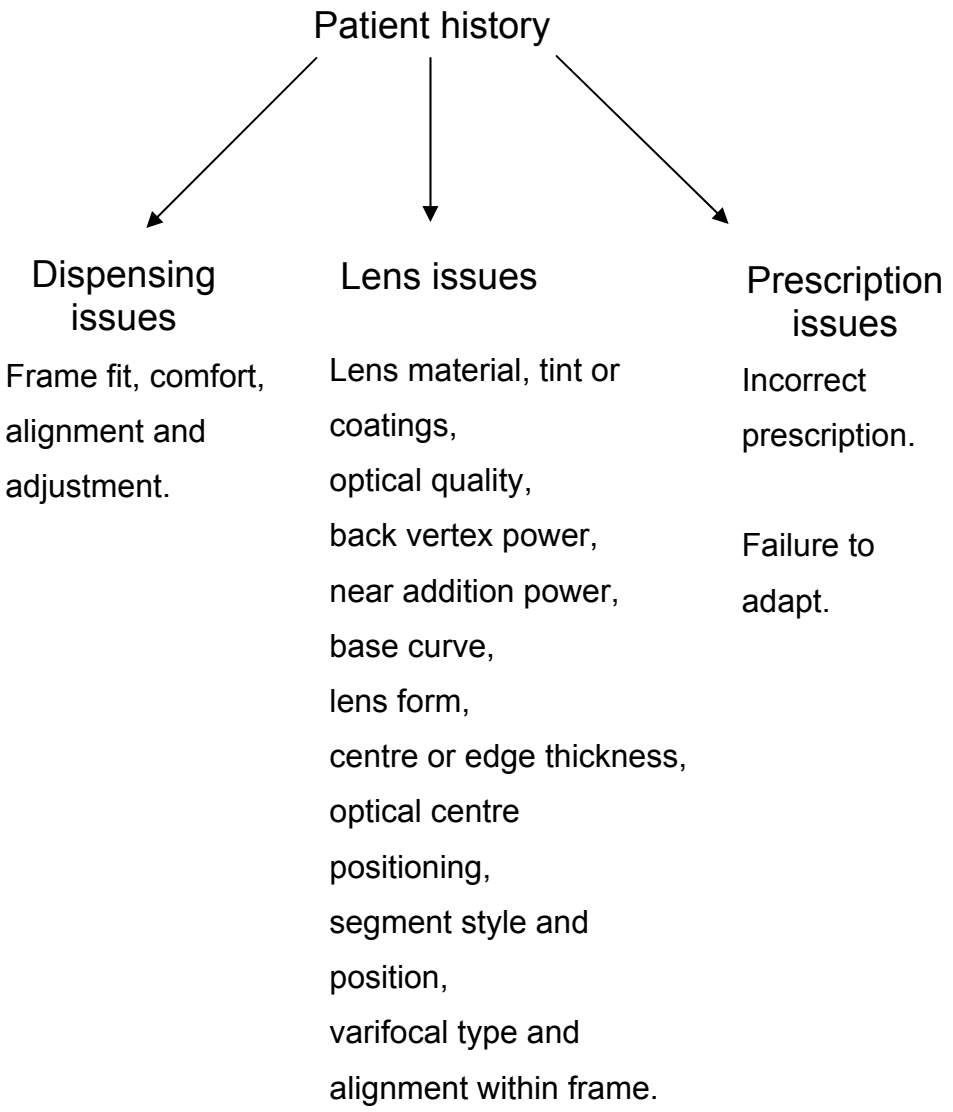

Table 1.2 Potential causes of patient dissatisfaction with new spectacles (from Gordon & Amos, 1987, D*iagnosis and Management in Vision Care*, Butterworths, Boston, USA, p. 256).

Refraction problems	**Lens problems**	**Frame problems**	**Other problems**
Refraction error	Poor cosmesis	Improper fit or adjustment	Financial
Laboratory error	Induced prismatic effects:	Improper alignment:	Patient not properly educated:
	Improper optical centre placement	*Pantoscopic tilt*	*How to use spectacles*
Change in patient's refraction:	*Vertical imbalance*	*Vertex distance*	*When to use spectacles*
Contact lens induced	*Image jump*		
Drug induced		Inappropriate frame selected:	Psychological:
Systemic disease	Induced magnification effects:	*Poor fit*	*Motivation*
Ocular disease	*Base curve*	*Poor cosmesis*	*Personality (vanity)*
Idiopathic	*Centre thickness*	*Excessive size or weight*	*"Appliance neurosis"*
	Vertex distance		*Hysteria or malingering*
	Cylinder form		
	Segment type and position		
	Reflections		
	Lens materials or weight		
	Surface quality		

1.2.1 Dispensing issues

Apart from the patient's perspective of the physical fit and comfort of their chosen spectacle frame, other factors such as vertex distance can produce significant visual symptoms when different to the patient's habitual spectacles. This is not only due to the effective power of the lens being changed but also due to the spectacle magnification power-factor component which will be discussed in more detail in section 1.5.1.

Pantoscopic tilt is another important dispensing factor which must be considered. Properly adjusted spectacles possess a tilt of 8 to 10 degrees so that the optical centre is positioned midway between the distance and near lines of sight to minimize induced prismatic effects (Brooks & Borish, 1979; Stephens, 2006). Incorrectly angled lenses may also induce both astigmatic and spherical power errors so affecting the patient's optimal visual acuity (Gordon & Amos, 1987). As with vertex distance changes, these induced power changes are accentuated in patients with high prescription lenses and aspheric lenses (Atchison & Tame, 1993). Further problems created by incorrect pantoscopic tilt can also be found in the fitting of varifocal lenses, whereby tilt may have to be increased to maximise the width of the reading area (Gordon & Benjamin, 2006; Essilor, 2012).

1.2.2 Lens issues

The distance prescription for all lenses is designated and verified in terms of back vertex power. Accordingly, one of the first steps is verification that the power of lens specified in the spectacle prescription is actually present in the new spectacles. Near addition power should be verified by use of the front vertex power as this power more closely approximates the near effectivity of the lens. This is due to the effective power of a lens being different for near objects than for distance objects and stems from the significant vergence effects produced by lens shape and thickness (Gordon & Amos, 1987).

The correct positioning both horizontally and vertically of the optical centres of the lenses should also be verified and compared to the habitual spectacles. Any asymmetry in vertical positioning may induce unwanted vertical prism and explain the cause of the patient dissatisfaction. In particular, the habitual spectacles should also be checked as incorrect optical centre positioning in these spectacles may have created a prismatic effect for which the patient has adapted (a case record of this occurrence can be found in Milder & Rubin, 2004a). Therefore seemingly correct optical centre positioning in the new spectacles may actually be the cause of the dissatisfaction in a patient adapted to the habitual prism.

A change in the base curve, lens form or centre thickness will induce magnification changes that may also produce symptoms in some patients.

Base curve and centre thickness exert an effect on the shape factor of the power-shape product that in turn determines spectacle magnification (see section 1.5.1). However the power magnification differences induced by the new prescription are usually much greater than any change in shape magnification difference (Stephens & Davis, 2006). Although modern toric ophthalmic lenses are mostly of the negative cylinder meniscus form, occasionally it may be found that the patient's habitual spectacles are of the plus cylinder form. The change from positive to negative cylinder form (or vice versa) may result in symptoms of spatial distortion due to the differences in meridional magnification provided by the two lens types. This also occurs due to the effect on the shape factor component of spectacle magnification (section 1.5.1) and thus one argument in favour of the use of minus cylinder form, is that the shape factor is the same for both principal meridians (Rabbetts, 1998). Therefore it would seem prudent to keep the same lens form especially for patients who wear spectacles constantly (Fox, Smith & Hirsch, 1972).

When spectacle dissatisfaction is reported with bifocal or multifocal lenses other parameters must be considered as potential sources of symptoms. Bifocal segment type, size and height and inset should be compared to the habitual spectacles. If possible, varifocal lenses should be of the same type as habitually worn and alignment and fitting cross positioning must be carefully verified (Gordon & Benjamin, 2006).

1.2.3 Prescription issues

This category represents cases of spectacle dissatisfaction resulting from either incorrect refractive error assessment or patients unable to adapt to their new prescription. Only three optometric studies have reported rates of patient dissatisfaction with spectacles in optometric practice and an indication of likely causes. Cockburn (1987) reported 53 cases of spectacle dissatisfaction arising from 937 patients who were dispensed spectacles (from 1,768 eye examinations; a 53% dispensing rate) by a Melbourne suburban practice and suggested a 5.7% “rate of complaints”. However this headline rate included patients who were dissatisfied as a result of dispensing errors and failure due to poor communication with the patient. Using Table 1 from this paper (reproduced as Table 1.3) suggests a spectacle dissatisfaction rate as previously defined above, in the range of 2.5-3.0%. An exact figure is not possible to calculate due to some cases of complaint having multiple causes and some patients registering more than one complaint. The most common causes of patient dissatisfaction were incorrect refractive assessment (approximately 43%), followed by image distortion (~ 26%) and unsuitable near working distance (~ 20%).

Table 1.3 "Causes of complaints about new spectacles in 53 cases arising from 937 patients for whom spectacles were prescribed in a prospective sample of 1768 consecutive patients of an optometrist."
(from Cockburn, 1987. Why patients complain about their new spectacles. *Clin. Exp. Optom.* 70, 92).

Incorrect refraction		15
Comprised of:		
Under corrected hyperope	4	
Over corrected hyperope	5	
Under corrected myope	1	
Over corrected myope	1	
Cylindrical lens power or axis incorrect	4	
Unsatisfactory communication with patient		10
Image distortion		9
Comprised of:		
Aniseikonia	7	
Distortion of lens surface	2	
Near working distance not as required		7
Unreasonable expectation of improvement in vision		6
Expected to see at distance with reading correction		3
No common language between patient and optometrist		2
Difficulty adjusting to multifocals		2
Monocular diplopia		2
Difficulty adjusting to low vision aid		2
Photosensitive lenses too dark		1
Laboratory dispensing error		1
Objects magnified through reading glasses		1
Objects not magnified through reading glasses		1
Vertical prism needed to prevent diplopia		1
No cause identified for complaint		7

Hrynchak (2006) reported 400 cases of "failure of spectacle lens acceptance" from an estimated 25,718 prescriptions (1.6%) from a Canadian University teaching clinic. The number of cases that were attributed to refraction errors and adaptation problems was 262 giving a spectacle dissatisfaction rate of approximately 1.02%.

Incorrect measurement of the refractive error was identified as the major cause in 223 cases (85% of 262) and failure to adapt in 39 (15%). This study assumed that 'Spectacle Reassessment Records' were completed for all "recheck" cases examined within the clinics. If these forms were not completed, the recheck case would not have been included in the study. In addition, the number of spectacles prescribed in the 6-year period was estimated as 58% of 44,341 patients from reviewing the prescription rate found in a random sample of 78 patient records. It is possible that this estimated 58% prescription rate figure is inaccurate due to the small sample size of patient records and may help explain the low spectacle dissatisfaction figure.

Recently, Freeman and Evans (2010) suggested an average "spectacle non-tolerance" rate in a community optometric practice in England of 1.8% (59 of 3,091 eye examinations). The methods section of the paper suggested that 3,091 was the number of eye examinations and not the number of spectacles prescribed. If the former is correct, then clearly, the spectacle dissatisfaction rate for the number of spectacles dispensed would be significantly higher. Given a typical UK dispensing rate of 67% (Optician Index, 2008), the "spectacle non-tolerance" rate would be 2.8%. The number of spectacle dissatisfaction cases was 36 (1.16% of 3091 eye examinations or 1.7% of likely spectacle dispensings).

Further reported rates of spectacle dissatisfaction from Ophthalmology clinic studies include 2.8% of 432 patients (Mwanza & Kabasele, 1998), 2.3% of 5467 patients (Riffenburgh, Wood & Wu, 1983) and 6% of 2000 patients (Milder, 1962). A survey by a US optical laboratory reported by Sims (1982) found that 5% of 6000 prescriptions were "doctor remakes". However, details of the methodology in these papers were limited.

Therefore average spectacle dissatisfaction rates for optometry practices are likely to be found in the range of 1.0-3.0%. Using an average figure of 2.0% would suggest that about 400,000 patients each year in the UK (based on an estimate of 19.5 million dispensings in the UK in 2008; FODO, 2008[1]) return to a practice dissatisfied with their spectacles due to refraction errors or adaptation problems. These patients not only reduce practitioner productivity by taking up an additional eye examination appointment and incur associated reglazing costs, but spectacle dissatisfaction can also tarnish a practitioner's professional reputation (Cockburn, 1987). Conventional marketing research would suggest that generating such consumer negative "word of mouth" opinion exhibits a much more powerful impact than positive word of mouth communication (Arndt, 1967) and dissatisfied customers are likely to tell at least twice as many people as satisfied customers and also tell their story to at least nine other people (Buttle, 1998). In addition, the figures above are likely to

[1] 19.5 million is the number of eye examination performed by FODO members in 2008 and they constitute about 2/3 of UK optometists (i.e. total eye examinations in the UK were approximately 29.25 million). 67% is a typical dispensing rate, suggesting an estimated 19.5 million dispensings in the UK in 2008.

underestimate spectacle dissatisfaction rates, as some patients may simply revert back to their habitual spectacles or alternatively seek remediation with a different practitioner. Thus spectacle dissatisfaction appears to be a significant problem both in terms of reduced practitioner productivity and loss of patient goodwill.

The commercial pressures that inevitably exist in optometry may in some respects contribute to the problem of spectacle dissatisfaction, by encouraging some practitioners to recommend new spectacles even in patients with minimal improvement in visual acuity. Although this practice will initially improve an individual optometrist's conversion rate (the percentage of patients examined that are informed that they need a change in spectacle prescription), it may exacerbate the problem of spectacle dissatisfaction by raising unrealistic expectations of patient visual improvement. Thus it is possible that the common commercial practice of monitoring conversion ratio, may be profitably supplemented by monitoring individual recheck rates and patient retention statistics (i.e. attendance for subsequent recall eye examinations).

1.3 Reasons for spectacle dissatisfaction

There is minimal research regarding the causes of spectacle dissatisfaction and whether some of them could be avoided. It may be that some refraction results will inevitably be incorrect leading to patients returning with problems. Refraction is not perfectly repeatable and test-

retest refractions suggest that 80% are typically repeatable to within 0.25DS mean sphere equivalent (MSE) and 15% of subjective refractions vary by up to 0.50DS MSE from test to retest (Goss & Grosvenor, 1996). Furthermore, refractions performed by multiple optometrists can differ by as much as 0.75D (MacKenzie, 2008; Shah, Edgar, Rabbetts, Harle *et al*., 2009). It is also likely that patients with poor visual acuity will exhibit even greater refractive variability due to greater tolerance of defocus (Leinonen, Laakkonen & Laatikainen, 2006). However, patients can experience symptoms such as mild headache, distortion or depth perception problems when the spectacle prescription is asymmetrically +/-0.25DS in error (Atchison, Schmid, Edwards, Muller *et al.,* 2001), and a binocular +0.25DS addition can make spectacles unacceptable to a substantial number of patients (Miller, Kris & Griffiths, 1997). These results suggest that some low level of spectacle dissatisfaction may indeed be inevitable. The complexity of the issue is further compounded by both the personality traits and demographic status of the patient. Anecdotally, many optometrists would be wary of the “archetypal physics lecturer who is intelligent, fastidious with detail” and questions “why a 5 degree change in axis is strictly necessary” (Constantine-Smith, 2002). Furthermore if spectacles are considered in the same category as other goods on the high street, then US marketing research would suggest that better educated, higher social class and higher earning patients are more likely to voice their dissatisfaction (Morganosky & Buckley, 1987), so that dissatisfaction rates may vary depending on the patient demographics of a

practice. This view is supported in part by Ryan (1974) who observed after ten years of ophthalmic practice that “the higher the rank, either in the forces or the clergy, the more likely patients will worry about their spectacles”.

1.4 Prescribing rules or clinical maxims

It is possible that some optometrists may simply be better refractionists than others or perhaps these optometrists are more adept at modifying the refraction result prior to prescribing new spectacles. Belmont (1961) suggested that the final prescription may not simply be the refraction result and “at times it is necessary to sacrifice sharpness of vision for comfort”. By implication the prescription may need to be modified to help patient adaptation and comfort. This approach is in some respects supported by the optometric literature as briefly discussed earlier. However the recommendations, clinical maxims or in American terminology “clinical pearls” provided can vary widely between authors. The variability of the advice is not surprising given that they are based almost exclusively on clinical experience of a variety of clinicians dealing with their own spectacle dissatisfaction cases and thus help substantiate the “art” viewpoint of spectacle prescribing.

Evidence-based medicine has been defined as the integration of best available evidence with clinical experience and patient values (Sackett, Rosenberg, Gray, Haynes *et al*., 1996; Greenhalgh, 1999; Straus,

Richardson, Glasziou & Haynes, 2005). Unfortunately there appears to be no research evidence on the usefulness or otherwise of the various experiential prescribing maxims found in optometry. This deficiency of formal research is probably more reflective of the difficulties found in addressing spectacle dissatisfaction rather than any lack of importance of the problem. Therefore these prescribing maxims appear to fall within what Sackett *et al*. (1996) describes as "proficiency and judgement that individual clinicians acquire through clinical experience and clinical practice" and are relied upon alone given the lack of research evidence in the practice of evidence-based optometry.

The four principal recommendations that gain the most direct support from textbooks and indirect support from the research literature appear to be the following:

1) "If it ain't broke, don't fix it".

2) Consider a partial increase in plus power when increasing a hyperopic prescription.

3) Partially prescribe a significant change in cylinder power or axis.

4) In older patients, prescribe large changes in prescription incrementally with a maximum change of 1.00DS.

Each of these potential prescribing recommendations will now be briefly described, with a more detailed consideration given to their underlying rationale and possible applications in Chapters 2, 3 and 4.

1.4.1 "If it ain't broke, don't fix it"

This prescribing guideline is mentioned in various guises in all of the three textbooks devoted mainly to the prescribing of spectacles (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004) and by some individual book chapters (Elliott, 2007; Eperjesi *et al*., 2007), yet other standard optometric sources that discuss other guidelines omit it completely (Augsburger, 1987; Obstfeld, 1988; Fletcher *et al*., 1998; Carlson & Kurtz, 2004; Newman, 2006). Werner and Press (2002) refer to this prescribing guideline as one of the "generic therapeutic rules" and state that "it is difficult to improve on an asymptomatic state" and "above all do no harm". The Greek equivalent of this latter phrase "primum non nocere" derived from the Hippocrate's universal injunction to physicians is given by Milder and Rubin (2004) and further qualified as Milder's Law #2 "Don't rock the boat". In essence if a patient is happy with their current habitual prescription and can achieve a satisfactory standard of vision then any changes made by the practitioner can only risk making the patient unhappy. Brookman (1996) states "change for the sake of change is not usually in the best interest of this patient". It is a prerequisite that all clinical information be considered by the practitioner as clearly a detailed case history together with accurate focimetry of the habitual prescription are mandatory before applying this prescribing guideline.

1.4.2 Consider a partial increase in plus power when significantly increasing a hyperopic prescription

Variants of this prescribing guideline are found in several sources (Augsburger, 1987; Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007) although Obstfeld (1988) advocates prescribing the full spherical correction in adult patients. As previously mentioned children are excluded from this potential guideline (Farbrother, 2008) as well as latent hyperopes exhibiting eso-deviations (Evans, 1997). Subtle variations exist with Milder and Rubin (2004) suggesting to under-correct by 0.25DS large increases in hyperopia, whilst Werner and Press (2002) more generally state "never prescribe more plus power at distance than is consistent with good distance vision". In this respect the common practice of refracting patients at 6m distance should be recognised as being equivalent to an overplus of 0.17D. Newman (2006) and Elliott (2007) recommend similar approaches with the former recommending "prescribe for the hyperope to answer the patient's complaints" and the latter "prescribe a hyperopic prescription that is sufficient to remove any symptoms". For the manifest hyperope this is likely to be ½ or ¾ of the prescription with the more pronounced symptoms requiring the fuller correction. In addition as the age of the patient increases, it is also becomes increasingly likely that ¾ to the full prescription will be required to alleviate symptoms (Elliott, 2007).

1.4.3 Partially prescribe a significant change in cylinder power or axis

Although this prescribing rule is frequently mentioned (Obstfeld, 1988; Brookman, 1996; Fletcher *et al*., 1998; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007) there are differing opinions over when and how it should be implemented. Milder and Rubin (2004) suggest that the partial prescribing of cylindrical changes should only be used after patients experience adaptation difficulties. Others (Obstfeld, 1988; Brookman, 1996; Werner & Press, 2002; Carlson & Kurtz, 2004; Marcus & Rubin, 2006) recommend partial prescribing after perceptual problems are reported by the patient when wearing the full prescription in the trial frame. A more pre-emptive approach is also recommended by some who advocate the use of this prescribing guideline in all patients with significant cylindrical change (Fletcher *et al*., 1998; Werner & Press, 2002; Elliott, 2007). Newman (2006) suggests that the character of the patient is also important as “laid-back” patients may well accept the full cylindrical correction without modification.

Apart from the wide variation in when to consider partially prescribing significant cylindrical change, practitioners are also faced with a large variety of opinion in how to modify the prescription. Obstfeld (1988) and Elliott (2007) suggest that 0.25D cylinders should not be prescribed when not observed during retinoscopy or when the accompanying sphere is moderate or large. Werner and Press (2002) go further and suggest that

cylinders up to 0.75D can be omitted in the case of large spherical corrections as long as reasonable visual acuity can be maintained. Many authors also recommend reducing the cylinder power of a first astigmatic correction or a large change in cylindrical power whilst maintaining the spherical equivalent (Elliott, 2008). Brookman (1996), Werner and Press (2002) and Marcus and Rubin (2006) recommending calculating the spherical equivalent whilst Fletcher *et al*. (1998) advise performing a best vision sphere assessment with the reduced cylinder power in place. With either method, the aim is to provide reasonable visual acuity with the lowest possible cylindrical power. Trial framing of the prescription can also be used to check for symptoms of spatial distortion by asking the patient to look out of a window or move around (Obstfeld, 1988; Brookman, 1996; Werner & Press, 2002; Carlson & Kurtz, 2004).

Recommendations for cylinder axis changes show similar levels of variability with partial prescribing most recommended with oblique axes (Obstfeld, 1988; Brookman, 1996; Newman, 2006) and/or large power cylinders (Fletcher *et al*., 1998; Werner & Press, 2002; Elliott, 2007) and/or with elderly patients (Werner & Press, 2002; Newman, 2006). Techniques suggested include making a partial change from the habitual axis to that found during the subjective refraction (Werner & Press, 2002; Elliott, 2007), perhaps halfway (Elliott, 2008) or refining the optimal sphere and cylinder power at the habitual cylinder axis (Brookman, 1996). Werner and Press (2002) recommend “approaching symmetry in the cylindrical axes

orientations" whilst more controversially some suggest moving the axes towards 90 and 180 degrees to reduce spatial distortion induced by oblique axes (Obstfeld, 1988; Werner & Press, 2002; Newman 2006). This approach is also mentioned but not advocated by Brookman (1996).

1.4.4 Limit changes in prescription to 1.00D

Newman (2006) advocates this approach as do Werner and Press (2002) by stating "it often is prudent in making a lens change of 1 dioptre or more to prescribe it in stages". Milder and Rubin (2004) particularly recommend this guideline when prescribing for elderly patients presumably because most texts suggest that older patients have more difficulty in adapting to new spectacles (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007).

1.5 Adaptation to a change in spectacle prescription

Spectacle adaptation problems occur despite the improvement in visual acuity provided by the new prescription. The two possible explanations cited by Elliott (2008) are the inevitable magnification / minification effects on retinal image size and the contribution from the vestibulo-ocular reflex (VOR).

1.5.1 Spectacle magnification

For any given eye, a spectacle lens will change the size of the retinal image of a distant object (Katz & Kruger, 2006) and this is termed spectacle magnification:

$$\text{Spectacle magnification} = \frac{\text{Retinal image size in corrected eye}}{\text{Basic height of retinal image in uncorrected eye}}$$

More generally, spectacle magnification can be defined as the "ratio of the angular subtense at the eye's entrance pupil of the image formed by the lens to that of the object viewed directly without change of position" (Rabbetts, 1998). This is equivalent to the ratio u'/u_o in Figure 1.1.

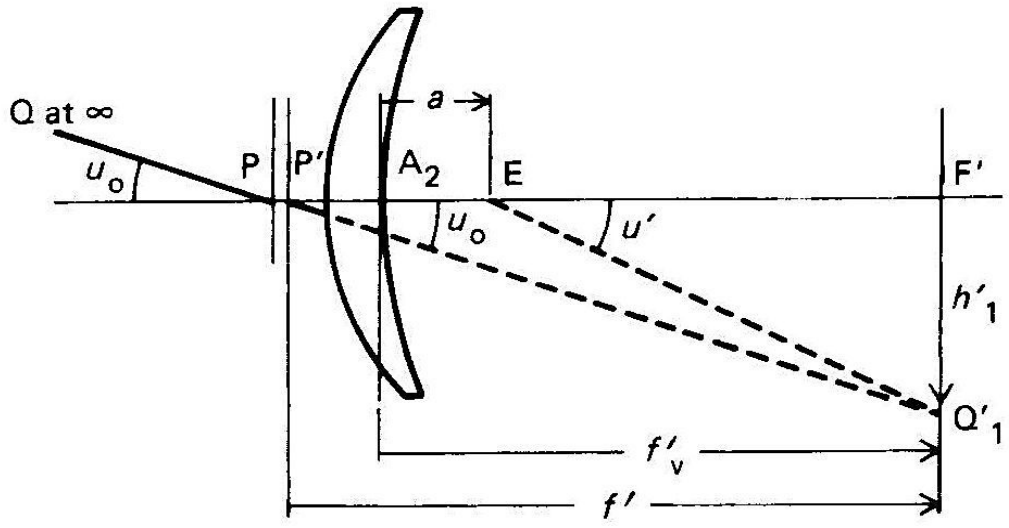

Figure 1.1 Spectacle magnification in distance vision: the ratio of the angular subtense u' of the image height h'_1, at the centre E of the eye's entrance pupil to that u_0 of the distant object (from Rabbetts, 1998, *Clinical Visual Optics*, Butterworth-Heinemann, Oxford, UK, p. 230).

Rabbetts (1998) states that spectacle magnification can be further derived as the power(P) - shape(S) product where:

Power P= 1/(1-aF'v)

Where F'v = back vertex power

a = distance from back vertex of lens to centre of eye's entrance pupil

Shape S= 1/(1-(t/n)F_1)

Where F_1=front surface power

t = lens thickness

n = refractive index of lens

By examining the terms in the above equations, it can be seen that front surface power (F_1), lens thickness (t) and refractive index (n) are all determinants of the shape equation and thus influence spectacle magnification in this way. Conversely vertex distance (closely related to a) is a factor in the power equation and therefore spectacle magnification is changed by its effects on the power (P). Thus when considering the reasons for a patient's dissatisfaction with new spectacles, these equations help to explain the possible "dispensing and lens issues" previously discussed in sections 1.2.1 and 1.2.2 respectively.

The other effect of changes in retinal image size will be that objects will appear closer or further away with the extra magnification or minification provided by the new prescription when compared to the habitual prescription. Reductions in myopia and hyperopia will lead to increases

and decreases respectively in ocular magnification and objects such as steps will consequently appear bigger (closer) or smaller (further away). This effect will be greater with larger changes in prescription and may have important implications with obstacle avoidance and the judgment of the size and position of kerbs and stairs (Elliott & Chapman, 2010; Chapman, Scally & Elliott, 2011). Many authors have also reported that older people experience more difficulty and take longer to adapt to these visual perceptual changes (e.g. Wick, 1960; Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007).

Furthermore it should be noted that large changes in refractive error (greater than 1.00D) are frequently encountered in patients having undergone cataract surgery. Modern techniques reduce the post-operative refractive error such that ~70% of patients do not need distance spectacles after the procedure (Wilkins, Allan & Rubin, 2009). Therefore patients with substantial pre-surgery refractive error will experience a large change in spectacle prescription after surgery, exacerbating any spectacle adaptation difficulties. These patients will also be most at risk of experiencing clinically significant aniseikonia after one eye cataract surgery, as there will be substantial differences in refractive error and hence magnification effects between the two eyes.

1.5.2 Astigmatism – meridional magnification

The eye becomes astigmatic when any of its refracting surfaces are toroidal and thus two far point planes are formed, each with its corresponding principal meridian of refractive error (Marcus & Rubin, 2006). The blur created by uncompensated astigmatism is not only dependent on its magnitude but also on the axis of orientation. Blur is relatively greatest with oblique axes, least when the axis is with-the-rule and somewhat in-between when against-the-rule (Werner & Press, 2002). Thus for any point object, a complex bow-tie shaped image is formed called the conoid of Sturm, with the circle of least confusion being the narrowest point (Figure 1.2).

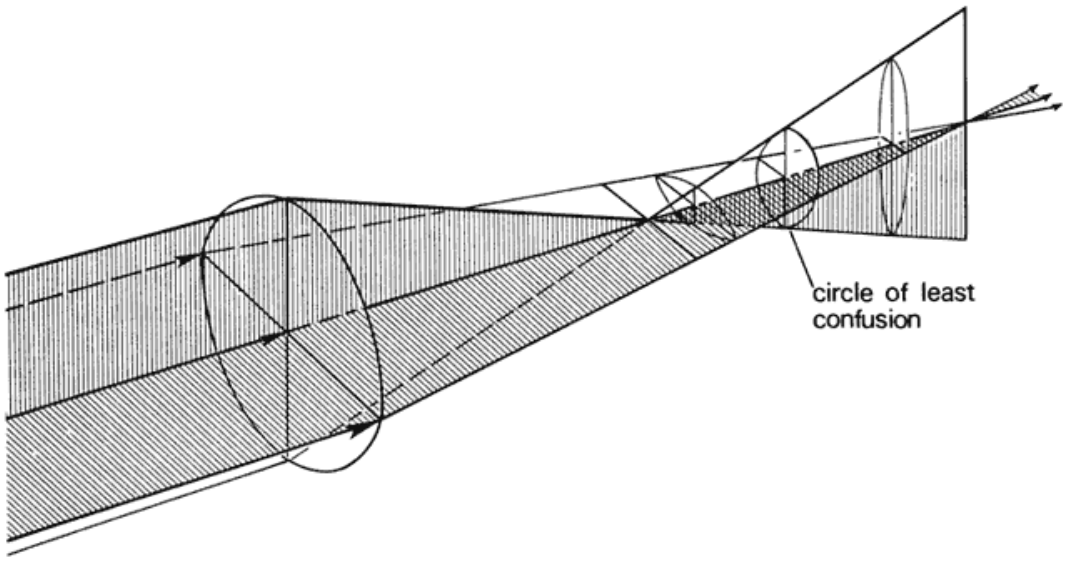

Figure 1.2 Formation of the circle of least confusion by a toroidal lens (from Katz & Kruger, 2006, *Duane's Ophthalmology*, (eds Tasmin & Jaegar), Lippincott Williams & Wilkins, Philadelphia, USA. http://www.oculist.net/downaton502/prof/ebook/duanes/pages/v1/v1c033.html#spe accessed 02 Mar 2012.)

In regular astigmatism, the meridians of maximum and minimum curvature are at right angles to each other and it is this type of astigmatism that is corrected by spectacle lenses. If both far point planes are located at different distances in front of the eye this is termed compound myopic astigmatism, while in compound hyperopic astigmatism both planes are located at different distances behind the eye. Simple myopic or hyperopic astigmatism refers to one far point plane at infinity whilst the other is located either in front or behind respectively. In mixed astigmatism, the two far point planes are located one in front and one behind the eye.

The inevitable consequence of the refracting powers of the two principal meridians being different is that of meridional magnification. As previously stated in section 1.2.2, the use of negative cylinder meniscus lenses equalises the shape factor component of spectacle magnification but differences in the power factor will still produce differing degrees of magnification in the principal meridians. Thus astigmatic patients may well complain of distortion, for example circles appearing elliptical when their astigmatic refractive error is corrected. Werner and Press (2002) suggest therefore that “prescribing for astigmatism often involves a trade-off between maximum comfort and maximum clarity”. Clinically, patients should be advised that time to adjust to new spectacles will be required especially when medium to large astigmatic corrections are prescribed (Adams, Banks & Van Ee, 2001).

1.5.3 The vestibulo-ocular (VOR) reflex

The VOR (schematically represented in Figure 1.3) links the vestibular system (motion detectors in the inner ear) with the extra-ocular muscles and produces the rapid (less than 15ms) compensatory eye movements needed to maintain stable vision during locomotion (Grossman, Leigh, Bruce, Huebner *et al*., 1989; Maas, Huebner, Seidman & Leigh, 1989). Loss of the VOR as occurs following ingestion of ototoxic drugs such as the aminoglycoside antibiotics, results in oscillopsia during locomotion (Crawford, 1952). Thus the VOR compensates for three types of natural head movements (Tusa, 2006):

(i) Head rotation activates angular VOR – head movement up and down (pitch) is detected by the anterior and posterior semi-circular canals (SCCs). Horizontal shaking of the head (yaw) is sensed by the horizontal SCCs and eye movement opposite to the rotation is initiated.

(ii) head translation activates linear VOR – vertical linear movement (such as riding in a lift) is detected by the saccule. Horizontal linear movement (riding on a train) is sensed by the utricle.

(iii) head tilt activates torsional VOR – detected by the otolith utricle and counter-rolls the eyes about 20% of head tilt within 30 degrees of the vertical (Diamond & Markham, 1981).

VOR performance is better when combined with visual cues and this response is more accurately termed visually enhanced VOR (VVOR). It is this aspect of the VOR that may in particular be influenced by changes in

the spectacle prescription of the patient. Therefore when large changes in spectacle correction are prescribed, the resultant magnification (or minification) of the retinal image size relative to the habitual retinal image, will mean that the patient's eyes will have to move slower (or faster) than before to maintain stable vision for the same amount of head movement. In other words the patient's VOR will have to undergo an "internal recalibration process" and if it was not for this plasticity in VOR gain then the use of correction spectacles would not be possible (Goldstein & Scott, 2006). Although this modification of VOR gain is initiated within minutes (Collewijn, Martins & Steinman, 1983), adaptation can continue for up to 5 days and beyond. During this period, some patients will feel uneasy and perceive the world as "swimming" (Demer, Porter, Goldberg, Jenkins *et al*., 1989) and it is possible that these effects represent a milder version of the oscillopsic symptoms produced by ototoxic drugs.

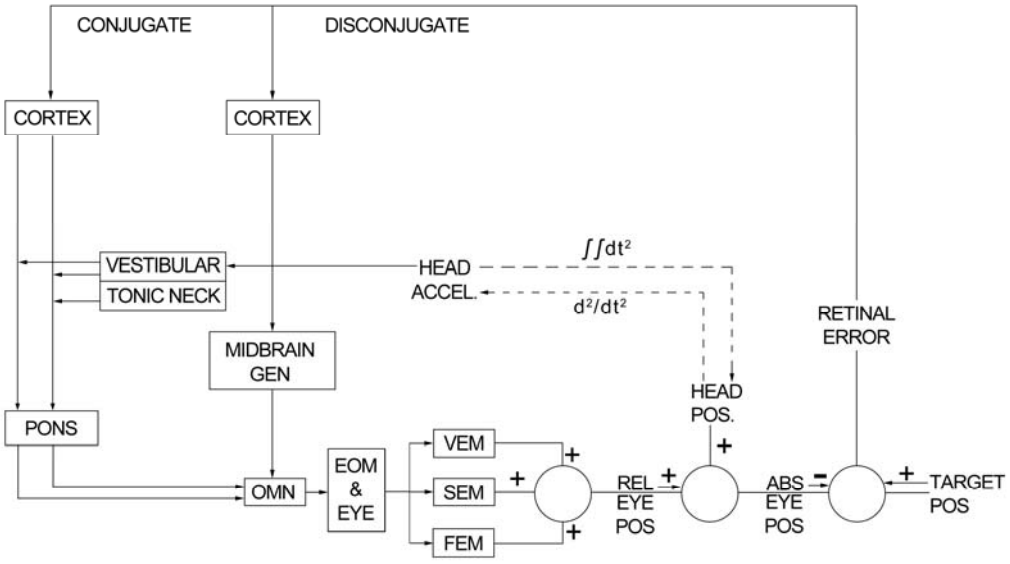

Figure 1.3 Basic open-loop block diagram of the vestibulo-ocular mechanism (heavy lines) superimposed on the block diagram of the total ocular motor control system. Head acceleration is the input and a neural signal proportional to head velocity is generated by the semicircular canals and sent to the vestibular nuclei. Motor commands are generated via the ocular motor nuclei (OMN) and the extraocular muscles (EOM) respond with a slow eye movement (SEM) to match head velocity and a fast eye movement (FEM) if required. Absolute eye position is the sum of the relative eye position and the non-zero head position. Key VEM = vergence eye movement).

(from Dell'Osso & Daroff, 2006, *Duane's Ophthalmology*, (eds Tasmin & Jaegar), Lippincott Williams & Wilkins, Philadelphia, USA.
http://www.oculist.net/downaton502/prof/ebook/duanes/pages/v2/v2c009.html accessed 02 Mar 2012.)

1.5.4 Practical implications of spectacle adaptation

The successful prescribing of new spectacles is not just important in purely fiscal terms but also from the patient's health and safety point of view. Rubenstein and Josephson (2002) and Buckley and Elliott (2006) conclude that although the risk of falling is multi-factorial, visual impairment is a significant and independent risk factor for falls in elderly people. Therefore it seems likely that in frail elderly people, an improved visual acuity from an updated refractive correction would help *reduce* the number of falls. Cummings, Ivers, Clemson, Cullen *et al.* (2007) designed an intervention randomised controlled trial that tested this hypothesis and surprisingly found the opposite. Six hundred and sixteen men and women, aged 70+ and living in the community were randomly assigned to the control and optometric intervention group. Of this latter group, 92 received new spectacles, 24 were referred for a home visit by an occupational therapist, 17 were referred for suspect glaucoma and 15 for cataract surgery. Falls occurred significantly more often ($p<0.001$) in the follow-up year in the intervention group (65% fell at least once, 758 falls in total) than in the control group (50% fell at least once, 516 falls in total). In addition, there were more fractures in the intervention group (N=31) compared to control (N=18) although this was not significant ($p=0.06$).

Cummings *et al*. (2007) suggested that their unexpected findings were either due to increased risk behaviour (e.g. outdoor activities) by the intervention group, as a result of increased confidence due to improved

vision or because some of the subjects had trouble adapting to large changes in spectacle prescription. There was no evidence to support the first hypothesis, but the second was supported by the finding that 74% of the intervention group who were deemed to have major changes in refraction (defined as +/- 0.75DS or DC, axis changes of 10° up to 0.75DC and 5° for 0.75DC+, any prism change or introduced anisometropia of 0.75DS+) fell at least once, compared with 53% of those who had minor changes. This view also supports the earlier work of Hakkinen (1984) who reported that some elderly people, particularly those with poor mobility or dizziness problems removed their spectacles when moving around due to adaptation difficulties. Further support for this view was later provided by Gillespie, Robertson, Gillespie, Lamb *et al*. (2009) who stated that "older people may be at increased risk of falling while adjusting to new spectacles or major changes in prescription".

1.6 Aims of the thesis

It can be seen from the preceding introduction that the issues involved in spectacle prescribing are far from simple. To reiterate, the lack of direct research in this area is surprising given that it is the principal function of many practicing optometrists. Therefore the aims of this thesis can be summarised as follows:

1) To assess whether clinical maxims are used by the UK optometric profession when determining what power of spectacles to prescribe.

2) To determine the extent that different clinical maxims are used.

3) To determine whether any demographic of the UK optometric profession utilise these clinical maxims more than others.

4) To evaluate whether an experiential maxim could have a role to play in reducing recheck eye examinations.

5) To examine the rate of falls in individuals prescribed potentially large changes in spectacle prescription due to cataract surgery. The data from McGwin, Gewant, Modjarrad, Hall *et al*. (2006) will be used as somewhat surprisingly no change in falls rate was found with cataract surgery in this study. The hypothesis was that the lack of change in falls rate may have been due to a decreased falls rate for those patients who had minor changes in refractive error and an increased falls rate for patients adapting poorly to large changes in refractive error, as reported by Cummings *et al*. (2007) for patients receiving updated spectacles. In addition, the change in visual acuity following unilateral and bilateral cataract surgery will be examined in this data to investigate whether this may be related to a

difference in falls rate.

6) To develop and validate a questionnaire (instrument) that identifies and quantifies the symptoms experienced by patients when they adapt to new spectacles. In particular, it is hoped that this instrument will then provide an avenue for further research by allowing patient reported spectacle adaptation problems to be related to other factors such as the magnitude of prescription change or the age of the patient.

Chapter 2

How many UK optometrists make adjustments to the subjective refraction result prior to prescribing spectacles?

2.1 Introduction

This chapter is based on the work previously published as Howell-Duffy, Umar, Ruparelia and Elliott (2010): What adjustments, if any, do UK optometrists make to the subjective refraction result prior to prescribing? *Ophthalmic Physiol. Opt.* 30, 225-239.

A questionnaire designed to investigate prescribing decisions made by UK optometrists had been previously written and distributed by two undergraduate optometry students as part of their third year project. Ethical approval had been readily granted due to the non contentious data requested by the questionnaire (see appendix B). A case scenario approach was adopted to investigate whether the subjective refraction result was routinely prescribed, or whether adjustments were made to the spectacle prescription to assist patient visual comfort and adaptation. The questionnaire incorporated a multiple choice format in which practitioners were invited to select their preferred spectacle prescription for each particular patient. The three possible alternatives were to either retain the habitual spectacle prescription, prescribe the subjective refraction result or "other", an open entry in which practitioners were free to write out their own recommended spectacle prescription.

As far as was known, no previous studies have examined how many optometrists modify the subjective result prior to prescribing, or when and what type of adjustments are made. Thus the purpose of the analysis of the data obtained from this study was to estimate how many optometrists make adjustments to the subjective refraction result prior to prescribing, whether these adjustments conformed to any of the existing "prescribing rules" and whether any particular practitioner profile could be identified as utilising these "rules" more than others. For completeness, the methodology employed in the original questionnaire design and mode of distribution will also be summarised.

2.2 Methods

2.2.1 Overview

The questionnaire (see appendix A) was designed to investigate the three most common prescribing rules in the literature and obtain demographic information from each respondent whilst keeping the time burden for completion low. This latter constraint (completion in 15 minutes or less) limited the number of prescribing scenarios to a maximum of eight (labelled A-H). Each hypothetical case scenario adhered to the same format and included all pertinent refraction details, followed by the question of what spectacle prescription would be recommended for that patient.

The most common prescribing rule found in the literature (Brookman, 1996; Constantine-Smith, 2002; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007) was “if it ain’t broke, don’t fix it” and accordingly this rule was assigned four case scenarios. In essence if the patient is happy with their habitual prescription and can attain a satisfactory level of visual acuity, any changes made by the practitioner can only risk making a previously content patient unhappy. One further scenario investigated the use of a variant of “if it ain’t broke, don’t fix it” in that the patient had near vision symptoms but none at distance. This case assessed whether the clinician would retain the distance correction but increase the near addition to help alleviate the patient’s symptoms. Milder and Rubin (2004) quote this prescribing situation as Milder’s Law #1 “as you endeavour to improve a patient’s vision in one context, do not make it worse in another.” Two further cases investigated partial prescribing of cylindrical power changes (scenario C – average 0.88DC *oblique* astigmatic change, scenario D – 1.*25*DC *against-the-rule* astigmatic change) and the remaining scenario assessed whether clinicians partially prescribed significant axis changes (scenario G – 10 degree shift of approximately -2.50DC cylinder). Practitioner demographic information collected included gender, location and type of practice, resident or locum optometrist and years of experience (grouped into categories of years).

In order to maximise exposure to as many optometrists as possible, two different media were used to distribute the questionnaire. A conventional

paper copy version was supplemented by making available an almost identical online version. This online version was composed using “Wufoo” (www.wufoo.com), an HTML form builder and links were posted on various optometry website forums and via optometry email discussion groups.

2.2.2 Case scenarios

The hypothetical cases were simplified versions of non-tolerance examples taken from Brookman (1996) and Werner and Press (2002) and each scenario was adapted to isolate the prescribing rule under consideration. The scenarios were kept as simple as possible with no anisometropic prescriptions or binocular vision problems. In all cases the history was presented in the same format with the phrase “all other assessments within normal limits for age and refractive error” included. This was aimed at preventing respondents from considering other confounding factors.

Initially it was intended that the multiple choice answer possibilities would include both the habitual and subjective prescriptions and two or three other midway prescriptions. However it was realised that this method may introduce unwanted bias with some practitioners subconsciously modifying their answers in light of the other prescription options present. Accordingly a more open question style was adopted with three possible choices available throughout the eight scenarios: habitual prescription (one), subjective prescription (two) and other – specify (three). In all cases

respondents were invited to explain the reasons for their prescribing decision. The online version was identical to the paper version except that it was split into three sections, each of which was submitted separately. In addition a separate pop-up instruction box was added to act as a reminder for the practitioner to note both the prescription and explanation if the "other" option was selected.

2.2.3 Distribution

The questionnaires were distributed between mid December 2008 and March 2009. All of the head offices of the major multiple Opticians in the UK were contacted by email and/or telephone and one agreed to distribute the questionnaire to 105 randomly selected optometrists working in their practices. Individual practices were sent out paper copies of the form in two batches. The first batch of 200 forms was dispatched in mid December 2008 to practices throughout the UK. The second batch of questionnaires was distributed in mid January 2009 and targeted areas identified with a poor response from the initial mailing. Paper copies of the form were then sent together with a stamped addressed envelope. Additional questionnaires were also distributed by hand to both large multiple stores and independent practices in several English cities. The online version of the questionnaire was publicised on several websites including the Association of Optometrists discussion forum, Optometry Today website (www.optometry.co.uk) and the Optician online (www.opticianonline.net). Further electronic links were emailed to all of the universities providing

undergraduate optometry training in the UK and other optometry discussion forums (www.theoptom.com) on the internet.

2.3 Results

A total of 426 questionnaires were returned (293 online responses and 133 paper replies). Each practitioner's prescription recommendation was grouped into habitual, subjective result and "other". During the analysis of the results, responses in the "other" category were grouped together where possible and included refining the prescription using a trial frame, partially prescribing sphere and cylinder changes and responses with no common theme. A practitioner's reply of 'use a trial frame' could mean that the partial prescription was added to a trial frame and visual acuity and comfort were checked and/or further modified. It could also mean that the spherical power was rechecked if a practitioner was thinking of partially prescribing a cylinder power change. Insufficient information was available to determine exactly what methods were being suggested by practitioners.

2.3.1 "If it ain't broke, don't fix it"

Patients A, B and E assessed the direct application of this rule. They were all asymptomatic, less than 40 years of age and wore spectacles to correct non-progressive myopia (i.e. myopia that had not increased over the previous 3-5 years) of about -6.50DS (patient A, aged 38 years), -3.00DS (patient E, aged 33 years), or low hyperopia of +0.75DS (patient B, aged 15 years) respectively. The results from scenarios A, B and E can be seen

in Figure 2.1, Figure 2.2 and Figure 2.3 respectively. Thus in these scenarios the average percentage of practitioners applying the "if it ain't broke, don't fix it" rule and prescribing the habitual correction (39%) was similar to the percentage prescribing the subjective refraction result (44%). Trial frame comparisons and other prescription modifications accounted for 17% of practitioner decisions.

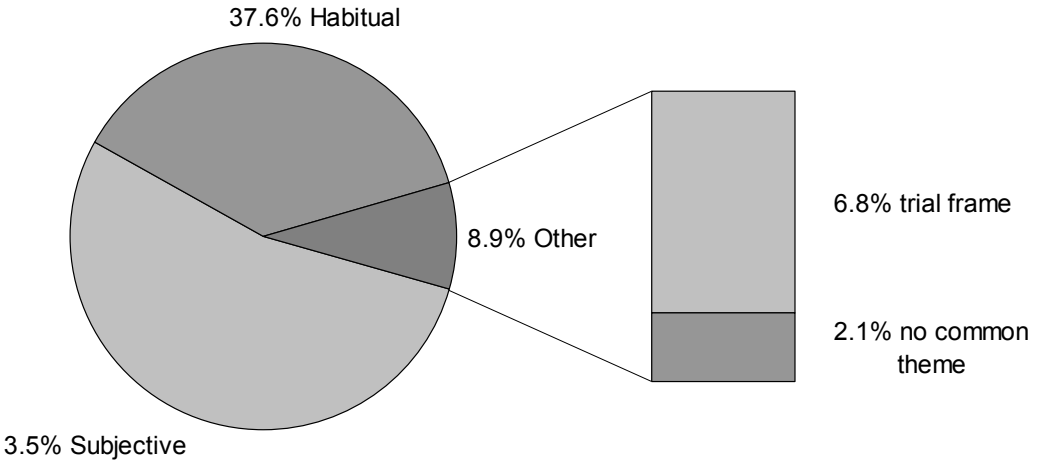

Figure 2.1 Prescribing decisions made by 426 UK optometrists for an asymptomatic 38 year old spectacle wearing non-progressive myope of about -6.50D (from scenario A), exhibiting no improvement in visual acuity (6/5 in both eyes) with the subjective refraction result.

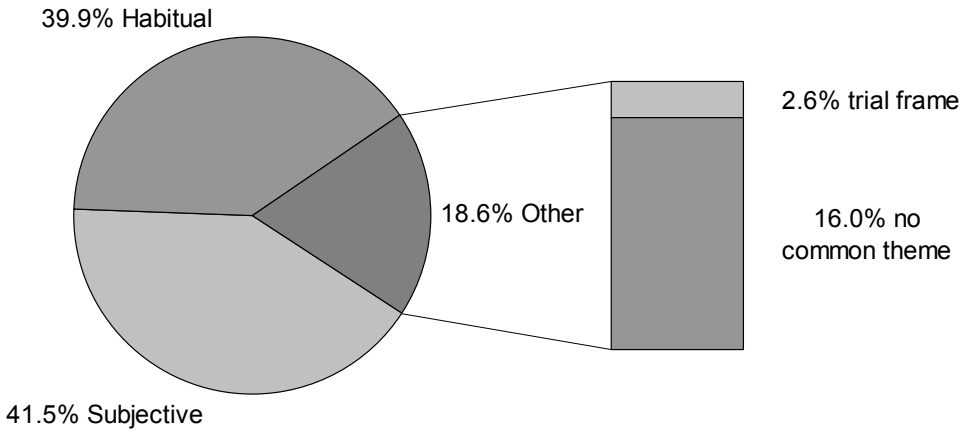

Figure 2.2 Prescribing decisions made by 426 UK optometrists for an asymptomatic 15 year old spectacle wearing low hyperope of +0.75D (from scenario B), exhibiting no improvement in visual acuity (6/5 in both eyes) with the subjective refraction result.

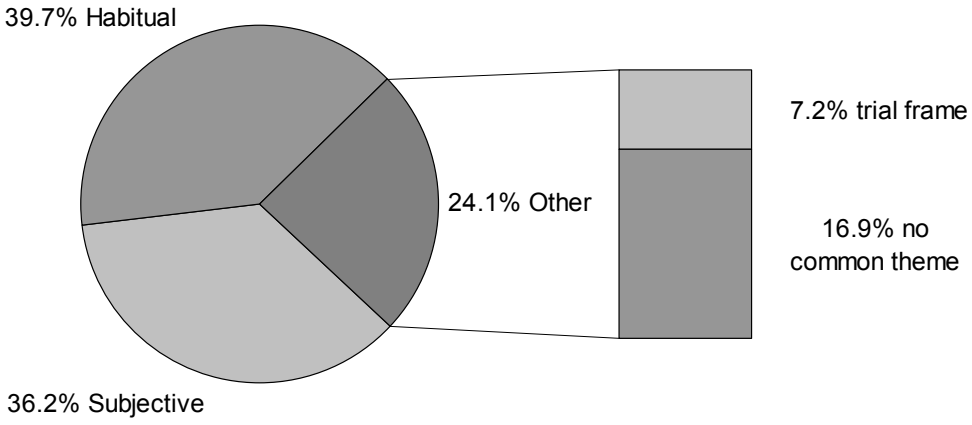

Figure 2.3 Prescribing decisions made by 426 UK optometrists for an asymptomatic 33 year old spectacle wearing non-progressive myope of about -3.00D myope (from scenario E), exhibiting no improvement in visual acuity (6/5 in both eyes) with the subjective refraction result.

Patient H was 75 years of age, asymptomatic and had a negligible change in prescription (-0.25DS/-0.25DC and plano/-0.50DC) due to early nuclear sclerosis that made essentially no difference to the visual acuity. Over half (55.4%) of the practitioners surveyed indicated that they would apply the "if it ain't broke, don't fix it rule" in this scenario. The subjective refraction result was prescribed by 39.4% of practitioners with trial frame comparisons and others totalling 5.2% (Figure 2.4).

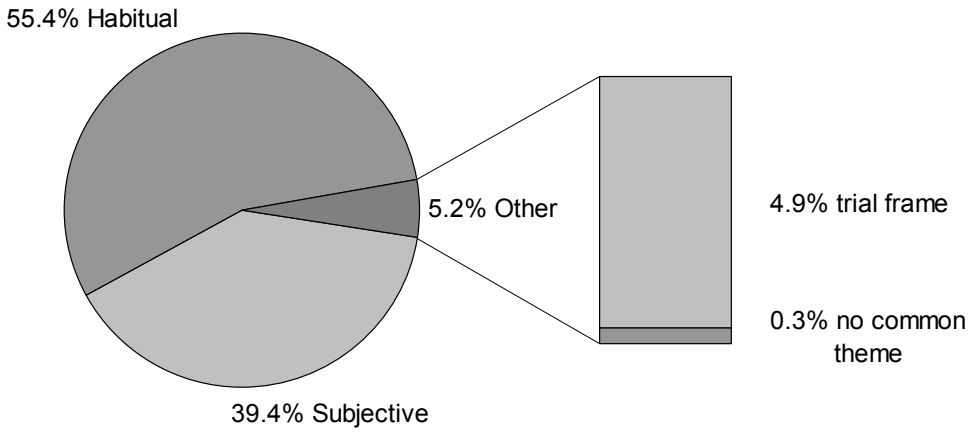

Figure 2.4 Prescribing decisions made by 426 UK optometrists for an asymptomatic 75 year old spectacle wearing patient (from scenario H), exhibiting only a marginal improvement in visual acuity (6/9 from 6/9-1 in the right eye only) with the subjective refraction result.

Patient F investigated the application of a modified version of the "if it ain't broke, don't fix it" rule. The 46 year old patient was an existing spectacle wearer, asymptomatic and complaint-free with their distance vision but experiencing symptoms with their near vision due to the onset of presbyopia. The scenario investigated how many practitioners would change the distance prescription even though the patient's complaint involved near work only. The majority (86.6%) of the respondents elected to prescribe the subjective refraction distance prescription with appropriate reading addition. Surprisingly, 8.8% of practitioners recommended the habitual distance prescription, which would not have resolved the patient's symptoms at near. A small number (2.3%) of respondents elected to present the prescriptions in the trial frame and let the patient decide which was preferred. The results suggest that responding appropriately to this case scenario was somewhat difficult and the results may not be that illuminating. It is likely that those respondents who replied that they would prescribe the habitual correction meant that they would prescribe the habitual distance correction with a near add (we had expected this response to have been made via the "other" category). The results are therefore not displayed graphically and are not discussed further.

2.3.2 Partially prescribe a significant cylinder power change

Patient scenarios C and D were selected to investigate whether partial prescribing is utilised when cylinder power changes over 0.75DC are encountered. The scenarios were similar except with regard to patient

age. Patient C involved a 71 year old patient whose habitual spherical prescription had developed on average a 0.88DC oblique cylinder due to cortical lens opacity changes. Although the majority (70.0%) of practitioners prescribed the full subjective refraction result, most warned of possible adaptation difficulties. The remaining 30.0% elected to prescribe a modified correction to aid adaptation. The amount of cylinder prescribed was similar (-0.50DC) in most cases but ranged from -0.25 to -0.75DC. However vastly different approaches were taken with the spherical component of the prescription. Of the 128 practitioners who indicated that they would partially prescribe the cylinder, 41 or 32% gave an appropriate modification of the sphere to maintain mean sphere equivalent (MSE); 36 or 28% prescribed the subjective refraction spherical component, 32 or 25% of partial prescribers prescribed the habitual spherical component and 17 or 13% elected to trial frame the prescriptions (Figure 2.5). The majority of practitioners (79%) were within +/- 0.12D of the MSE, 14% were within +/- 0.25D in 1 eye, 5% +/- 0.25D both eyes and 2% more than 0.25D from MSE in one eye.

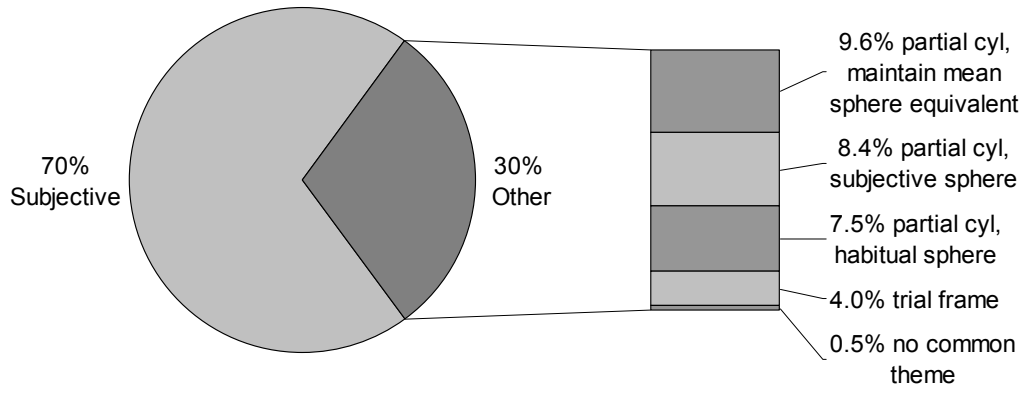

Figure 2.5 Prescribing decisions made by 426 UK optometrists for a 71 year old spectacle wearing patient complaining of headaches and eye strain, whose habitual spherical prescription had developed a -1.00DC oblique cylinder due to cortical lens opacity changes (scenario C).

Scenario D involved a 36-year old patient who had experienced an *against-the-rule* astigmatic change of -1.25DC. Approximately half the respondents (51.4%) indicated that they would prescribe the full subjective refraction result. Partial cylinder correction with appropriate modification to maintain the subjective MSE was prescribed by 35% of the partial prescribers. 31% of partial prescribers recommended partial cylinder power combined with the habitual spherical component and 26% of partial prescribers prescribed a partial cylinder together with the subjective spherical component. The majority of partial prescribers in all categories chose the cylinder power midway between the habitual and subjective cylinder result. Only 3.7% of all practitioners elected to trial frame the

prescriptions and let the patient express their preference (Figure 2.6). The MSE was maintained exactly or within +/- 0.12D by 47% of practitioners, 26% were +/- 0.25D from MSE in 1 eye, 18% +/- 0.25D in both eyes, 5% were more than 0.25D from MSE in 1 eye and 4% of practitioners had prescribed more than 0.25D difference from MSE in both eyes.

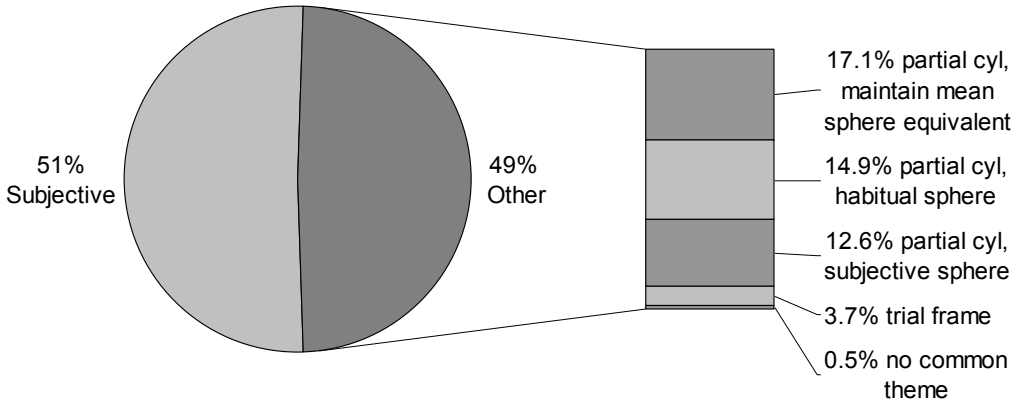

Figure 2.6 Prescribing decisions made by 426 UK optometrists in response to scenario D, a 36-year old spectacle wearing patient complaining of headaches and eye strain whose habitual astigmatic prescription had changed by -1.25DC in both eyes.

2.3.3 Partially prescribe a significant cylinder axis change

The patient in scenario G was a 33 year old spectacle wearer with a moderate level of astigmatism (approximately -2.50DC) who reported a reduction in vision due to a cylindrical axis change of ten degrees. The vast majority of practitioners (85.6%) indicated that they would prescribe

the full subjective refraction result with most warning of possible adaptation problems. 12.1% of respondents indicated that they would prescribe a partial change in cylinder axis and the remaining 2.3% decided to trial frame the prescription options to the patient (Figure 2.7).

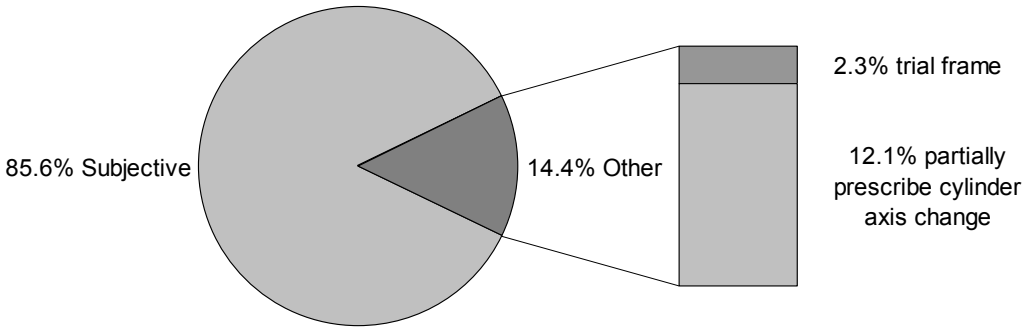

Figure 2.7 Prescribing outcomes from 426 UK optometrists in the case of a 33-year old spectacle wearer with approximately -2.50D of astigmatism who reported a reduction in vision due to a cylindrical axis change of ten degrees (scenario G).

2.3.4 Demographic analysis of practitioner data

The proportion of practitioners prescribing the subjective refraction results compared to an adjustment of the subjective result was calculated. A Z-test was used to determine whether various demographic aspects, including gender, years since qualified (<1, 1-2, 3-5, 6-10, 11-20, 20+ years), type of practice (large multiple, small multiple, independent, university clinic) and type of practitioner (locum or resident), significantly affected this proportion. The only statistically significant result was found from the first two scenarios (A and B) that addressed the "if it ain't broke, don't fix it" rule. In these scenarios the independent practitioner was found more likely to prescribe the habitual prescription rather than the subjective refraction result ($p=0.008$). All other factors had no significant effect on the use of any prescribing rule ($p>0.10$).

2.4 Discussion

The "if it ain't broke, don't fix it" prescribing rule is one of the principal recommendations in the three textbooks dedicated to prescribing (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004). The rationale for the rule is that if the patient is happy with their current refractive correction and can attain a satisfactory level of vision, then any prescription changes will only introduce the possibility of making that particular patient unhappy. This is especially true for astigmatic changes that by their very nature can induce distortion because of meridional differences in the size of the retinal image, resulting in symptoms of

asthenopia in some patients (Brookman, 1996; Adams *et al*., 2001). The results from the three scenarios that addressed "if it ain't broke, don't fix it" with patients less than 40 years old showed that approximately 39% of optometrists used this prescribing rule whilst a similar 44% prescribed the subjective refraction result. Demographic analysis revealed little differences between types of practitioner and prescribing except that the independent practitioner was more likely to apply the rule and prescribe the habitual prescription ($p=0.008$; Z test). This may suggest a more conservative approach to prescribing by the independent practitioner. Werner and Press (2002) suggest that it may be partly the need to justify the eye examination that causes some optometrists to issue a modified prescription even in the absence of symptoms and a currently satisfied patient. Commercial pressures may also encourage this approach.

In a similar "if it ain't broke, don't fix it" scenario with a 75-year-old patient, 55% of optometrists utilised the rule while 40% still prescribed the subjective refraction result. Thus it would appear that the age of the patient influenced the prescribing decision with more practitioners prescribing the habitual prescription in an older patient. This seems reasonable given that older patients may experience more adaptation problems with new spectacles as opposed to younger patients (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007) and that presbyopes account for the majority of spectacle dissatisfaction cases (Constantine-Smith, 2002; Freeman & Evans, 2010).

The results from scenarios C and D, which examined partial prescribing for cylinder power, revealed that 70% and 51% respectively of optometrists prescribed the subjective refraction result. The remaining 30% (patient 71 years old) and 49% (patient 36 years old) of optometrists elected to prescribe a partial cylinder correction. This is perhaps surprising given the results of the previous scenarios in which prescribing was more conservative in the elderly. It has been shown that elderly patients fall more often after they have been prescribed spectacles with a large change in refractive correction (Cumming *et al.*, 2007) and several authors have suggested that older adults are less tolerant of prescribed refractive changes (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007), particularly astigmatic changes that are oblique (Elliott, 2007). The older patient's subjective refraction results included oblique cylinders (at 35 and 60 degrees) of 0.75 and 1.00DC when her habitual correction had previously been spherical. We therefore expected a greater proportion of partial prescribing for the older patient scenario. The difference in prescribing pattern is presumably because the refraction showed slightly larger changes in cylinder power of -1.25DC in the younger patient compared to the older patient (average of 0.88DC). For some practitioners it is possible that 1.00DC or more of astigmatic change triggers partial prescribing. Analysis of the partial prescriptions showed wide variation in strategies with approximately equal percentages of prescribers choosing to maintain mean spherical equivalent with partial cylinder, habitual sphere with partial cylinder and subjective sphere with

partial cylinder. As a consequence, 6% and 25% of optometrists in scenarios C and D respectively, failed to maintain the subjective refraction mean spherical equivalent value. Theoretically this is required to ensure that the circle of least confusion is on the retina (Fletcher *et al*., 1998; Constantine-Smith, 2002; Marcus & Rubin, 2006; Elliott, 2007). The selection of the habitual sphere or subjective sphere with a partially corrected cylinder would lead to errors in the mean sphere value and the patient would theoretically be under or overplussed and/or under or overminussed in their spectacles. Research suggests that patients prescribed with incorrect mean sphere values would have symptoms with these spectacles (Atchison *et al.,* 2001) and find them unacceptable (Miller *et al*., 1997). The lower percentage of optometrists not maintaining MSE in scenario C is likely to be due to the low cylinder powers involved in the case history rather than a true indicator of MSE prescribing. Overall, the relatively high percentage of practitioners not maintaining the subjective MSE was not expected and suggests the need for continuing education in this area.

Cylinder axis changes can potentially produce adaptation problems for a patient especially in higher cylinder powers. Thus for high power cylinders it has been suggested that partial prescribing of axis changes midway between habitual and optimal prescription may be considered (Constantine-Smith, 2002; Elliott, 2008). An alternative strategy suggested by Brookman (1996) is to prescribe the habitual cylinder axis and refine

the sphere and cylinder power using this axis. The results of scenario F would suggest that the vast majority of optometrists (86%) prescribe the subjective axis result without any modification. Only 12% of respondents modified the axis obtained in the subjective refraction with almost all choosing a midway point between the habitual and subjective cylinder axes. The relatively young age of the patient (33 years) in this scenario may have influenced the prescribing decision, as most optometrists decided that the cylinder axis changes would not induce symptoms. It is possible that the prescribing outcome of cylinder axis changes may have been more conservative with an older patient.

2.4.1 Study limitations

The study is limited in that we cannot be sure how representative the sample is of the UK optometric population. The 426 questionnaires received from UK optometrists represent a sample size of approximately 4% of the 11094 registered optometrists in the UK (FODO 2008). It is possible that the type of practitioner who responded to the questionnaire may be different in some way to non-respondents as the sample is somewhat skewed to those using the internet. It is also likely that optometrists who completed the questionnaire were more enthusiastic and/or less busy and/or more interested in prescribing issues than those who did not complete it. The results may therefore slightly overestimate, rather than underestimate, the prevalence of partial prescribing in the UK. However, we made every effort to make the sample as representative as

possible. The case scenario approach allows a large number of responses to be collected relatively easily for a wide range of cases, but it clearly has some limitations. For example, when prescribing in practice, practitioners would likely consciously or subconsciously consider factors such as the patient's intellect and personality and both verbal and non-verbal clues about their current level of satisfaction with their spectacles. We must assume that the practitioners considered only the information provided in the case scenarios. Finally, the freeform entry under "other" for each scenario was used to ensure that it did not bias or restrict the response. However, it did make the responses in this section difficult to analyse. In some cases, no reasons were given and in others, no common themes arose.

2.5 Conclusions

The results of this study are very revealing about the prescribing decisions made by a large number of UK optometrists. The overall impression is that the subjective refraction result has a strong hold on the prescribing outcome, with a large percentage of practitioners indicating that they would always prescribe the subjective refraction result. The percentage of practitioners prescribing the subjective refraction result ranged from 36% in case E to 86% in case G. Surprisingly, the optometrists who did suggest that they would modify the refractive correction prior to prescribing, employed a wide variation in techniques. When partially prescribing cylinder power changes, but not altering the prescribed sphere to provide

the mean sphere equivalent of the subjective refraction result (or using a trial frame to determine the appropriate sphere), the prescribing is at odds with formally taught ophthalmic and physiological optics. As discussed previously, many authorities in the literature support the view that prescription modification may be required to improve the rate of spectacle acceptance by the patient. It is evident that further research is required to determine when and how partial prescribing of refractive correction would be beneficial to both patient (improving spectacle acceptance) and to the practitioner (reducing spectacle dissatisfaction cases and thus increasing productivity and income). In addition, the need for continuing education regarding prescribing rules and the importance of maintaining the mean sphere equivalent in the prescription are highlighted.

Chapter 3

Practitioner experience is linked to the likelihood of UK optometrists suggesting a partial prescription.

3.1 Introduction

This chapter is based on the work published as Howell-Duffy, Scally and Elliott (2011): Spectacle prescribing II: practitioner experience is linked to the likelihood of suggesting a partial prescription. *Ophthalmic Physiol. Opt.* 31, 155-167.

The overall purpose of this investigation was to incorporate the experience gained from the analysis of the results and comments provided by practitioners in Chapter 2 to extend the investigation of partial prescribing behaviour by UK optometrists. In particular the aim was to determine whether any demographic of the optometric profession utilised prescribing rules or clinical maxims more than another. This was achieved by increasing the range of potential partial prescribing scenarios by incorporating more radical changes of cylinder axis (40°) and power (2.00DC) and introducing three further scenarios designed to test other possible prescribing recommendations from the literature. Specifically, the large cylindrical power change scenario was chosen to indicate whether practitioners maintained the best mean sphere revealed by the subjective refraction. The results from the first study suggested that many optometrists viewed sphere and cylindrical powers somewhat

independently, contrary to conventional optometric teaching (Fletcher *et al*., 1998; Constantine-Smith, 2002; Marcus & Rubin, 2006; Elliott, 2007).

3.2 Methods

3.2.1 Overview

As the questionnaire requested non contentious data, institutional ethical approval was readily obtained (see appendix B). As in the previous chapter, the questionnaire was designed by way of a case scenario approach to investigate commonly cited prescribing rules in the literature and to obtain basic demographic information from each respondent. Each case scenario provided a brief patient history, basic refraction details and then posed the question of what spectacle prescription would be recommended for that particular patient. Respondents could either select the existing (habitual) prescription, the subjective refraction result or "other", a freeform selection in which any desired prescription could be entered. In all cases practitioners were invited to explain their prescribing decision.

3.2.2 Experience gained from first study

The subjective impressions from the initial research could be summarised as follows:

(i) Subtlety was not required in the hypothetical case history as most practitioners seemed to have firmly held prescribing view points irrespective of the patient's visual demands. For example,

consider the case scenario designed to investigate whether practitioners would recommend reducing a myopic prescription in a non-progressive (i.e. myopia that had not increased over the previous 3-5 years) asymptomatic patient. The patient's occupation was deliberately chosen as being a taxi-driver (hence likely to drive frequently at night and thus raising the possibility of night myopia as a prescribing issue).

(ii) Different sphere powers were required in the habitual and subjective refraction results even when the case scenario was meant to be investigating large cylindrical power changes. This was to facilitate the identification of whether practitioners had chosen the habitual or subjective sphere in combination with the prescribed cylinder power.

(iii) Some practitioners commented that eight case scenarios required too much time for completion and that a shorter questionnaire would have been preferable. Accordingly the new questionnaire was shortened to five case scenarios with the aim that completion should be possible in 10 minutes or less.

(iv) In light of the previously collected demographic data and the lack of correlation with the prescribing decisions elicited, practitioner demographic data collection was modified. The actual number of years qualified was now requested (continuous data enabled easier statistical analysis than the previous grouped data) and an additional question asking the number of

CET points accumulated by the end of the current cycle (31 Dec 2009) was included. The type of practice (large multiple, small multiple up to 10 branches, independent, university eye clinic or "other") and locum or resident practitioner status were also requested. Geographical information and practitioner gender were now not required for completion.

(v) The original internet website questionnaire was divided into three separate sub-sections or "forms" which could be completed at different times (this was also as a result of the host html form builder which restricted the number of questions per form to qualify for free hosting). Inevitably this meant that some partial entries were received and thus it was felt that the entire follow up questionnaire would be better accessed by a single internet address.

(vi) The percentage of practitioners reporting that they would prescribe the full subjective result in each of the case scenarios in the first questionnaire was reasonably high (36% to 86%). Therefore an initial question was incorporated in the second questionnaire that enabled practitioners who routinely prescribe their subjective refraction result to opt out of the case scenario analysis and provide solely demographic information. Once again, the aim was to reduce the time required for completion and thus improve response rate.

(vii) The original investigation was skewed towards practitioners who used the internet for submission. The aim of the second questionnaire was to improve the paper response from practitioners and allow a better comparison of prescribing decisions between the two distribution media. Thus a prepaid return envelope was included in all mailings and a target distribution of one thousand paper questionnaires was arbitrarily agreed upon. This large "mail-shot" was generated via a Microsoft Excel spreadsheet into which practitioner names, qualifications and practice address details obtained from the General Optical Council website were entered. (http://www.optical.org/en/about_us/registrant_search_form.cfm) The use of the "mailmerge" function in Microsoft Word then enabled a personalised covering letter to be generated for each practitioner and an appropriate address label.

(viii) The original questionnaire did indicate that it was part of a third year Optometry project. Unfortunately it is possible that some practitioners were deterred from completing the study by this information. Thus it was decided to make clear in the second questionnaire that the research was supported by the College of Optometrists and formed part of a PhD thesis.

3.2.3 Case scenarios

The five hypothetical case scenarios were written after discussions with a focus group of experienced optometrists (3-30 years qualified) using some of the more extreme refractive changes reported by Werner and Press (2002) and Milder and Rubin (2004). These refractive changes were also selected to represent cases judged to be those that an optometrist could come across in practice, albeit relatively infrequently. For instance, significant myopic shifts are well documented with the development of nuclear sclerosis (Brown & Hill, 1987; Reeves, Hill & Brown, 1987; Levin, 1989; Brown, 1993; Wensor, McCarty & Taylor, 1999) and account for the "second sight of the elderly" in which reading without spectacles is possible but at the expense of distance vision blur (Brown, 1993). Astigmatic changes both in power and axis are also possible with the development of cortical cataract (Brown, 1993; Pesudovs & Elliott, 2003) and have even been reported with nuclear cataract (Tint, Jayaswal, Masood & Maharajan, 2007). It is also possible to infer some indirect support for the partial prescribing of hyperopia by the finding of McGarry and Manning (2003) that "wearing reading spectacles for intermediate or distance work can have a detrimental effect on distance visual acuity". Furthermore each scenario was deliberately kept as simple as possible with no binocular vision problems and where possible, it was indicated that the patient was a not a driver to eliminate confounding factors such as achieving the driving standard of vision. In all cases the history was presented in the same format with the phrase "all other assessments

within normal limits for age and refractive error" included where appropriate. The full questionnaire is included in appendix C.

In addition to the cylinder axis and power change scenarios, the potential applications of three further prescribing recommendations were tested:

(i) Don't "push the plus" in non-progressive myopes. Werner and Press (2002) describe this as "Pearl 5: be very cautious about reducing minus at distance with myopic patients". The patient in this case was an asymptomatic taxi-driver requiring a new spectacle frame whose prescription had changed by +0.50DS.

(ii) Limit large changes in sphere power to 1.00DS in patients aged over 65 years (Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006). This scenario described an 85 year-old patient having undergone a -2.00DS myopic shift due to nuclear sclerosis.

(iii) Prescribe minimum plus to alleviate symptoms (Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007). A 22 year old spectacle neophyte was experiencing headaches when using a computer.

3.2.4 Distribution

In order to maximise the exposure of the questionnaire to the UK optometric profession, two different media were used to publicise the research. A conventional paper questionnaire was distributed by post

between September and early December 2009. Named individual optometrists throughout England, Scotland and Wales were randomly selected from the GOC online register and mailed copies of the questionnaire. The mailings were carried out in small batches of approximately 50 and in total 975 questionnaires were sent out over the 3 month distribution period. In addition an almost identical online version was made available between these same dates for internet based completion. This online version was composed using "Wufoo" (http://www.wufoo.com) an HTML form builder. The only additions made to the web edition were a forced choice answer to the initial question of whether the subjective refraction result was always prescribed and the addition of separate "pop-up" boxes to prompt the practitioner to enter their prescription decision and explanation. The online version of the questionnaire was publicised via various websites, e-mail discussion groups and professional journals. The cut-off for accepting either paper or web based questionnaires was set at 31 January 2010, once the number of completed questionnaires had reached 500 and prior to the results of the first study being published.

3.3 Results

A total of 592 completed questionnaires were received. These consisted of 273 completed online questionnaires and 319 paper replies (from 975 questionnaires posted, a 33% response rate). 87% of completed questionnaires were from resident optometrists and 13% from locum

practitioners. Figure 3.1 depicts the wide distribution of the 592 respondents in terms of number of years qualified and Table 3.1 shows the breakdown of responses from the different types of optometric practice with the median years qualified for each practice type. Kolmogorov-Smirnov tests indicated that the data sets obtained were not normally distributed and hence medians and ranges are provided and further analysis was carried out using non-parametric statistics. Respondents from the large multiples were qualified for significantly less time (median 5 years) than those from the other types of practice (median values between 13 and 23 years, see Table 3.1) (Wilcoxon-Mann-Whitney $p<0.0001$).

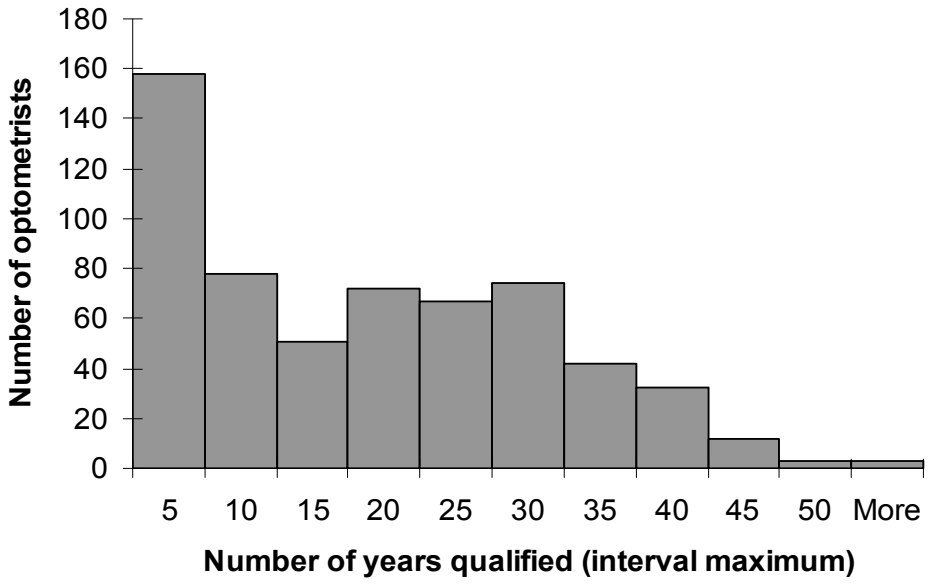

Figure 3.1 Distribution of 592 questionnaire respondents in terms of number of years since qualification.

Table 3.1 Number of years qualified for 592 UK optometrists completing the questionnaire divided on the basis of type of practice.

Type of practice	% of total 592 Questionnaires returned	Median (range) years qualified
Independent	270 (46%)	23 (0.2 - 54)
Large Multiple	229 (39%)	5 (0.1 - 42)
Small Multiple (up to 10 branches)	35 (6%)	21 (2.0 - 57)
Mixed practice	33 (5%)	13 (1.0 - 53)
Hospital, university, “other”	25 (4%)	17 (0.5 - 33)

The first question (…..in what circumstances would you prescribe your full subjective refraction result?) was aimed at stream-lining questionnaire completion for optometrists who always prescribe their subjective refraction result. However 12% of paper replies failed to answer this question and in the online version (where completion was mandatory), over a third (35%) of the overall 22% of optometrists who indicated that they always prescribe their subjective refraction result, went on to partially prescribe in one or more of the five case scenarios. Conversely, out of the remaining 78% of respondents who did admit to partially prescribing in some circumstances, 14% then prescribed the full subjective refraction result in all five cases. These results suggest that this question was not helpful and accordingly the results are not discussed further.

For each case scenario, the practitioner's prescribing decision was grouped into **habitual** (or in case C, "no prescription issued" as spectacles had never been worn by this patient), **subjective** and "**other**". During analysis of the results, responses in the "other" category were grouped together where possible and included partial prescribing of sphere and cylinder changes, responses with no common theme and trial frame refinement. In the case of the latter, we were not provided with sufficient detail to expand on what individual practitioners meant by this statement. It is likely that a variety of prescribing techniques were encompassed by this category. Analysis of the levels of partial prescribing in one or more case scenarios was found to be similar (Chi square $p>0.1$) between the two questionnaire media (see Table 3.2). Only ~4% of optometrists indicated that they would partially prescribe in all of the five case scenarios.

Table 3.2 Comparison of the number of UK optometrists who indicated that they would partially prescribe for each of the five case scenarios and the two respondent formats.

Case scenario	Paper entries (319 in total)	Web entries (273 in total)	Total of 592 who partially prescribe
A (Non-progessive myope)	189 (59 %)	149 (55 %)	338 (57 %)
B (Axis shift 40°)	60 (19 %)	37 (14 %)	97 (16 %)
C (Hyperope)	122 (38 %)	115 (42 %)	237 (40 %)
D (Myopic shift -2.00D)	55 (17 %)	43 (16 %)	98 (17 %)
E (Cylinder power change)	195 (61 %)	156 (57 %)	351 (59 %)

3.3.1 Patient A. Do not always "push the plus" for non-progressive myopes

This scenario involved a 30-year old asymptomatic myopic taxi driver with a habitual spectacle prescription of RE -2.25DS and LE -2.00DS. The case history indicated that his current spectacles were approximately three years old and that he would like a new spectacle frame. The subjective refraction result was RE -1.75DS and LE -1.50DS. Almost half (42.9%) of practitioners suggested that they would prescribe the new subjective

prescription, 43.1% prescribed midway between habitual and subjective and 14.0% recommended the habitual prescription.

3.3.2 Patient B. Partially prescribe a cylinder axis change

The patient was a 68 year old spectacle wearer with a moderate-high level of astigmatism (approximately -2.50 DC) who complained of a reduction in distance vision due to a cylindrical axis change of 40 degrees towards the oblique in each eye. The case history indicated that this considerable shift in astigmatism was due to cortical cataract. Results in Figure 3.2 show that the overwhelming majority of practitioners (83.6%) indicated that they would prescribe the full subjective refraction result with 52% of these advising that a period of adaptation would be required. 9.9% responded that they would partially prescribe the shift in cylinder axis with the majority electing to prescribe midway between the habitual and the subjective axes. 5.4% elected to prescribe the subjective cylinder axis but reduce the cylinder power by 0.25-0.50DC and the remaining 1.1% suggested that trial framing the prescription options would be appropriate.

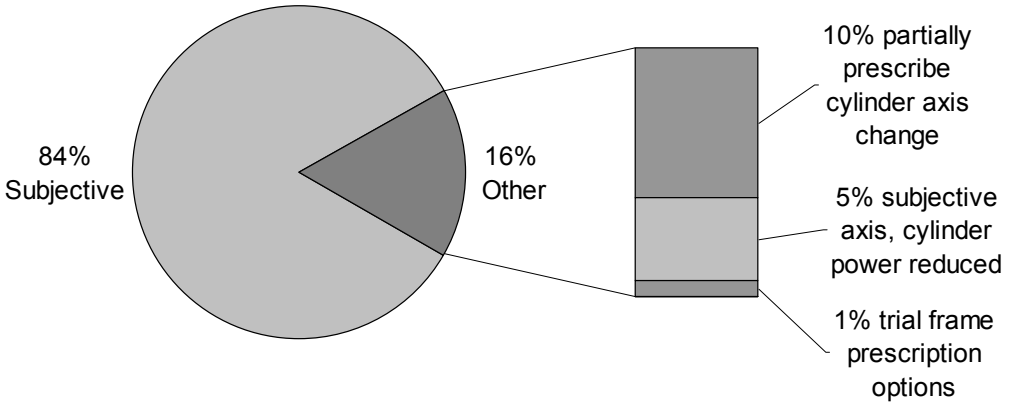

Figure 3.2 Prescribing decisions made by 592 UK optometrists for a 68 year old spectacle wearer with a moderate level of astigmatism (approximately -2.50DC) who complained of a reduction in vision due to a cylindrical axis change of 40 degrees towards the oblique (scenario B).

3.3.3 Patient C. Prescribe a reduced first hyperopic prescription

This patient was a 22-year old non-spectacle wearer who presented for her first eye examination complaining of intermittent headaches, especially after using her computer. The subjective refraction revealed RE: +2.00/-1.00x135; LE: +1.50DS. 60% of the practitioners indicated that they would prescribe the full subjective result with opinions varying on full-time (128, ~36%) or part-time computer and near vision wear (165, ~46%). Figure 3.3 shows the partial prescribing variations, with the two most popular decisions (each chosen by ~7% of practitioners) involving reducing the

sphere component (by 0.50DS in each eye) with one group maintaining the -1.00 cylinder and the other reducing the cylinder to -0.75DC. A further 5% of optometrists applied the bilateral 0.50DS sphere reduction but reduced the cylinder further to -0.50DC (hence prescribing R +1.50/-0.50x135 and L+1.00DS) and 2% prescribed RE: +1.50/-0.50x135 and LE: +1.25DS). Other variations of prescription each chosen by 2-3% of optometrists are also shown in Figure 3.3.

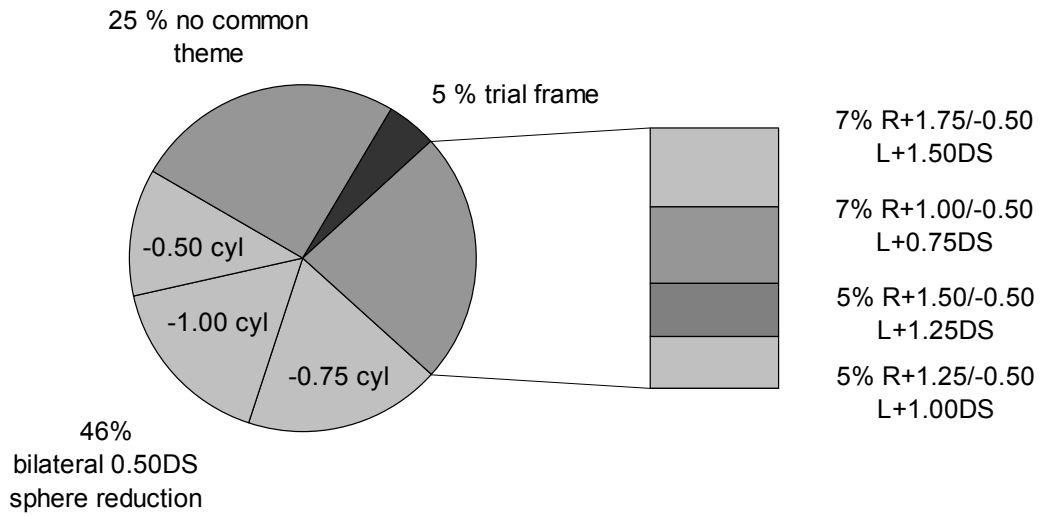

Figure 3.3 Prescribing outcome of the 237 UK optometrists who elected to partially prescribe in the case of a 22 year old spectacle neophyte prescribed her first hyperopic prescription (patient C). The remaining 355 optometrists elected to prescribe the full subjective refraction result.

3.3.4 Patient D. Partially prescribe large changes in sphere power in an older patient

This patient was an 85 year old hyperope (originally R +4.75DS, L+6.50DS) who at her last eye examination had been diagnosed with bilateral nuclear cataracts. Patient D was now complaining that reading was difficult due to a reduced near working distance. Subjective refraction revealed a symmetrical myopic shift of -2.00DS. Figure 3.4 shows that the vast majority of prescribers (83.4%) elected to prescribe the full subjective result. Partial prescribing decisions that modified either the distance and/or near addition could be grouped together in three main categories each being chosen by ~5% optometrists. One group elected to prescribe a distance sphere change of only -1.00DS and another prescribed a -1.50DS change in each eye. In both cases, the prescribed reading addition varied from +2.00 to +3.50 depending on practitioner. The remaining group of optometrists decided to prescribe the subjective distance prescription but modify the reading addition with opinions varying from +2.50 to +4.00.

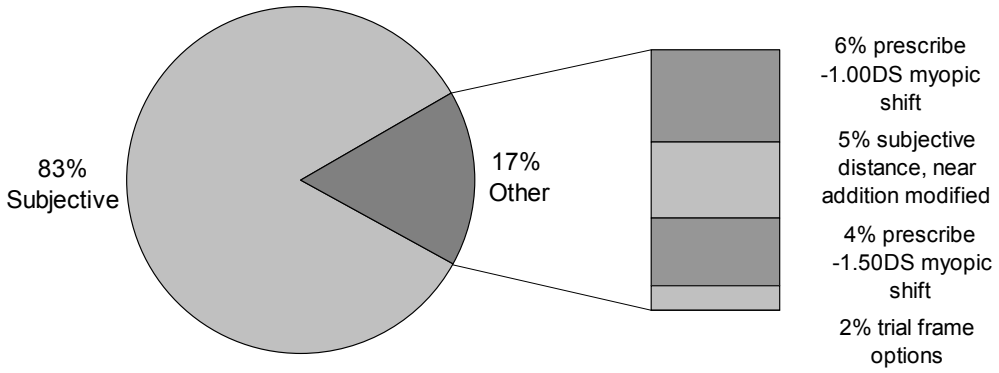

Figure 3.4 Prescribing decisions of 592 UK optometrists in the case of scenario D, an 85 year old with nuclear sclerosis and a bilateral myopic shift in prescription of -2.00DS complaining of reduced near working distance.

3.3.5 Patient E. Partially prescribe large cylindrical power changes

This patient was a 75 year old myope (approx -4.50D) complaining of reduced distance and near vision. The subjective refraction result in both eyes showed a 2.00D increase in cylindrical power, which was explained by cortical cataract in both eyes. Figure 3.5 shows that 59.3% of respondents indicated that they would partially prescribe the cylindrical change. The most common prescription modification suggested by 19.8% of respondents was to prescribe the subjective sphere and only half the cylindrical power change (-1.00DC increase). 8.6% reduced the cylindrical power half-way (between habitual and subjective), and modified the sphere to maintain the best mean sphere of the refraction. 4.0% decided

to prescribe the subjective sphere but reduce the subjective cylinder power by +0.50DC.

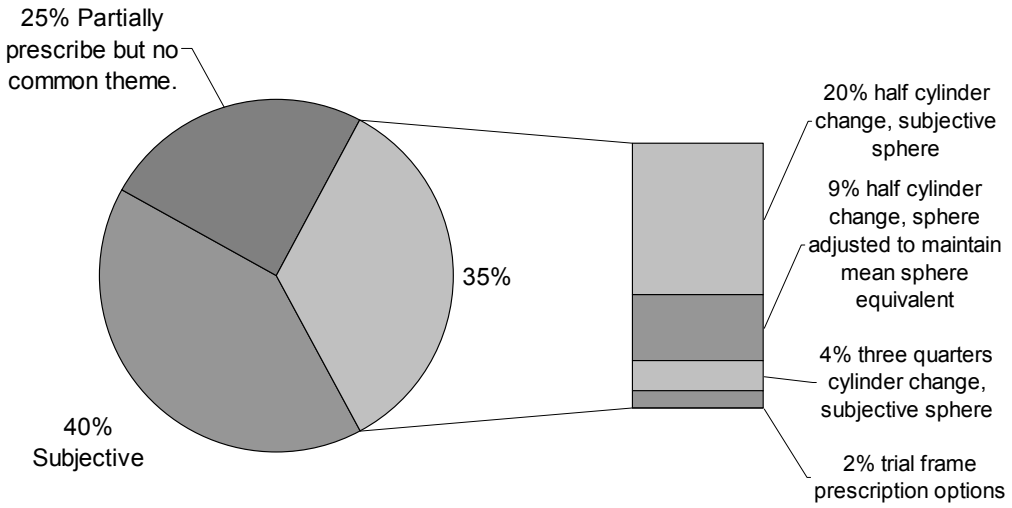

Figure 3.5 Prescribing decisions of 592 UK optometrists in response to patient E, a 75 year old spectacle wearer complaining of deteriorating distance and near vision whose habitual astigmatic prescription had changed by -2.00DC in both eyes.

3.3.6 Investigation of potential links between respondent profile and partial prescribing

Individual respondent prescribing decisions were converted into a binary outcome of either the subjective refraction result or partial prescribing (the habitual prescription was included in the latter category). Collaboration with a medical statistician (A J Scally, University of Bradford) allowed a random effect logistic regression model of the data to be generated using the Stata version 9.0 statistical programme (Stat Corp., College Station, USA). Demographic factors were incorporated sequentially and their statistical significance assessed. Factors with a *p*-value less than 0.1 were provisionally retained, whereas those above 0.1 were discarded. Significance of the two-level factors was determined by the 'Z'-statistic, while the significance of higher-level factors was tested using a likelihood ratio chi-squared test after dropping individual factors from the model. The final model adopted was the most parsimonious one that adequately explained the data, with the final level of significance set at $p < 0.05$.

No significant differences were found for the levels of partial prescribing between the two questionnaire media ($z=0.30$, $p=0.76$), whether optometrists were resident or locum ($z=0.38$, $p=0.67$), the number of CET points accumulated ($z=1.6$, $p=0.11$) or practice type (Likelihood ratio chi square = 2.70, $p=0.26$). However, the number of years respondents had been qualified was found to be significantly related to partial prescribing behaviour ($z=4.57$, $p<0.0001$) with an odds ratio of 1.03 (95% confidence

interval of 1.017-1.044) per year since qualification. This trend was linear as polynomial fits to the data provided no improvement to the logistic regression model. The 3% increase per year was cumulative, so that for every 10 years following qualification there was an increased probability of indicating a partial prescription choice by 34%. In addition, there were no significant interaction effects for case scenario and years qualified (Likelihood ratio chi square = 5.00, p=0.28) indicating that prescribing differences were consistent across the five scenarios.

3.4 Discussion

The study built on the experience gained from our first questionnaire on this subject and extended its scope to reveal the prescribing habits of a large pool of qualified optometrists in the UK. The prescribing recommendation of “not to push the plus” for non-progressive myopes (Elliott, 2007) or to be “very cautious about reducing minus at distance with the myopic patient” (Werner and Press, 2002) can be likened to a modified “if it ain’t broke, don’t fix it” prescribing rule discussed previously by Howell-Duffy *et al*. (2010) and very similar to “if it ain’t broke, don’t fix it much” discussed by Howell-Duffy *et al*. (2012) and in chapter 4. The rationale for this recommendation is that by fully reducing the minus in an asymptomatic myopic patient happy with their current correction, the practitioner only risks creating an unhappy patient. Patient A’s occupation of a taxi driver was deliberately chosen to alert practitioners to the possible effect of night myopia on their prescribing decision. Myopic shifts in

prescription of 1.00 dioptre have been reported in young adults when in complete darkness (Fejer & Girgis, 1992; Charman, 1996). Furthermore Cohen, Zadok, Barkana, Shochat *et al.* (2007) found that up to one quarter of younger drivers may experience night myopia and drivers with a myopic shift greater than -0.75D were involved in more accidents at night. Over half (~57%) of practitioners agreed with the approach of being cautious about reducing the prescription, by either prescribing the habitual correction or only reducing the prescription by +0.25DS. Many practitioners added comments in this scenario to the effect that this was "a recheck waiting to happen" if the subjective result had been prescribed. Some practitioners who did recommend the full subjective result justified their decision by stating that accommodative effort would be reduced by the new prescription, although the 30 year old patient in this case would still be expected to have 6.0-7.0D amplitude of accommodation (Hofstetter, 1944; Tunnacliffe, 1993), so that more than 90% of this amplitude would still be available for near work if the habitual prescription had been recommended. Given that the patient was asymptomatic and that Hrynchak (2006) reported that over-plussing the distance correction was the most common reason for spectacle dissatisfaction, it would seem appropriate for practitioners to be wary of reducing the habitual prescription by more than 0.25DS. A rationale for reducing the prescription by 0.25DS rather than prescribing the habitual correction is that it is possible that the correction will continue to become less myopic, so that the patient could become symptomatic within a few months. Such a

patient would then not be very happy after paying for a new pair of glasses if he was prescribed the old habitual correction.

Patient B investigated the level of partial prescribing for large axis changes (40 °) and was found to be remarkably similar to the results of our previous study, with ~84% of practitioners prescribing the full subjective result. This level of subjective prescribing was surprising given the greater age of the patient in this questionnaire (68 years compared to 33 years in chapter 2 and Howell-Duffy *et al*., 2010) combined with the oblique nature of the subjective cylindrical correction (40 and 45°). A more conservative approach by practitioners was expected as older adults are reported to be less tolerant of prescribed refractive changes (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007) especially astigmatic changes that are oblique (Brookman, 1996; Obstfeld, 1998; Newman, 2006; Elliott, 2007). In addition presbyopes account for the majority of spectacle dissatisfaction cases (Constantine-Smith, 2002; Freeman & Evans 2010). Although over half of practitioners did indicate that they would warn of potential adaptation problems, it is possible that the prescribing of the full subjective result in this patient would have produced such meridional differences in the size of the retinal image as to make the prescription intolerable to the patient.

Patient C examined the prescribing decisions of optometrists when faced with a symptomatic, 22 year-old hyperope. The subjective refraction result

suggested low bilateral hyperopia with a small cylinder (-1.00DC) of oblique astigmatism in one eye. It is likely that the combination of the uncompensated astigmatic error and the uncorrected hyperopia were the cause of the asthenopia, especially when the visual system was stressed. 40% of optometrists elected to partially prescribe in this scenario, which perhaps was due to the fact that over-plussing the distance correction has been shown to be the most common reason for spectacle dissatisfaction (Hrynchak, 2006). It is possible that as experience increases, optometrists are more likely to recommend a partial prescription sufficient to alleviate symptoms rather than the full subjective result, an approach advocated by Newman (2006) and Elliott (2007). Only 3 respondents (~0.5%) elected to simply reduce the sphere by 0.25DS in both eyes as recommended by Milder and Rubin (2004). However, it is important to note the plethora of different options suggested by the clinicians (N=29).

In the penultimate patient scenario D (-2.00DS shift due to nuclear sclerosis), the possible prescribing guideline of limiting changes of sphere power to a maximum of around 1.00D in older patients was tested (Werner and Press 2002; Newman, 2006; Elliott, 2007). This was not implemented by the vast majority of practitioners with only ~17% electing to partially prescribe in this situation. Although the principal aim was to test the prescribing decision for distance, many practitioners (~50%) commented that this scenario was the one in which more information would have been preferable. It is accepted that the type of spectacles used by the patient

could have exerted a significant effect on the ultimate prescribing decision. For instance, if the habitual spectacles had been bifocals then the prescribing of the full subjective distance and near prescriptions may have caused problems for the patient's intermediate vision. Clearly there are many possible variations of spectacle type and lens form in this scenario that were not detailed in the case history and this omission may have skewed the results. Nine optometrists indicated that they would use a trial frame to refine the prescription and two practitioners indicated that referral for cataract surgery was mandatory, despite the patient's wishes to the contrary. The patient was purposefully given as elderly to alert practitioners to potential spectacle adaptation problems. Accordingly, the 83% of subjective refraction prescribing was again somewhat unexpected with only 17% of practitioner's electing to partially prescribe. It was noted that a number of practitioners (N=20) indicated that they felt that the full subjective prescription should assist patient mobility, when research evidence suggests the exact opposite (as previously discussed in section 1.5.4). In summary, this may be due to spectacle magnification changing the patient's judgment of the position of kerbs and stairs (Elliott & Chapman, 2010; Chapman *et al*., 2011) and adaptation of their vestibulo-ocular reflex (VOR). Spectacle magnification disrupts the VOR so that the rapid compensatory eye movements linked to head movements are not in synchrony leading to the patient's view appearing to "swim" when moving their head (Demer, 1989). Adaptation to these visual perceptual changes also takes longer in older people (e.g. Wick, 1960; Brookman, 1996;

Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007).

The final patient E described a 75 year old who was complaining of deteriorating distance and near vision due to a bilateral prescription change of -2.00DC. The majority of respondents (59%) elected to partially prescribe in this scenario, the highest level encountered in the questionnaire. Unfortunately the use of familiar clinical notation of sphere, cylinder and axis precluded the direct comparison of prescription changes between scenarios as these terms are not independent of one another (Raasch, Schechman, Davis & Zadnik, 2001). Therefore in order to enable the comparison of the scenarios generating the lowest (scenario B, cylinder axis change) and highest levels (scenario E, cylinder power change) of partial prescribing, the magnitude of change between habitual and subjective prescriptions was quantified using a vector representation of the refractive correction components as proposed by Thibos, Wheeler and Horner (1997). The resultant magnitude of difference (MOD) was then be calculated by application of Pythagorean theorem in 3-dimensional space (Miller, 2009):

- mean spherical equivalent (M) = sphere + 1/2cylinder
- Jackson cross-cylinder at axis zero J_0 = (-cylinder/2)cos(2xaxis)
- Jackson cross-cylinder at axis 45º J_{45} = (-cylinder/2)sin(2xaxis)
- Magnitude of difference (MOD) = $\sqrt{(\Delta M)^2 + (\Delta J_0)^2 + (\Delta J_{45})^2}$

Thus in scenario B, the MODs between habitual (R -1.50/-2.00x80 and L -1.50/-2.25x85) and subjective prescriptions (R -1.25/-2.50x40 and L -1.25/-2.75x45) were calculated to be equivalent to 1.5 and 1.6 dioptres respectively. Therefore only 16% of respondents (the lowest level of partial prescribing in the questionnaire) considered that an average change of 1.55D warranted partially prescribing. Conversely in the final scenario E, the MOD was calculated and found to be very similar at 1.80D and yet this triggered the highest level (59%) of partial prescribing from respondents. Clearly, changes in cylinder power and axis must be viewed differently by practitioners since the difference between lowest and highest levels of partially prescribing was only 0.25D, a one step difference in trial lens power. It seems that optometrists feel that patients tolerate the prescribing of full axis changes more favourably than the prescribing of large cylinder power changes. However this was surprising, particularly in scenario B as the subjective axis had deliberately been made oblique, maximising potential spatial distortion and thus making spectacle adaptation all the more difficult for the patient (Guyton, 1977; Brookman, 1996; Werner & Press, 2002).

3.4.1 Variation in partial prescribing.

Practitioners with the greater number of years following qualification were more likely to partially prescribe, with the logistic regression model indicating that for every ten years increase in number of years qualified, the odds of suggesting a partial prescription increased by 34%. There are

several possible causes for this finding, with some more likely than others. It is possible that this is a cohort effect, with older practitioners perhaps having been taught partial prescribing during their training, whilst younger clinicians had not. However, this seems unlikely given the presence of partial prescribing guidelines in currently used textbooks (Brookman, 1996; Fletcher *et al*., 1998; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007). Although respondents from large multiples did show lower partial prescribing behaviour than other practice types, this was purely due to the typically lower number of years qualified for practitioners working in these practices. When both 'years qualified' and 'practice type' were included in the logistic regression model, there was no significant effect for practice type (Likelihood ratio chi square = 2.70, p=0.26). The most likely cause of the strong link between years qualified and the likelihood of partially prescribing is increased experience, as with more exposure to patients who return unsatisfied with their spectacles, a greater appreciation of partial prescribing is achieved. This is certainly how the authors of the various textbooks on the subject came to develop their particular prescribing guidelines. (Brookman, 1996; Fletcher *et al*., 1998; Werner & Press, 2002; Milder & Rubin, 2004). Broadly speaking, the partial prescribing suggestions obtained from the questionnaire tended to match the commonly proposed rules in the prescribing guideline literature. (e.g., Ball, 1982; Obstfeld, 1988; Polasky, 1991; Brookman, 1996; Fletcher *et al*., 1998; Werner & Press, 2002; Carlson & Kurtz, 2004; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007; Lee &

Tahran, 2007). The one major discrepancy was the lack of appreciation of prescribing the mean sphere equivalent power of the subjective refraction when partially prescribing a cylinder power. This occurred in case scenarios B, C and E. In case scenario E, which was specifically developed to investigate this issue, 78% of respondents who elected to partially prescribe did not suggest the use of the mean sphere equivalent and instead 52% chose to use the subjective refraction sphere value and 2% the habitual sphere value. It would appear that some practitioners view the sphere and cylinder component of the refractive correction as separate elements that do not interact with each other. The prescribing of at least 0.50DS from the mean sphere equivalent in one eye in patient B by ~4% of partial prescribers and in one or both eyes with patient E by ~53% of respondents would very likely result in patient dissatisfaction (Miller *et al*., 1997; Atchison *et al*., 2001). The relatively high level of practitioners not maintaining the subjective mean sphere equivalent power was similar to those obtained from our first prescribing questionnaire (Howell-Duffy *et al*., 2010) and reiterates the need for continuing education in this area.

3.4.2 Study limitations

The 592 completed questionnaires represent a sample size of approximately 5% of UK optometrists (GOC 2009). Every effort was made to include as wide a range of practitioner profile as possible, but it is accepted that the type of practitioner sufficiently motivated to complete the questionnaire may not be fully representative of the UK optometry

profession. It is possible that respondents were practitioners with a less hectic work schedule and the free time to complete the questionnaire or optometrists with an interest in the issue of spectacle prescribing. However it would be hoped that since the prescribing of spectacles is the primary function of the majority of optometrists in the UK, most practitioners would be interested in the prescribing conundrums posed in this research.

It is accepted that the practitioner registration profile obtained from the questionnaire was limited and took no account of possible career breaks taken by respondents and also the differing work patterns found in the profession. Other limitations include the questionnaire style format which, while allowing a wide appeal to the profession, may self-select the more conscientious practitioners and thus not represent the prescribing opinions of the general optometric population. In this regard, questionnaire type surveys have been previously reported to overestimate the quality of care (Stevenson, 1998).

It may also be that the intrinsic nature of any questionnaire style research, in which the practitioner may feel in an “assessment situation”, makes respondents more likely to give their optimal “text book style” answer (Shah, Edgar & Evans, 2010). Whether this prescribing decision would be the outcome of a real eye examination is therefore open to debate. However, we would contend that the “text book” answer in this case would be to partially prescribe so that the results may actually over-estimate the

extent of partial prescribing (Ball, 1982; Obstfeld, 1988; Polasky, 1991; Fletcher *et al.*, 1998; Brookman, 1996; Werner & Press, 2002; Carlson & Kurtz, 2004; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007; Lee & Tahran, 2007).

3.5 Conclusions

The case scenarios were deliberately chosen as representing situations where partial prescribing may be necessary to improve patient visual comfort and ease spectacle adaptation. Despite this, the subjective refraction result exerted a strong hold on the reported prescribing outcome and between 41% and 84% prescribed the subjective result depending on the scenario. This was particularly true in our survey of newly qualified optometrists, many of whom worked for the large multiples. Partial prescribing was increasingly more likely the more years the respondent had been qualified and over three times more likely at the end of a 40 year career rather than the beginning. Perhaps some of these experienced clinicians were practice owners and so were particularly sensitive to the negative commercial effects that patient dissatisfaction can produce (Buttle, 1998; Dawn & Lee, 2004). We feel that the link between practitioner experience and partial prescribing is an important finding that provides significant support for the prescribing rules suggested by various authors (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007). Presumably, the more experience an optometrist gains (and the more dissatisfied patients he or she has dealt with), the more likely

they are to partially prescribe. The low level of partial prescribing by optometrists in the case involving large changes of oblique cylinder axis (case scenario B) was unexpected. Some authors have highlighted that these changes should be partially prescribed, (Obstfeld, 1988; Brookman, 1996; Newman, 2006), so either such refractive changes are seldom encountered in UK optometric practice resulting in few optometrists gaining experience in dealing with them or alternatively they do not cause as much problem as suggested. In addition, the results of case scenario E highlight the lack of basic understanding of the mean sphere equivalent power of a sphero-cylindrical correction, with some optometrists appearing to consider sphere and cylinder changes within a sphero-cylindrical refractive correction as separate entities.

Chapter 4

Retrospective evaluation of the clinical maxim: "If it ain't broke, don't fix it"

4.1 Introduction

This chapter is based on the work published as Howell-Duffy, Hrynchak, Irving, Mouat and Elliott (2012): Evaluation of the Clinical Maxim: "If it ain't broke, don't fix it". *Optom. Vis. Sci.* 89, 105-111.

As previously stated, in its various guises, the most common prescribing maxim pervading the literature (Brookman, 1996; Constantine-Smith, 2002; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007) is the "if it ain't broke, don't fix it" approach, also known as "don't rock the boat". The rationale underpinning this maxim is that if a patient is happy with their current refractive correction and can attain a satisfactory level of vision, any prescription changes implemented by the prescriber have the possibility of making that patient unhappy. Accordingly, the aim of this study was to retrospectively examine the potential usefulness of the "if it ain't broke, don't fix it" maxim in over 300 documented spectacle dissatisfaction (recheck) cases. The potential benefits (or otherwise) had this maxim been followed in the original eye examination were estimated and the resultant change in recheck eye examinations calculated.

4.2 Methods

4.2.1 Overview

Following institutional ethics clearance, recheck data from "Spectacle Reassessment Records" (SRRs) collected from the University of Waterloo, School of Optometry Clinic, Canada over the period 1 January 1998 to 1 June 2008 were obtained. These records were generated when a patient failed to adapt to their new spectacle correction after any dispensing issues were addressed, appropriate counselling on lens design and lens accuracy being verified. The SRRs were completed in the Primary Care Clinic following a recheck eye examination carried out by an optometry student under the supervision of an optometrist. A similar sample was used in an earlier study (Hrynchak, 2006), but from a shorter time frame (1998-2004) and only data exclusively from the SRRs was utilised. The present study used data from an extended period (1998-2008) and the SRR data was supplemented by patient record information.

During the 10.5 year period, 339 SRRs were deemed to have resulted from problems of refractive error measurement or prescribing issues. SRR data included the following for both the initial and recheck eye examinations: chief complaint, spectacle powers including lens type and form, distance visual acuity with spectacles, subjective refraction results with optimal visual acuities and prescribed refractive correction. The time taken for the patient to present for a recheck eye examination was also determined. Clearly, if a patient only complained of spectacle

dissatisfaction after 12 months had elapsed since their initial eye examination, then this could not be legitimately categorised as a recheck. In this protracted period of time it would be possible that either the patient's refraction had changed or that clinically significant ocular disease had developed. Intuitively it was also felt that 6 months was too long for a case to be assigned a recheck eye examination and thus a time period of 23 weeks (5.3 months), determined from the upper 95% confidence limit of the number of days from initial to recheck eye examination, appeared to be a sensible cut-off. By being deliberately benevolent in our definition of a recheck, it is possible that the results may underestimate rather than overestimate the potential advantages of employing the "if it ain't broke, don't fix it" maxim.

4.2.2 Record categorisation

Two experienced (20 and 18 years experience) and one relatively inexperienced (4 years experience) optometrists were independently given identical copies of the data and requested to assign each individual case into one of the following four prescribing categories:

(a) – Application of the "if it ain't broke, don't fix it" maxim may have prevented the recheck eye examination. This category was defined pragmatically to include cases where the patient was initially asymptomatic (i.e., attending for a routine eye examination) and could achieve a satisfactory level of visual acuity (improvement of one line only obtained after subjective refraction and visual acuity

(VA) of 6/6 or better for younger patients and VA of 6/9 or better for those older than 60 years) with their habitual spectacles. Following the initial eye examination, their habitual prescription had been changed, dispensed and subsequently the patient returned to now report dissatisfaction with their new spectacles. At the resultant recheck eye examination, the prescription had either been returned to the original habitual prescription or close to it (within +/- 0.25DS of the habitual mean sphere equivalent, Miller *et al*., 1997; Smith, 2006). A further number of cases were deemed appropriate for this category but the recheck prescription was outside the stringent +/- 0.25DS limit of the original habitual prescription and these were recorded separately.

(b) – Application of a variant of the "if it ain't broke, don't fix it" maxim may have prevented the recheck eye examination. In this case an initial chief complaint of blur at one distance was substituted by a recheck complaint of visual problems at a different distance. For example, a patient initially complaining of near blur then returned for a recheck eye examination with visual problems at distance. It could be argued that in this example, if the distance refractive correction had not been changed ("if it ain't broke, don't fix it") and only the reading addition had been altered to appropriately address the near vision problems, the patient would have been satisfied with their new spectacles or "Milder's law #1", (Milder & Rubin, 2004).

(c) – Application of “if it ain’t broke, don’t fix it” maxim may have caused the symptoms and recheck eye examination. In this category the practitioner was deemed to have already followed the maxim (by not changing the prescription significantly) and yet despite this, the initially asymptomatic patient now returned complaining of symptoms for a recheck eye examination.

(d) – Remaining category for all cases that were deemed not to fit any of the above criteria.

Following categorisation, the results were pooled to identify cases where prescribing categories had been unanimously agreed upon. The remaining disputed cases were discussed by the three authors and a majority decision taken if necessary, to allocate each case into its most suitable category.

4.3 Results

Out of the initial 339 records, 21 cases were omitted from the analysis due to insufficient data (N=3) or a recheck time period exceeding the previously defined 23 week cut-off point (N=18, 24 to 46 weeks). Prescriptions for myopia accounted for 146 (46%) of cases, hyperopia 151 cases (47%) and the remaining 21 prescriptions were for antimetropia. Kolmogorov-Smirnov tests indicated that the age data of the recheck patients were not normally distributed and hence non-parametric descriptive values were used. The median age was 57 years with a range

of 11-89 years (Figure 4.1). The majority (~90%) of the recheck eye examinations were for patients over 40 years of age.

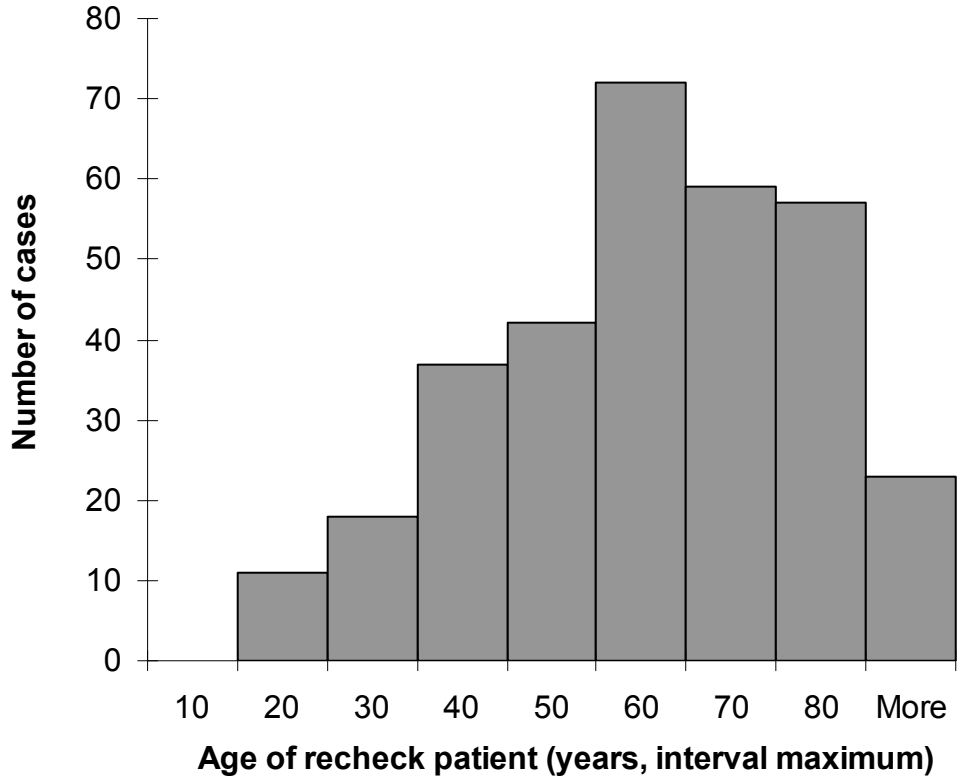

Figure 4.1 Age distribution of 318 patients attending for recheck eye examinations at the University of Waterloo, School of Optometry Clinic, Canada over the period 1 January 1998 to 1 June 2008.

Categorisation of the data into one of the four categories was unanimously agreed upon in 84% of the cases and majority agreement was reached in the remaining cases. Figure 4.2 shows the breakdown of results into the four previously defined categories. Further analysis of the 69 (22%) recheck cases that may have been prevented by application of the proposed maxim (a), revealed that approximately one third of the final

recheck prescriptions were within +/-0.12D of the mean sphere equivalent (MSE) of the habitual prescription and two thirds were within +/- 0.25D of habitual MSE. A further 6% or 10% of recheck cases may have been preventable by application of the proposed maxim if the difference between habitual and recheck MSE had been more flexible at +/- 0.50D and +/- 0.75D respectively.

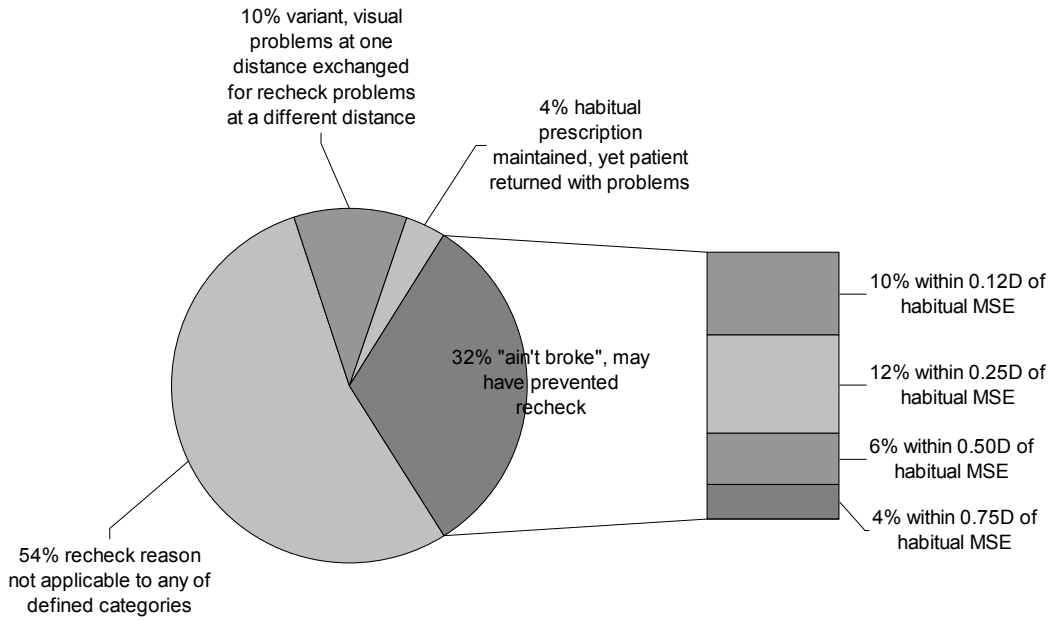

Figure 4.2 Results of retrospective analysis of 318 documented recheck eye examination cases from the University of Waterloo, School of Optometry Clinic, Canada over the period 1 January 1998 to 1 June 2008, (MSE mean sphere equivalent).

4.4 Discussion

The majority (91%) of the patients attending for a recheck eye examination were over 40 years of age. This is in agreement with Constantine-Smith (2002) and Freeman and Evans (2010) who reported that 84% and 88% respectively of their recheck data involved presbyopic patients. In addition as Fylan and Grunfield (2005) found that 49% of presbyopic patients were worried about adapting to new spectacles, it would seem appropriate for optometrists to particularly consider this information when prescribing new spectacles to older patients.

The number of recheck case records that were deemed to comply exactly with prescribing scenarios intended for the “if it ain’t broke, don’t fix it” maxim was 69 (22%). These were cases in which the patient was asymptomatic, attending for a routine eye examination and had good visual acuity with his or her spectacles. The optometrist had changed the prescription which resulted in the patient returning to complain of problems with his or her new spectacles. Following a recheck eye examination, the prescription had been reinstated to within +/- 0.25D of the MSE of the original spectacle prescription. This typically represents a one step difference in trial lens power and is the level at which Goss and Grosvenor (1996) suggested that 80% of test-retest refractions are repeatable and well within the +/-0.75DS inter-practitioner variability (MacKenzie, 2008; Shah *et al*., 2009). One illustrative example from the 69 cases of this type is shown in Table 4.1.

Table 4.1 Representative case record from the 69 recheck examinations deemed to comply with prescribing scenarios intended for the "if it ain't broke, don't fix it" clinical maxim.

Patient age:	65 years.	
Chief complaint:	Routine eye examination. No visual problems.	
Habitual correction:	R +2.25 / -1.75 x 165 Add +2.50 L +1.75 / -1.25 x 20 Add +2.50	VA 6/4.5 VA 6/4.5
Prescribed correction:	R +2.50/-1.50 x 170 Add +2.50 L +2.25/-1.00 x 15 Add +2.50	VA 6/4.5 VA 6/4.5
Recheck complaint:	Distance blur both eyes.	
Recheck correction:	R +2.25/-1.75x170 Add +2.50 L +1.75/-1.25x 25 Add +2.50	VA 6/4.5 VA 6/4.5

The habitual prescription provided excellent VA in both eyes, yet the practitioner had prescribed the subjective refraction result and increased the power of the hyperopic correction by +0.38D MSE in the right and +0.63D MSE in the left. The patient returned after 25 days to complain of distance blur with their new spectacles. However, if the practitioner had followed the "if it ain't broke, don't fix it" maxim, then it seems very unlikely that patient dissatisfaction would have occurred. Following the recheck eye examination the original habitual prescription was to all practical purposes reinstated and we presumed that this proved satisfactory to the patient as the records indicated attendance for future eye examinations.

An awareness of the maxim would have prompted the original clinician to query a significant increase in positive power in the refractive correction despite the absence of patient symptoms and no improvement in visual acuity. This could have led to a retest of the subjective refraction or at the very least a partial prescribing of the increase in positive power.

The habitual and recheck corrections were identical apart from a 5 degree change in cylinder axis in both eyes. These small changes in cylinder axis equated to 0.15D and 0.10D magnitude of difference (MOD) in terms of vector changes in power (Thibos *et al*., 1997) and both were less than the traditional 0.25D trial lens increment (Miller *et al*., 1997; Smith, 2006). This presumably successful correction, which was very similar to the original spectacles, combined with no symptoms at the original examination and good visual acuity in both eyes, suggests that the original habitual prescription would have been equally acceptable to the patient.

4.4.1 Use of the maxim when determining refractive correction for distance or near only

A further (32) 10% of records were deemed to comply with the second defined group or variant of the maxim (b), in which a patient initially complained of visual problems at one distance and then returned with problems at a different distance. For example, consider the case in Table 4.2.

Table 4.2 Representative case record from the 32 recheck examinations in which application of the clinical maxim "if it ain't broke, don't fix it" may have been appropriate for determining the distance or near correction only, i.e. a patient initially complained of visual problems at one distance (e.g. at near) and then returned with those problems "fixed", but with different problems (at distance in this example).

Patient age:	46 years.	
Chief complaint:	Near blur both eyes.	
Habitual correction:	R -1.50/-0.25x 66 L -2.00/-0.50x 75	VA 6/4.5 VA 6/6
Prescribed correction:	R -1.00/-0.25x 68 Add +1.50 L -1.75/-1.00x 90 Add +1.50	VA 6/4.5 VA 6/4.5
Recheck complaint:	Distance blur both eyes.	
Recheck correction:	R -1.50/-0.25x 66 Add +1.50 L -2.00/-0.75x 90 Add +1.50	VA 6/4.5 VA 6/4.5

This patient was satisfied with their habitual distance vision but complained of visual problems at near due to the onset of presbyopia. The practitioner had recommended a reading addition to address the near problems but had also reduced the myopic distance prescription in the right eye by a MSE of +0.50D (MOD 0.50D) and modified the left eye but kept the original MSE (MOD 0.31D). This change in distance prescription did not improve the right VA but was recorded as improving the left VA by one line to 6/4.5. Subsequently the patient returned to complain of distance blur and following a recheck eye examination, the distance prescription was reinstated exactly in the right eye and within -0.12D of MSE (MOD 0.24D) in the left eye. It could be argued that had the original prescriber followed a variant of the maxim and only modified the part of the prescription pertaining to the patient's visual complaint then a recheck could have been avoided.

4.4.2 Additional cases in which application of the maxim may have been appropriate

All cases in which asymptomatic patients with good visual acuity were prescribed new spectacles that subsequently required a recheck prescription were investigated. As stated earlier, 69 (22%) of corrections were returned to within 0.25D of the MSE of the original habitual prescription. In a further 33 (10%) of cases the prescription was returned to nearer the habitual power, but within 0.50-0.75D of the MSE (Figure 4.2 on page 93). These cases could still judged as clinical situations in which

the habitual prescription may have sufficed for the patient. Alternatively, and perhaps more appropriately, they seem to be cases where a partial prescription of the initial change in refractive correction would seem appropriate.

It should also be noted that during the data analysis, records were only allocated to “if it ain’t broke, don’t fix it” category if the patient was asymptomatic and attending for a routine eye examination and had adequate visual acuity. If this requirement had been less stringent, to include patients reporting possible non-visually related symptoms at their initial eye examination, then this figure may have been slightly higher. It is difficult to quantify how many more records may have been added to this group as insufficient clinical data were available to allow this distinction to be made. For example, a significant number of patients will attend for an eye examination complaining of headaches (Thomas, Boardman, Ogden, Millson *et al*., 2004; Glover, Greensmith, Ranftler, Donkin *et al*., 2006). However the belief of a common relationship between uncorrected refractive error and headache is debatable (Gordon, Chronicle & Rolan, 2001; Gil-Gouveia & Martins, 2002) and the International Headache Society classification whilst acknowledging refractive error as a causative factor suggests that its importance is widely overestimated (IHS, 2004).

4.4.3 Cases where the maxim did not work

The discussion so far has focussed on the possible prescribing benefits to optometrists of employing the "if it ain't broke, don't fix it" maxim or minimising the prescription change experienced by the patient in order to reduce spectacle dissatisfaction cases. However, it is possible that some patients will experience dissatisfaction with new spectacles even when this maxim is followed and thus the frequency of this clinical situation was also assessed. Approximately 12 records (4%) were deemed to fit this category and described the prescribing situation in which an asymptomatic patient attended for a routine eye examination, the habitual prescription was retained, yet the patient returned unhappy with their new spectacles. An example is shown in Table 4.3.

Table 4.3 Example case taken from the 12 records allocated to the prescribing scenario in which an asymptomatic patient attended for a routine eye examination, the habitual prescription was retained, yet the patient returned unhappy with their new spectacles.

Patient age:	31 years.	
Chief complaint:	Routine eye examination. No visual problems.	
Habitual correction:	R -6.00DS L -6.00DS	VA 6/4.5 VA 6/6
Prescribed correction:	R -6.00DS L -6.00DS	VA 6/6 VA 6/6
Recheck complaint:	Distance blur in both eyes	
Recheck correction:	R -5.75DS L -5.75DS	VA 6/6 VA 6/6

The variability in VA assessment is illustrated in this example with the prescribed refractive result in the right eye recorded as 6/6, yet initially with the same habitual prescription the VA was better at 6/4.5 (this was noted in many other cases). The practitioner did not change the habitual prescription yet the patient returned 49 days later complaining of blur in both eyes. Following a recheck eye examination the prescription was bilaterally reduced by +0.25DS. It seems unlikely that this small reduction in prescription would have proved beneficial to the patient as a 31-year-old would have been expected to possess an accommodative amplitude of at

least 6D (Tunnacliffe, 1993) and thus should have been able to cope easily with a slight over-minussed correction. Since no vertex distance data were available in the records it is possible that this recheck occurred due to the patient selecting a frame with a different vertex distance to the original. In addition, there could have been other changes in lens design parameters that the patient did not appreciate such as differences in base curve, centre thickness, lens material and distance between the optical centres (Gordon & Amos, 1987). It is also plausible that the patient had taken a dislike to the spectacle frame initially chosen and that this was the real underlying reason for the recheck appointment. Finally, another explanation for these clinical scenarios could be that the initial case history was poor and a history of reduced vision and/or symptoms were missed. Thus, an important caveat to the use of the "if it ain't broke, don't fix it" maxim is that a good case history is essential and an accurate assessment of the patient's habitual spectacle prescription is mandatory. Table 4.4 exemplifies this latter point and represents one of four similar cases found during the data analysis. It seems likely that at the initial eye examination, the presence of vertical prism was missed when the patient's habitual spectacles were neutralised and this omission prevented the successful application of the maxim.

Table 4.4 Case record that exemplifies the importance of accurately assessing the habitual refractive correction (it seems likely that the presence of vertical prism was missed when the habitual spectacles were neutralised) before applying the clinical maxim "if it ain't broke, don't fix it".

Patient age:	84 years.	
Chief complaint:	Routine eye examination. No visual problems.	
Habitual correction: (recorded)	R -0.50/-2.00x 90 Add +2.75 L +0.50/-1.50x 95 Add +3.00	VA 6/9 VA 6/12
Prescribed correction:	R -0.50/-2.00x 90 Add +2.50 L +0.50/-1.50x 95 Add +2.50	VA 6/7.5 VA 6/7.5
Recheck complaint:	Diplopia at distance with new spectacles, no symptoms with habitual correction.	
Recheck correction:	R -0.50/-2.00x 90 Add +2.50 L +0.50/-1.50x 95 Add +2.50 1.5Δ base UP	VA 6/7.5 VA 6/7.5

4.4.4 Study limitations

The data contained within the SRRs had certain intrinsic limitations in that vertex distance was not recorded for any of the spectacle prescriptions and accurate near visual acuity data were also not available for many records. It is also accepted that initial and recheck appointments were most likely performed by different students and supervisors in different

clinic rooms which may have contained alternative visual acuity charts especially in the first half of the study period. This could account for the variation in visual acuity measurements that became apparent from consideration of the dataset as a whole. By definition the categorisation of the data was subjective and despite the high level of concordance (84%) in the focus group, it is possible that other practitioner's would have judged some of the cases differently. The data were obtained from a teaching clinic and any findings must be viewed cautiously when applied to a non-institutional optometric population.

4.4.5 "If it ain't broke, don't fix it much"

The inherent difficulty faced by any practitioner is to identify the patient most likely to benefit from an application of the clinical maxim "if it ain't broke, don't fix it". Previous work by Howell-Duffy *et al*. (2010, 2011) has suggested that a large majority of optometrists would prescribe the subjective refraction result without modification and this must include cases where only a small change in prescription would have been recommended. Presumably some of these patients would have been equally satisfied with their existing habitual prescription. However it is worth noting that in this study, the 22% of rechecks that may have been preventable by application of the maxim, represented cases in which the prescription was not returned exactly to the original but within 0.25D of the MSE. Therefore it is perhaps more appropriate for the practitioner to interpret the clinical maxim "if it ain't broke, don't fix it", as a

recommendation to minimise the refractive change experienced by the patient especially when no symptoms and good visual acuities are recorded in the eye examination ("if it ain't broke, don't fix it much"). Furthermore it could be argued that there are potential clinical benefits to the patient by making small incremental changes in prescription rather than making much larger changes at a future date. This last point seems particularly pertinent given that poor adaptation to large refractive correction changes may increase the risk of falls in older patients (Cumming *et al*., 2007).

4.5 Conclusion

Presbyopic patients comprise the majority of patients attending for recheck examinations due to spectacle dissatisfaction. In the recheck data analysed in this study, 22% of non-tolerance cases were judged to have been preventable by direct application of the proposed maxim. This figure increased to 32% if a more liberal interpretation of the maxim was adopted and a further increase to 42% was possible by including the use of the variant of the maxim when used at either the distance or near components of the patient's spectacle prescription. Conversely only 4% of cases were deemed to comprise of scenarios in which the habitual prescription had been maintained by the practitioner yet the patient returned later to report visual problems. This appears to provide further evidence of the value of this clinical maxim, which is the most common prescribing recommendation in the literature (Brookman, 1996; Constantine-Smith,

2002; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007). An important caveat prior to using the “if it ain’t broke, don’t fix it” maxim in any form is that a complete case history and accurate assessment of the patient’s habitual spectacles and visual acuities is essential. It is perhaps pertinent to stress that accurate focimetry of the patient’s spectacles may be difficult to guarantee in practice, as this task is commonly delegated to lesser trained support staff. Therefore it may be advisable for any optometrist applying this clinical maxim to carry out focimetry themselves, thus eliminating any possible sources of error such as missing prism in the spectacles.

Chapter 5

Could spectacle adaptation difficulties explain the minimal effect of cataract surgery on falls rate in older people?

5.1 Introduction

Falls ("an unexpected event in which the participants come to rest on the ground, floor, or lower level") are a major cause of disability and the leading cause of mortality due to injury in people aged 75 years and over in the UK (NSF, 2001). Injuries from falls are also the third most common reason for hospital bed occupancy (Cryer, Davidson, Styles & Langley, 1996). Therefore, falls prevention is a priority area for research and intervention with the National Service Framework for older people (2001), standard 6 aim "to reduce the number of falls which result in serious injury and ensure effective treatment and rehabilitation for those who have fallen". Observational studies indicate that visual impairment is an important risk factor for falls in older people (Dargent-Molina, Favier, Grandjean, Baudoin *et al*., 1996) and that many older people have correctable visual impairment due to cataract and refractive error (Wormald, Wright, Courtney, Beaumont *et al*., 1992). These studies and others suggest a beneficial effect of correcting refractive error and performing cataract surgery on the likelihood of older adults falling. However, intervention studies on falls rates to date have not shown the same expected results. Of the four cataract surgery interventional trials, only one (using an open study design with no control group) has shown a

decrease in falls rate post-surgery (Brannan, Dewar, Sen, Clarke *et al*., 2003), while Harwood, Foss, Osborn, Gregson *et al*. (2005) showed no effect of surgery on the overall rate of falls but with a reduction in multiple falls. Foss, Harwood, Osborn, Gregson et *al*. (2006) and McGwin *et al*. (2006) reported no significant change in falls rate following cataract surgery. Desarpriya, Subzwari, Scime-Beltrano, Samayawardhena *et al*. (2010) subsequently combined the results of Harwood *et al*. (2005) and Foss *et al*. (2006) in a meta-analysis and concluded that "cataract surgery is effective in significantly enhancing vision but is inconclusive in preventing falls".

Therefore the aim of this chapter was to perform a more detailed analysis using some of the raw data from the McGwin *et al*. (2006) study. The proposed hypothesis was that the lack of change in falls rate may have been due to a decreased falls rate in patients with minor changes in refractive error and an increased falls rate for patients adapting poorly to large changes in spectacle prescription, as previously suggested by Cummings *et al*. (2007). In addition, the change in visual acuity following unilateral and bilateral cataract surgery was examined to investigate whether this was related to the change in self-reported falls. McGwin *et al*. (2006) reported visual acuity changes from visit 1 to visit 2 for the surgery and non-intervention groups, but did not report any analysis of change in refractive correction or visual acuity change due to surgery in fallers and non-fallers.

5.2 Methods

Ethical approval from the committee at the University of Alabama was obtained. Data relating to age, gender, ethnicity, refractive correction, visual acuity, date of surgery(s), date of visits and responses to the falls question were provided by Gerald McGwin and Cynthia Owsley after discussions with them regarding the research question discussed above. The data collection is described in McGwin *et al*. (2006). In summary, people aged 55 and older with cataract were recruited from 10 eye clinics in Alabama, USA between 1994 -1996. Participants were classified into two groups: those who had cataract surgery (n=165) and those who had not (n=92). The sample size was slightly larger than that cited in the earlier report (McGwin *et a*l., 2006) as only baseline to the first visit (1-year follow-up) was compared here and not the second year follow-up visit. At baseline and the 1-year follow-up visit, monocular visual acuities (VAs) were measured using the early treatment of diabetic retinopathy study (ETDRS) letter chart with the patient's current spectacles (if usually worn). Information on the occurrence of falls in the last 12 months was also collected by asking the patient "Have you fallen in the past 12 months?". Fall information was thus based on the subject's recall of events and since the date of any falls was not recorded, the incidence of falls and 1st or 2nd eye surgery chronology for bilateral surgery was not available.

The initial analysis focussed on the magnitude of change of the spectacle correction from pre to post surgery in relation to either an improved or

worsening falls rate. The Thibos *et al*. (1997) vector representation method as described in chapter 3 (section 3.4), was used to convert from conventional clinical notation to calculate the magnitude of change experienced by the patient. The change in falls rate for the patients having undergone cataract surgery were binary encoded into one group with reduced falls and the other with increased falls. A logistic regression analysis was then performed to investigate any link in falls rate and prescription change.

Further analysis was carried out by dividing the cataract surgery group into unilateral and bilateral surgery recipients, with additional segregation into those that had no change in falls from pre to post-surgery and to those that had increased or decreased falls. Given that VA in the better eye is very predictive of binocular VA (Pardhan & Elliott, 1991; Rubin, Muñoz, Bandeen-Roche & West, 2000) and that this is used by patients from a functional perspective, best eye VA changes were used for subsequent analysis. Data were analysed using Fisher's exact test for univariate analyses of categorical variables (gender, race) and a linear regression (ANOVA) model used to assess association of falls classification with age, and to compare VA changes in the surgical groups. The association of VA change with surgical group and falls classification was assessed using a linear regression model, incorporating a two-way interaction term between surgical group and falls classification. All analyses were conducted using the Stata version 9.2 statistical programme (StataCorp., College Station,

USA) in collaboration with a medical statistician (A J Scally, University of Bradford).

5.3 Results

70 records out of the 165 surgery patients had incomplete refractive correction data with essential prescription information either missing or containing incongruous data such as identical prescriptions pre and post cataract surgery. The logistic regression analysis of the remaining 95 refractive corrections and falls showed no link between falls rate and refractive error change from pre to post cataract surgery (p=0.58).

A smaller number of 30 records out of 165 were excluded from the second analysis due to incomplete or missing visual acuity information. Of the 92 patients with cataracts who did not have surgery, 47 (51%) did not report falling in the year prior to baseline or follow-up visit; 16 (17%) reported falling less at the follow-up visit and 29 (32%) reported falling more. Although there was a tendency for more patients having reduced falls after unilateral surgery (48% no falls, 27% reduced falls and 25% increased falls) and a greater number of increased falls after bilateral surgery (45% no falls, 15% reduced falls and 40% increased falls, see Table 5.1), these differences were not significant (Fisher's exact test, p = 0.26). Falls classification was also not affected by age ($F_{2,223}$=1.29, p=0.28, on ANOVA), gender (Fisher's exact test, p=0.14) or race (Fisher's exact test, p=0.61).

There were highly significant improvements in better eye VA for the unilateral and bilateral surgery groups compared to the non-surgical group ($F_{2,223}$=82.4, p<0.0001). No surgery: VA change = +0.03 (95%CI: -0.001, +0.06; p=0.06). One eye: VA change = -0.13 (95%CI: -0.17, -0.08; p<0.001). Both eyes: VA change = -0.33 (95%CI: -0.38, -0.28; p<0.001).

Test and retest VAs for the non-surgical group were 0.16 (~ Snellen VA 6/9.5, SD 0.16) and 0.19 (SD 0.16). The mean VAs of the first eye operated on for cataract before and after surgery for the whole sample (N=135) were 0.55 (~ 6/21, SD 0.26) and 0.16 (~ 6/9.5, SD 0.20) respectively. The mean first eye VAs before and after cataract surgery for those who had surgery on both eyes (N=54) were 0.57 (~ 6/21, SD 0.26) and 0.17 (~ 6/9.5, SD 0.19).

Table 5.1 shows the mean (SD) VAs from both eyes before (baseline) and after unilateral and bilateral cataract surgery (1 year visit) further divided on the basis of fall category. From a functional perspective, the mean "best eye" VA before and after cataract surgery for those who had unilateral and bilateral surgery divided into fall categories are also shown in Table 5.2. Note that these were habitual VAs and thus measures of VA with spectacles if worn. Therefore it should be noted that some patients post operatively, may well prefer to go without spectacles for convenience purposes despite a further achievable improvement in VA if spectacles are worn.

Table 5.1 Mean (SD) visual acuities (VA in logMAR) from both eyes before and after unilateral and bilateral cataract surgery in a sample of 135 patients from 10 eye clinics in the USA.

		Pre-op VA	**Post-op VA**	**Test VA of non-operated eye**	**Retest VA of non-operated eye**
Unilateral Cataract surgery	**Non-fallers** (N=39)	0.56 (0.29)	0.15 (0.20)	0.24 (0.19)	0.29 (0.22)
	Reduced falls (N=22)	0.51 (0.19)	0.20 (0.25)	0.29 (0.20)	0.28 (0.19)
	Increased falls (N=20)	0.53 (0.30)	0.14 (0.19)	0.16 (0.16)	0.24 (0.25)
		Pre-op VA of 1st eye	**Post-op VA of 1st eye**	**Pre-op VA of 2nd eye**	**Post-op VA of 2nd eye**
Bilateral cataract surgery	**Non-fallers** (N=25)	0.52 (0.25)	0.13 (0.17)	0.37 (0.22)	0.12 (0.13)
	Reduced falls (N=8)	0.75 (0.23)	0.12 (0.14)	0.47 (0.09)	0.12 (0.09)
	Increased falls (N=21)	0.55 (0.26)	0.23 (0.21)	0.36 (0.23)	0.26 (0.24)

Table 5.2 The mean (SD) 'best eye' visual acuity (VA in logMAR) before and after unilateral or bilateral cataract surgery divided on the basis of self reported falls, in a sample of 135 patients from 10 eye clinics in the USA.

		Pre-op best eye VA	Post-op best eye VA
Cataract surgery on one eye	**Non-fallers** (N=39)	0.21 (0.18)	0.12 (0.17)
	Reduced falls (N=22)	0.26 (0.15)	0.10 (0.10)
	Increased falls (N=20)	0.16 (0.15)	0.11 (0.18)
Cataract surgery on both eyes	**Non-fallers** (N=25)	0.37 (0.22)	0.06 (0.09)
	Reduced falls (N=8)	0.47 (0.09)	0.07 (0.06)
	Increased falls (N=21)	0.36 (0.23)	0.13 (0.14)

The change in the better eye VA from baseline to follow up for all groups is shown in Figure 5.1. To compare the three groups (non-surgery, unilateral and bilateral surgery), the change in VA as a function of falls classification as a linear variable (1=reduced falls, 2=no change, 3= increased falls) was considered. This enabled the identification of a linear trend in VA change with falls category and also facilitated investigation of an interaction term

between surgical group and falls category. The model was highly significant ($F_{5,220}$=38.7, p<0.0001), with a significant interaction term (LR chi-squared(2)=8.09, p=0.018). Bilateral (slope 0.096, Wald t = 2.68, p=0.008) and unilateral surgery groups (slope 0.062, Wald t = 1.97, p=0.05) were shown to be significantly different from the non-surgery group, which showed an essentially flat slope with falls classification (slope -0.003).

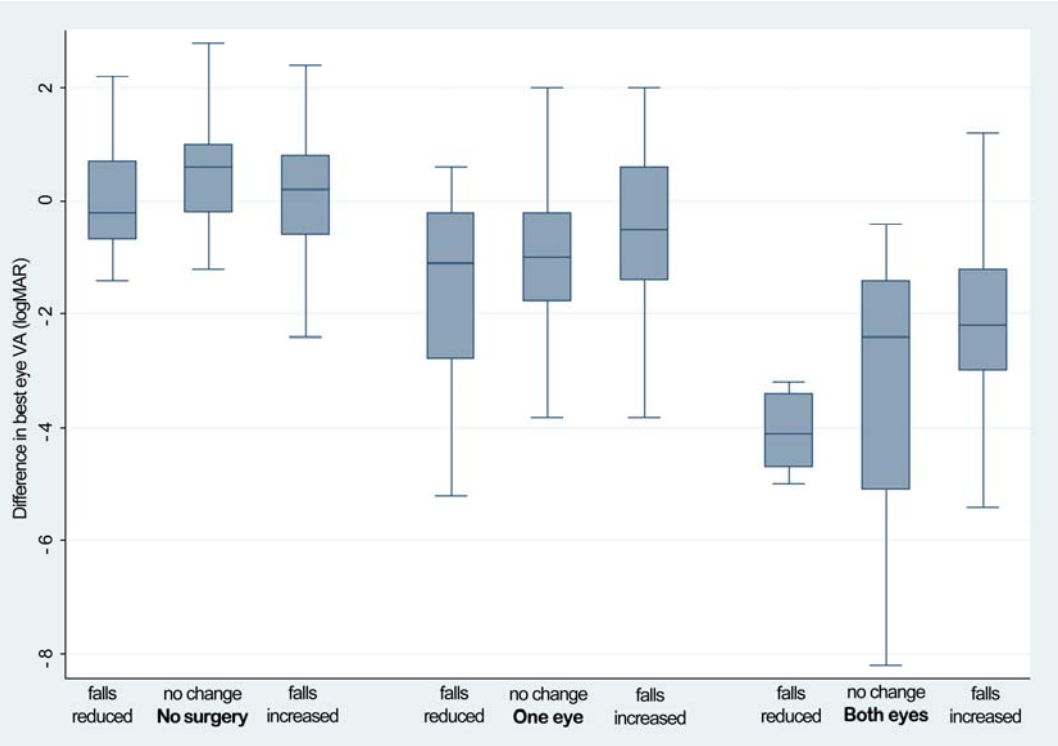

Figure 5.1 Change in better eye visual acuity in logMAR as a function of falls classification group (non-fallers, increased falls, decreased falls) for no surgery, unilateral and bilateral cataract surgery groups in a sample of 227 patients from 10 eye clinics in the USA.

5.4 Discussion

The results confirm that for all patients there was no change in falls rate before and after cataract surgery as concluded in the earlier report (McGwin *et al*., 2006). Figure 5.1 shows that patients with bigger changes in best eye VA due to cataract surgery, typically those with worst VA pre-operatively in both eyes (Tables 5.1 and 5.2) tend to have reduced falls, while those with reasonably good better eye VA pre-operatively (Table 5.2) and poorer VA post-operatively (Table 5.1) tend to have increased falls. This might suggest that those patients with the most VA improvement due to surgery (i.e. those having bilateral surgery and mean improvement of best eye VA of approximately 3 lines) would have greater reductions in falls than those having unilateral surgery (mean improvement 1.5 lines). In fact, the proportions of subjects with reduced falls (unilateral surgery 27%; bilateral surgery 15%) were not significantly different, statistically, but tending towards less 'fall-improvers' with bilateral surgery. It is possible that this potential trend is merely reflective of the small numbers of patients in this dataset (see section 5.4.1 limitations). However another possibility is that the greater improvements in VA provided by bilateral surgeries may to some extent, be offset by the negative aspects associated with having two surgical procedures rather than one. These could include adapting to changes in magnification caused by changing refractive error (Cumming *et al*., 2007; Elliott & Chapman, 2010) and/or adapting to dizziness caused by ocular magnification changes on the vestibulo-ocular reflex gain (Demer *et al*., 1989; Elliott & Chapman, 2010) as discussed in Chapter 1. It seems unlikely that increases in rate of falls

are due to increased risk behaviour (e.g. patients going out more due to better post-operative vision) as those with the worst VA after bilateral surgery tended to fall more, but this remains a possibility. Furthermore, anecdotal evidence would seem to suggest that patients requiring bilateral cataract surgery are usually keen to undergo the second procedure to "even-up" their vision. Clearly, more research is needed in this area, in particular to clarify the effects of bilateral cataract surgery on rate of falls and to investigate whether this can be related to the magnitude of change in spectacle prescription.

5.4.1 Limitations

As previously noted, significant data was absent with a large number of records found to be missing prescription (N=70) or visual acuity information (N=30) or containing nonsensical information. In addition, some prescriptions were found to be recorded in positive cylinder in one eye and negative cylinder in the other. It is difficult to ascertain whether these were in fact accurate prescription information or perhaps more likely transcription or typographical errors. For example, some pre and post-operative data looked as though a change had occurred, but the two corrections were provided in different cylinder format and when transposed, both were exactly the same. This was despite the patient having undergone surgery and being highly myopic and astigmatic pre-surgery. The accuracy of some of the VA data was also questionable, with for example an improvement (median VA improvement 0.04 logMAR,

range 0.02-1.14) in the non-operated eye between baseline and visit 1 noted in some participants. This is probably a reflection of the variability of techniques employed by differing personnel (including non-optically trained personnel) when measuring VA, rather than a true representation of VA change. The incidence of falls was also obtained by retrospective questioning of older people and therefore was likely to be an underestimate due to poor memory recall (Cummings, Nevitt, & Kidd, 1998).

5.5 Conclusions

The study found no link between refractive correction change and falls before and after cataract surgery. This may have been due to the relatively small sample size. In addition, the study highlighted the limitations of refractive error and visual acuity data collection by technicians, regardless of how well trained. Further studies are needed, with more complete and accurate data from a larger number of patients undergoing cataract surgery. Statistical power analysis would suggest a minimum requirement of 350 cataract surgery patients (Hulley & Cummings, 1988).

Chapter 6

Development of a questionnaire to quantify spectacle adaptation problems.

6.1 Introduction

Self-reported patient rating scales are becoming of increasing importance in the evaluation of patient status or therapy effectiveness (Knutsson, Rydstrom, Reimer, Nyberg *et al*., 2010). By their very nature spectacle adaptation problems are subjective, widely variable and patient reported, thus they may be amenable to quantification by the design of a suitable questionnaire (instrument). However their subjective nature and inherent variability also means that accurate assessment may be difficult. In this respect, spectacle adaptation issues must be considered a latent trait as they cannot be measured directly. Despite this, newer techniques in questionnaire development and validation have led to improved accuracy and sensitivity (Massof & Rubin, 2001; Pesudovs, Burr, Harley & Elliott, 2007). In particular, it is proposed that Rasch analysis, an item response theory model widely used in health studies, education and psychology as well as vision science (Massof & Rubin, 2001; Pesudovs, Garamendi, Keeves & Elliott, 2003; Pesudovs, Garamendi & Elliott, 2004; Garamendi, Pesudovs & Elliott, 2005; Garamendi, Pesudovs, Stevens & Elliott, 2006; Pesudovs, Garamendi & Elliott, 2006; Pesudovs *et al*., 2007; Leong, Rubin & Allan, 2009) will be utilised in the following methodology, to develop an

interval measure of spectacle adaptation problems. As far as we know, no previous questionnaires have been developed to assess this issue.

Before considering the potential benefits of applying Rasch measurement to questionnaire design, it is useful to summarise some of the traditional category rating scales used in questionnaire development. One example is the relatively simple visual analogue scale (VAS) which consists of a fixed length line with a descriptive anchor at each end (Figure 6.1)

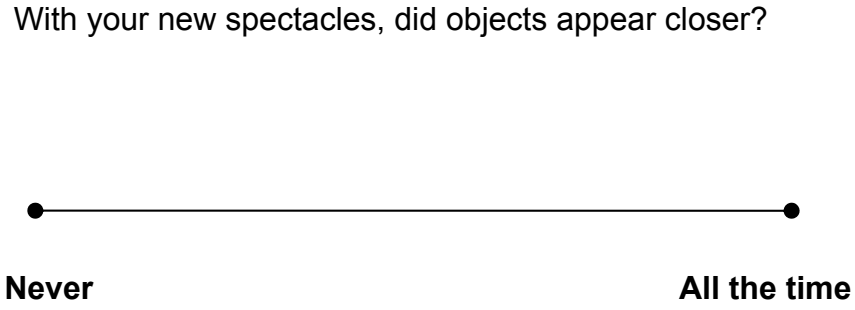

Figure 6.1 Example of visual analogue scale

Respondents mark a point on the line which they consider appropriate for the question (item) under consideration and measurement of the distance from one anchor ending is used as the indicator of response. Alternative rating scales include dichotomous response categories (e.g. yes/no, agree/disagree) and Likert polytomous responses (e.g. strongly agree,

agree, neither agree nor disagree, disagree, strongly disagree). This latter example illustrates a bipolar Likert scale where evenly spaced descriptors are bisected by a neutral middle point (Likert, 1952). Unipolar Likert scales range from none to a maximal amount (e.g. none, a little, moderate, a lot, all the time). Generally it is preferable to use Likert scales rather than dichotomous scales as these permit better definition of patient responses and thus increased measurement precision (Streiner & Norman, 1995). Nagata, Ido, Shimizu, Misao *et al*. (1996) compared the feasibility of various response scales (4, 5, 7 point scales and VAS) in the context of a 10 item health status questionnaire in a population with a range of conditions and concluded that the 5 point Likert scale was the most useful for measuring health status. Accordingly this approach was adopted in the following instrument development, with Rasch enhancement to reduce the number of items whilst still maintaining the credible psychometric properties of the questionnaire (e.g. Stelmack, Szlyk, Stelmack, Demers-Turco *et al*., 2004; Massof, Hsu, Baker, Barnett *et al*., 2005a, Massof, Hsu, Baker, Barnett *et al*., 2005b; Massof, Ahmadian, Grover, Deremeik *et al*., 2007; Stelmack & Massof, 2007). Subsequently, by applying Rasch scoring to the descriptive response categories (e.g. none, mild, moderate, severe) that reflect the underlying quantitative continuum under investigation (spectacle adaptation problems), a total score should be calculable that grades the spectacle adaptation problems experienced by the respondent.

6.1.1 Rasch analysis

All of the Rasch analysis in this thesis was performed using "Bond & Fox Steps", a more user friendly version of Winsteps 3.62 that applies the Andrich rating scale model using the joint maximum likelihood estimation method (Wright & Masters, 1982). Rasch analysis uses psychometric modelling to provide a valid measurement of a latent trait (McAlinden, Pesudovs & Moore, 2010) and has been shown to be superior to traditional scoring methods (Rasch, 1960; Rasch, 1980; Massof, 2002). The inherent weakness of the traditional Likert rating scale is that it assigns the same score in each response category for every question (or item) of the questionnaire. For this approach to hold true, it has two important prerequisites; it assumes that each item represents equal difficulty to the respondent and secondly within an item's response category range, linear uniform change must be present between categories. Both these pre-requisites seem counter-intuitive and Rasch analysis has been used to confirm that appropriate weighting is necessary not only for each item but also within an individual item's response scale to provide a valid scale (Velozo, Lai, Mallinson & Hauselman, 2000). This can be illustrated by the following items derived from the Visual Function-14 vision disability instrument (Steinberg, Tielsch, Schein, Javitt *et al*., 1994):

How much difficulty do you have driving during the day because of your vision?

- no difficulty (4 points)

- a little difficulty (3 points)
- a moderate amount of difficulty (2 points)
- a great deal of difficulty (1 point)

How much difficulty do you have driving at night because of your vision?

- no difficulty (4 points)
- a little difficulty (3 points)
- a moderate amount of difficulty (2 points)
- a great deal of difficulty (1 point)

Clearly, these two items do not appear to represent equal levels of difficulty as driving at night is a far more difficult and complex task than driving during the day. In addition, the response of “no difficulty” (score 4) is used to represent twice the ability of “a moderate amount of difficulty” (score 2) which again is twice the ability of “a great deal of difficulty” (1 point). Intuitively this distinction is arbitrary and not the uniform linear separation demanded by the concept of Likert scoring. Rasch analysis aims to allow for the differences both in item difficulty and category scoring by applying an appropriate weighting factor for each item and category (Velozo *et al*., 2000). This Rasch transformation to interval scoring is carried out via the probabilistic relationship between questions and respondents (McAlinden *et al*., 2010).

The Rasch modelling process is derived from the Rasch item response model (Rasch, 1960) and incorporates a specific measurement property;

the difficulty of items and respondent ability are measured on a common scale – the logit (log odds unit) scale. A logit is calculated from log (p/1-p) where p is the probability of a respondent selecting a specific item response category (Vianya-Estopa, Elliott & Barrett, 2010). The logit scale is an interval scale in which the unit intervals between the locations on the person-item map have a consistent value (Bond & Fox, 2007). To help explain this concept it is useful to consider some hypothetical exam results, in which Rasch analysis will permit a direct comparison of question difficulty and the probability of a student getting a particular question correct. Thus in spectacle adaptation terms, items will be ranked on the basis of symptom severity (or in exam parlance question difficulty) as will the patients, according to the severity of the symptoms they experience. In other words, a person-item map will be generated that ranks all the questions and patient responses on the same logit scale according to the spectacle adaptation problems reported.

Once again to help explain the concept, it is easier to consider an example of a person-item map (Figure 6.2) taken from the Rasch analysis of the Activities of Daily Vision Scale (Mangione, Phillips, Seddon, Lawrence *et al*., 1992) carried out by Pesudovs *et al*. (2007). Persons are represented by X and are situated on the left of the dashed centre line and items are denoted by their cross-over point on the right. More able patients and more difficult items are located near the top of the map with conversely less able patients and easier items near the bottom. The logit scale is

usually transformed to run from 0-100, with M indicating the mean, S one standard deviation from the mean and T two standard deviations from the mean. In Figure 6.2, an indication of the targeting ability of the instrument can be seen from a comparison of the vertical position of the two means (M). If the items are well targeted to the patients, the means of the two distributions should be vertically close together (Pesudovs *et al*., 2007). Furthermore, Rasch analysis generates fit statistics such as infit (information-weighted fit) and outfit (outlier-sensitive fit) which provide an indicator of how well an individual item or patient fits the Rasch model, thus allowing misfitting items and patients to be identified and eliminated from the questionnaire results. Other benefits of Rasch include the identification of the appropriateness of the response categories, so that categories can be collapsed into one another whilst still maintaining the discriminability of the questionnaire (Bond & Fox, 2007). Rasch analysis is also beneficial when only partial questionnaire data is available such as occurs when respondents fail to answer some items. Rasch weighting enables person estimates to be made from the valid data, effectively ignoring missing data without adding noise to the measure (Pesudovs *et al*., 2007).

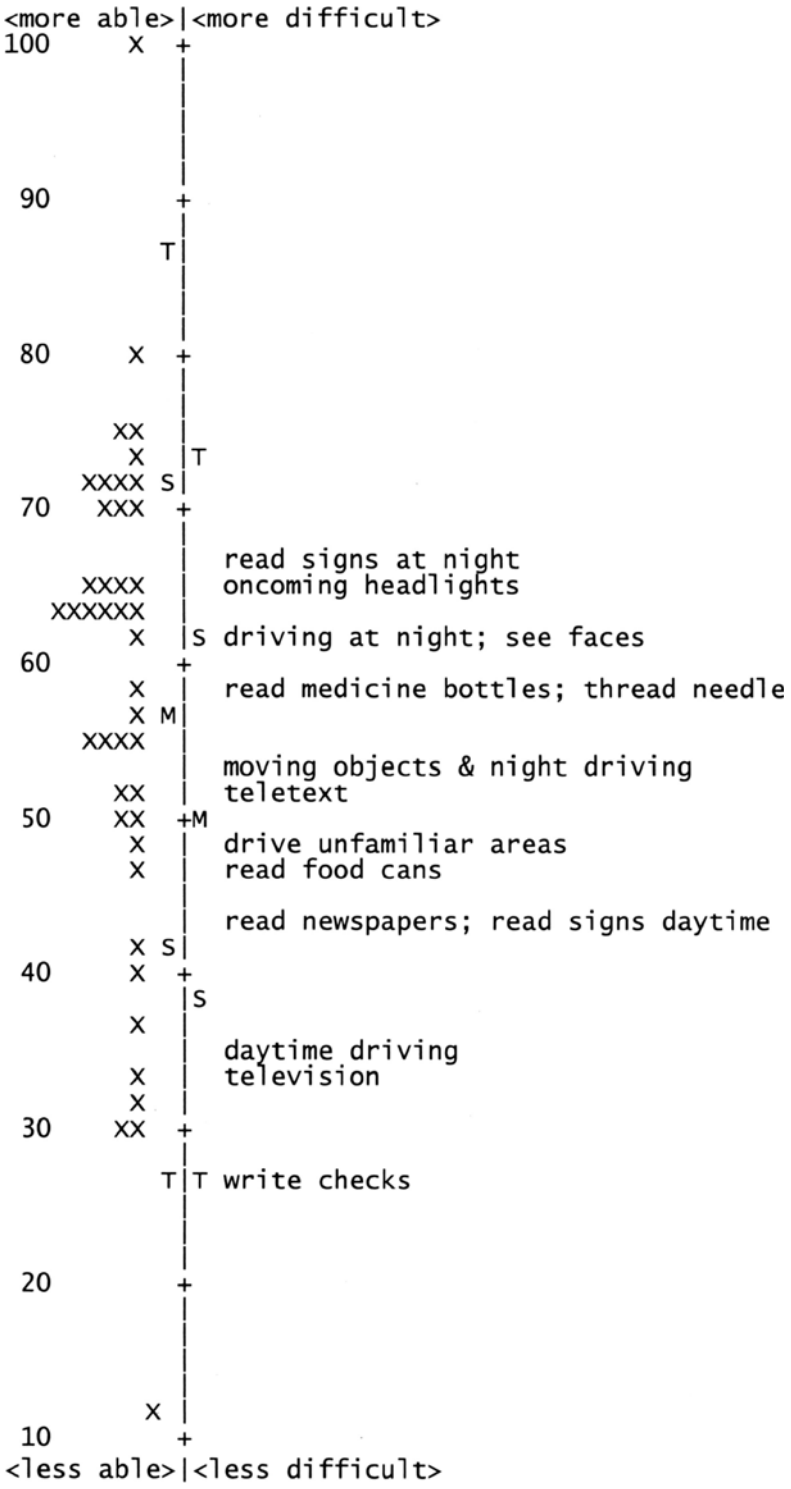

Figure 6.2 Example of Rasch person-item map on 0-100 scale.

Patients are represented by X on the left and items on the right, M is mean, S is 1sd from mean, T is 2sd from mean.

(from Pesudovs *et al.*, 2007. The development, assessment and selection of questionnaires. *Optom. Vis. Sci.* 84, 663–674).

6.1.2 Rasch item fit statistics

The infit and outfit statistics are generated for each individual item (and person) and help to identify the items which contribute to the measurement of the latent trait (Pesudovs *et al*., 2007). Both statistics are reported in an unstandardised and standardised form with the former as a mean square and the latter as a t statistic. The mean square is the mean of the squared residuals for that item and it is this statistic that will be used in the following methodology to identify misfitting items/persons. As the infit statistic is weighted by its variance, it takes more account of performances of persons closer to the item value (providing a more sensitive insight into item performance) and thus it is generally less affected by outliers and is therefore paid more attention than outfit values (Bond & Fox, 2007; Pesudovs *et al*., 2007). Consequently infit statistics are more sensitive to irregular in-lying patterns when compared to the Rasch modelled expectations while outfit statistics tend to be influenced by off-target observations. Both infit and outfit mean squares have an expected value of 1.00, with values of less than 1 indicating items that are too predictable (thus providing limited information) and values greater than 1 identifying items that exhibit more variation (therefore may be unreliable or assess a different trait) than expected by the Rasch model. The limits chosen for outfit and infit mean square depend both on the sample size becoming stricter as the sample size increases over 100 (Linacre, 2003) and the type of rating scale employed (Bond & Fox, 2007). However a typical range of 0.60-1.40 (Table 6.1) has been previously suggested for a Likert type questionnaire (Wright & Linacre, 1994; Bond & Fox, 2007). In

the following questionnaire development, more stringent limits will be placed on infit measures rather than outfit measures (Pesudovs *et al*., 2004; Bond & Fox, 2007; Pesudovs *et al*., 2007).

Table 6.1 Interpretation of parameter-level mean-square fit statistics
(from Wright & Linacre, 1994, Reasonable mean-square fit values. *Rasch Measurement Transactions,* 8, 370).

>2.0	Distorts or degrades the measurement system
1.5 - 2.0	Unproductive for construction of measurement, but not degrading
0.5 - 1.5	Productive for measurement
<0.5	Less productive for measurement, but not degrading. May produce misleadingly good reliabilities and separations

6.1.3 Dimensionality

One of the pre-requisites of the Rasch model is that of *unidimensionality* in that the measures should only focus on one attribute or dimension at a time. The infit and outfit mean squares generally reveal the extent to which any item or person performance might suggest that more than one latent trait is being assessed. Factor analysis still remains the most common statistical tool for assessing dimensionality (Bond & Fox, 2007) despite the lack of linear measure construction and hence lack of reproducibility of

factor sizes and loadings when new sets of data are reanalysed with the same procedure (Wright, 1996). Therefore in the context of Rasch measurement and factor analysis, a crucial difference exists in that Rasch uses residual based unrotated principal components analysis (PCA) to show the contrast between opposing factors, not the loadings on one factor, as in conventional factor analysis (Linacre, 2009). Thus the purpose of PCA is to explain variance in the contrast of the residuals so that if this contrast is at the "noise" level, no shared second dimension is present. According to Linacre (2009) "In Rasch analysis of residuals, we want not to find contrasts, and, if we do, we want to find the least number of contrasts above the noise level, each, in turn, explaining as much variance as possible". From a practical viewpoint Linacre (2009) suggests the following rules of thumb to indicate unidimensionality when using the Winsteps software to perform Rasch analysis:

(i) Variance explained by measures > 60% is good.

(ii) Unexplained variance explained by 1st contrast < 3.0 eigenvalue units is good. A more stringent limit of greater than 2.0 eigenvalue units has been suggested by Vianya-Estopa *et al*. (2010) to indicate a possible second dimension to the questionnaire.

6.1.4 Rasch differential item functioning (DIF)

Rasch analysis allows possible interactions between respondent characteristics and item classification to be investigated. In other words potential item bias can be reported, however persons and items with extreme scores are excluded from the analysis because they do not exhibit differential ability across items (Linacre, 2009). In the context of spectacle adaptation, questionnaires were deliberately anonymous and hence only gender and age were possible DIF issues.

6.2 Methods

6.2.1 Domain and item selection

In order to encompass the widest possible range of items in the pilot questionnaire, an extensive literature review was carried out to list as many possible spectacle adaptation issues as possible. An initial literature review was carried out via MEDLINE, using the search term title words of “spectacles” and “vision” with medical subject headings of “eye glasses, ocular, vision”. Further searches included terms such as “blurred vision, nausea, dizziness, eyestrain, headaches, distortion, quality of life, adaptation, satisfaction” to see if any of these were reported in a spectacle adaptation context. Existing reference sources from earlier work in this thesis were also re-reviewed to elicit as many possible spectacle adaptation problems previously encountered by optometrists and clinicians.

Using the data obtained from above, the author compiled a list of 55 items that had been previously implicated when adapting to new spectacles. These could be further categorised into domains of problems seeing with new spectacles (n=28), symptoms (n=14) and activity limitations (n=13). This initial qualitative phase of pilot development was then supplemented by using focus groups. A professional focus group that comprised 2 experienced optometrists (20 and 18 years), 1 relatively inexperienced optometrist (4 years qualified) and 2 dispensing opticians (5 years qualified) reviewed each of the questions and discussed its merits and whether this issue had been previously encountered in a case of spectacle dissatisfaction. Using a transcript of this focus group, spectacle adaptation issues were re-analysed for content and the key issues previously identified by focus group participants. By merging items with similar content, the original 55 items were reduced to 46 by the professional focus group. A further lay focus group of spectacle wearers (chaired by Prof. David Elliott) was then used to check for item understanding and comprehension. The results of this were incorporated into the final pilot questionnaire design by simplification of the wording of some items and improvements to the general instructions provided for respondents. Thus the completed pilot questionnaire (appendix D) comprised 46 items divided into 3 domains of problems seeing with new spectacles (n=23), symptoms (n=11) and activity limitations (n=12). Question format was kept as simple as possible with two domains (problems seeing and symptoms) assessing frequency of problems (e.g. with your new spectacles, how

often did you experience……?) and activity limitations being addressed by asking “When wearing your new spectacles, how much concern did you have about…..?”. As previously stated (section 6.1) a 5 category rating scale was used for all items using suitably spaced response labels of “*never, occasionally, fairly often, very often and all the time*” (Skevington & Tucker, 1999).

6.2.2 Distribution

The questionnaire was designed to be relevant to the majority of spectacle wearers who had experienced adaptation issues following a change in the power of their spectacles. In order to obtain the maximum amount of data possible, only two specific exclusion criteria were described on the first page; i.e. patients experiencing adaptation problems due to changing spectacle lens types and patients only using spectacles for reading. Both these exclusionary details were further verified by asking respondents to indicate the type (eg. single vision, bifocal, varifocal) of spectacles habitually worn and whether this had been changed immediately prior to experiencing the adaptation difficulties. This was to confirm that the problems revealed by the questionnaire were related to prescription issues and not adaptation problems experienced when changing to multifocal lenses or when trying to wear reading spectacles when moving around. In addition to the paper version, an identical online questionnaire was made available to participants via the “Wufoo” questionnaire host website (www.wufoo.com).

As in chapters 2 and 3 (and appendix B), ethical approval was readily granted by the University of Bradford ethics committee due to the uncontentious nature of the questionnaire. The nature and reasons for the research were clearly explained on the front cover of the questionnaire and participants were assumed to have given consent by their decision to return the questionnaire (or complete and submit the online version).

The paper based questionnaires together with prepaid return envelopes were distributed over a 3 month period at the University of Bradford Eye Clinic and other community optometric practices in the Yorkshire area. The research study was also publicised in local evening newspapers and other community based organisations in West Yorkshire.

6.3 Results with Rasch analysis

6.3.1 Initial analysis

Although we mainly expected people who had experienced adaptation problems with spectacles to complete the questionnaire, it was expected that some questionnaires would be completed by people who had never had adaptation problems thus selecting "*never*" for all items. These data would provide no useful information regarding the usefulness or otherwise of individual items in the pilot questionnaire and were therefore excluded from any analyses. In addition, questionnaires were also excluded in the following situations:

1) patients who had changed spectacle lens type,

2) patients using only reading spectacles (as many items were related to distance vision activities, patients would respond to these items regarding their vision without glasses),

3) questionnaires with more than 33% missing item responses.

A total of 364 questionnaires were returned over the three month data collection period. Of these 52 were excluded due to “never” being selected for all items, 20 were removed due to the respondent only wearing reading spectacles or changing lens type and 10 for greater than 33% missing item responses. Rasch analysis was used to generate model fit statistics for each respondent (infit and outfit mean squares) to identify unusual response patterns. Thirty-five respondents generated infit and outfit mean squares of greater than 1.40 indicating that their responses were different to the majority of respondents. Each of these questionnaires was individually reviewed to assess the reliability of their responses. In total 8 records were eliminated due to what appeared to be dry eye symptoms (n=4), in which the same category was chosen for every item (n=2) and problems reported that were highly likely to be varifocal adaptation difficulties (n=2). For instance, one respondent answered never for all items apart from question 33: “with your new spectacles how often did you experience your eyes feeling watery or runny” to which they replied “all the time”. This was highly suggestive of a dry eye problem rather than a spectacle adaptation issue and a further 3 questionnaires were found to be similarly completed. Varifocal adaptation difficulties were also highly

probable for the two respondents who replied “never” for all items apart from their maximal endorsement of “vision being worse through the edges of your spectacle lenses” and “the need to move your head around more often”, items 19 and 20 respectively.

Kolmogorov-Smirnov tests indicated that the age distribution of the respondents that comprised the remaining 274 questionnaires were not normally distributed (Figure 6.3), with a median age of 61 years (range 18-97yrs). Slightly more female (n=155) than male patients (n=119) responded to the questionnaire.

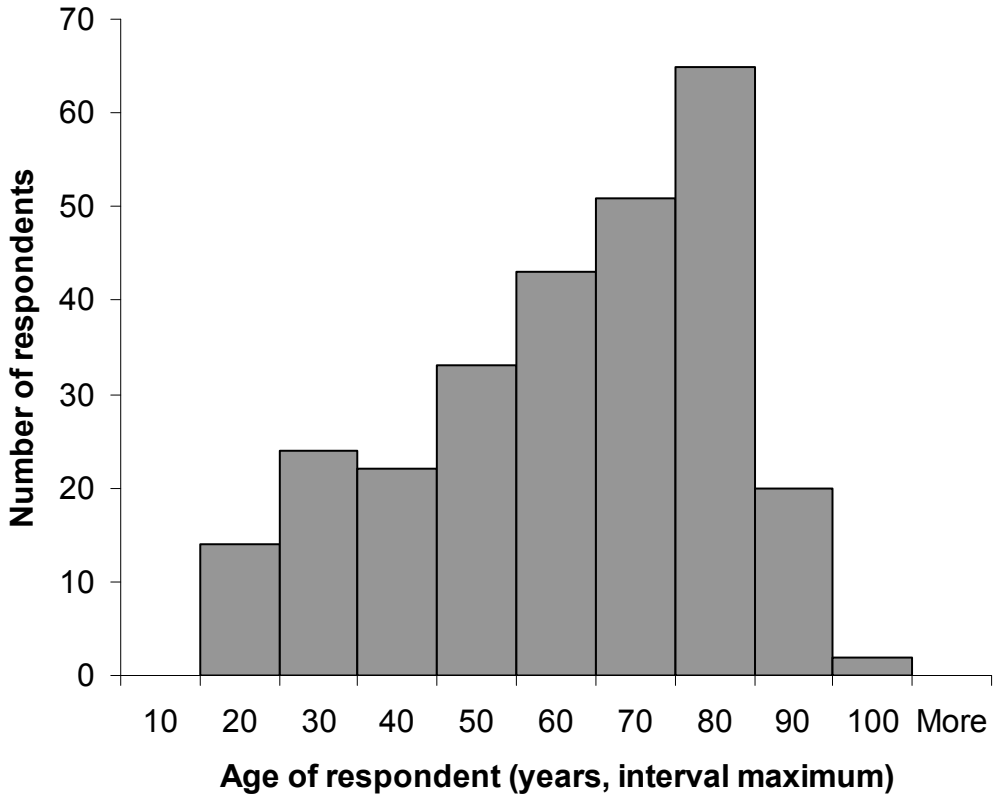

Figure 6.3 Age distribution of the 274 respondents to the spectacle adaptation pilot questionnaire (46 items).

Figure 6.4 shows the patient / item map generated by Rasch analysis of the 46 item pilot questionnaire. Subjects (# on the left) appear in ascending order of spectacle adaptation problems (lowest at the bottom, highest at the top) based on their average score for all items. Items are represented on the right in ascending order of severity from the bottom to the top. Both subjects and items appear on the same scale which is a linear transformation of the Rasch logit scale to fit a 0-100 scale (Umean=50.086, Uscale= 7.892). The large vertical separation of items from subjects indicates an inadequate targeting of item difficulty to patient spectacle adaptation problems, as the subjects denoted by # are located lower than the items (difference between mean of subjects and mean of items is 2.06 logit units or 16.2 units when scaled 0-100). As previously stated, good targeting is indicated by the means of the two distributions (denoted by M in Figure 6.4) being vertically close to one another. Another important statistic reported in the analysis was the patient separation index (ratio of adjusted standard deviation to root-mean square error). This gives an indicator of how well subjects are significantly different in ability across the measurement distribution and thus is an important indicator of the precision by which patient variability is assessed (Pesudovs *et al*., 2004). A patient separation index of 3.03 was obtained, which is well above the minimum acceptable value of 2.00 suggested by Bond and Fox (2007).

< more spectacle adaptation problems>|<rarer problems>

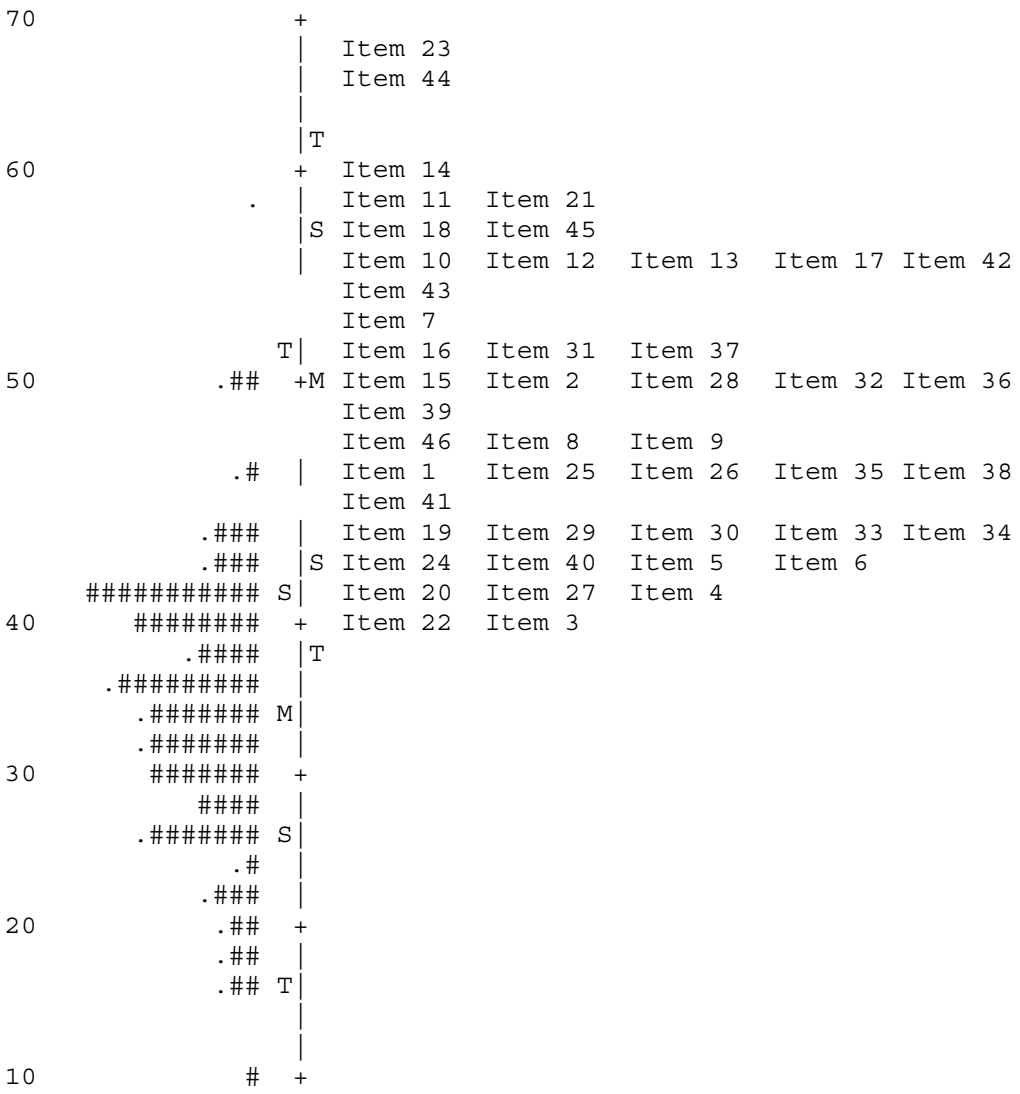

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Figure 6.4 Person-item map for pilot questionnaire of 46 items and 274 respondents using the original 5 response categories.

6.3.2 Category collapsing

Rasch analysis was also performed with the aim of response category reduction (category collapse). The category probability curve generated by the analysis illustrates the frequency and probability of a category being selected by respondents. This allows under-utilised categories and disorder in the category scale to be identified prior to item reduction. In other words the aim of category collapse is to improve the targeting of the questionnaire to the subjects. The principal guideline to be followed in response category collapse is that it must make intuitive sense (Wright & Linacre, 1992; Wright, 1996). Figure 6.5 shows the Rasch model category probability curve generated for the pilot questionnaire using the initial 5 category response scale.

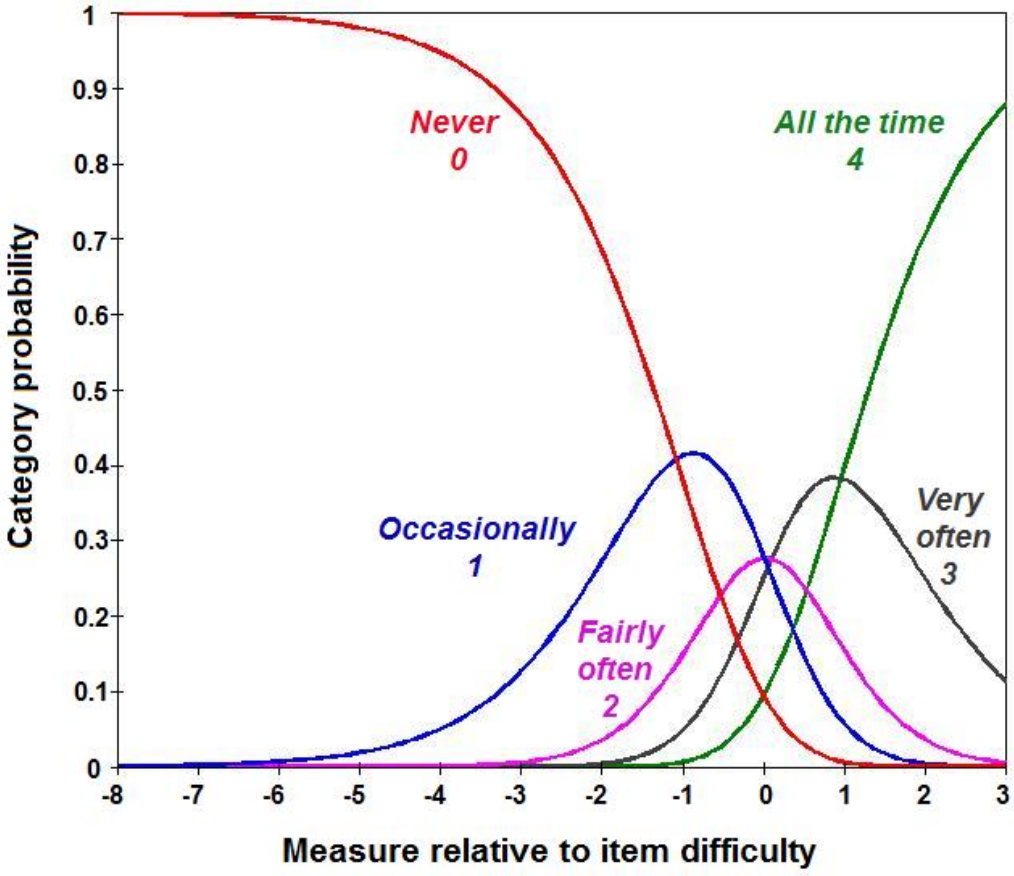

Figure 6.5 Rasch category probability curve for pilot questionnaire using original 5 response categories.

It can be seen from Figure 6.5 that category 2 (fairly often) is under used and in no part of the scale was the most likely category to be selected. This could have been combined with either category 1 or 3. However, reference to the Rasch output indicated that the highest two response categories (*very often, all the time*), had only 3 items with greater than 10% of responses in any one of these categories and only a further 9 items contained greater than 5% of responses in any of these categories. Thus intuitively, collapsing the two highest response categories *(very often*

3, all of the time 4) was a deemed a reasonable step and accordingly the analyses were rerun with these two categories amalgamated. The difference between the mean value of items and subjects improved to 1.70 logit units from 2.06 logit units, whilst patient separation also improved slightly from 3.03 to 3.10. However by reference to Figure 6.6, it can be seen that response category (*fairly often 2*) was still under used and still never the most likely category to be selected. In addition the analysis showed that the combined response category (*3+4*) still only contained less than 10% of responses for 39 items.

Therefore it was decided to repeat the analysis by combining the highest three response categories (*fairly often 2, very often 3, all the time 4*) as previous work has shown that in some cases people tend to only use 3 response categories (Pesudovs *et al*., 2004). The Rasch analysis probability curves generated by collapsing (*2+3+4*) are shown in Figure 6.7 with a more even distribution of response curves visible. The magnitude of distance between adjacent thresholds estimates was also assessed as according to Bond and Fox (2007) these measures should "neither be too close together nor too far apart on the logit scale". Linacre (1999) suggested "that thresholds should increase by at least 1.4 logit units to show distinction between categories, but not more than 5 logit units, so as to avoid large gaps in the variable". The thresholds obtained in this analysis of -1.77, 0 and +1.77 logit units respectively for the response categories (*never 0, occasionally 1*, *fairly often 2+very often 3+all the time*

4) suggested that a 3 category response scale was the most appropriate in this investigation. Other Rasch indicators also improved with this category collapse as the difference between mean value of items and subjects reduced further to 1.43 logit units (from 1.70 logit units with *3+4* collapse) or 12.2 units when scaled 0-100 and patient separation increased to 3.29 (from 3.10 with *3+4* collapse). The person / item map following this category collapse is shown in Figure 6.8 and the improved targeting ability can be seen by the closer vertical separation of item mean and person mean.

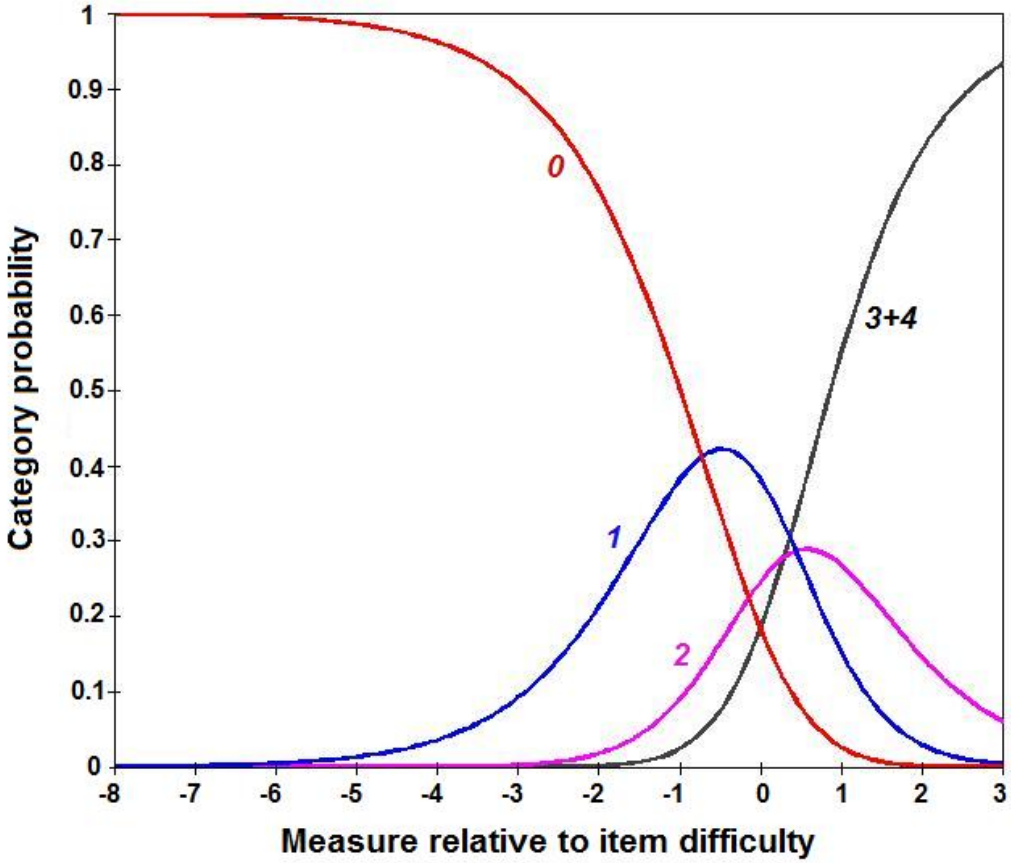

Figure 6.6 Rasch category probability curve for pilot questionnaire using 4 response categories achieved by collapsing categories 3+4.

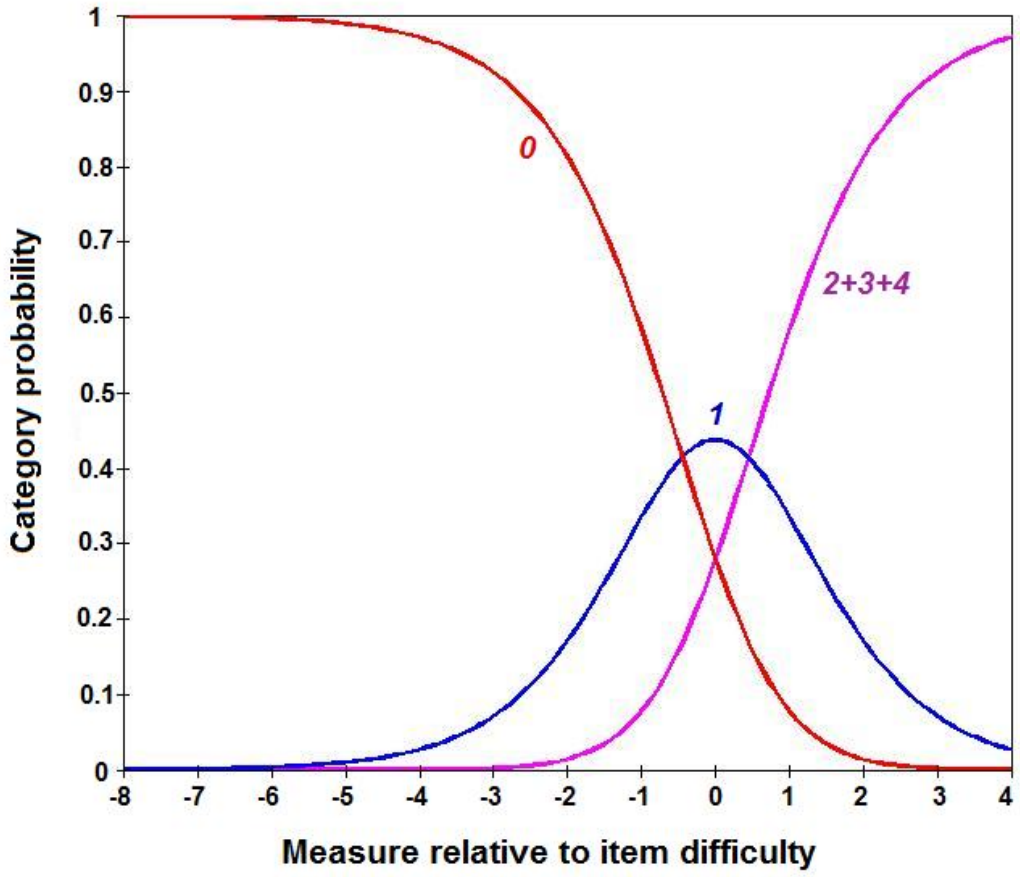

Figure 6.7 Rasch category probability curve for pilot questionnaire using 3 response categories achieved by collapsing categories 2+3+4.

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```
70                +  Item 23
                  |  Item 44
                  |
                  |T
                .    Item 14  Item 21
               ###
60                +
                  |S Item 11  Item 45
                ##   Item 10  Item 18
                ##   Item 12  Item 13  Item 17  Item 42 Item 43
                     Item 7
              .###   Item 16  Item 31  Item 37
50          .####  +M Item 15  Item 2   Item 28  Item 32 Item 36
                     Item 39
                     Item 46  Item 8   Item 9
     .########### S|  Item 1   Item 25  Item 26  Item 38
     ############   |  Item 19  Item 33  Item 35  Item 41
          .######   |  Item 29  Item 30  Item 34  Item 5
           .#####   |S Item 24  Item 6
40   ############   +  Item 20  Item 40
        .######## M|  Item 27  Item 4
        #########   |  Item 22  Item 3
        .########   |T
         ########   |
30      .########   +
        .########   |
             #### S|
             ####   |
           .#####   |
20          .####   +
                    |
              .### T|
                    |
                    |
10              .#   +
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Figure 6.8 Person-item map for pilot questionnaire of 46 items and 274 respondents, collapsing the three highest response categories.

6.3.3 Item reduction

Item reduction is an iterative process whereby one item is deleted from the dataset and then the whole gamut of Rasch fit statistics, person separation and mean item/person separation are recomputed. Item reduction is performed until an undesirable effect on patient separation is invoked (ie. falls to less than 2.0). The specific criteria used to identify items for potential removal were as described by Pesudovs *et al*. (2004):

(i) Infit mean square outside 0.8 to 1.20

(ii) Outfit mean square outside 0.7 to 1.30

(iii) Item with mean furthest from the subject mean (see Figure 6.5)

(iv) Missing data >50%

(v) Ceiling effect or high proportion of subject responses in item end response category (>50%)

(vi) Skewness and kurtosis outside -2.00 to +2.00

Items were sequentially removed on a priority basis with items that satisfied the highest number of exclusion criteria removed first from the analysis. Rasch statistics were calculated and monitored after each item deletion. Based on this rationale, 28 items were removed before adequate patient separation was compromised. This resulted in a questionnaire of only 18 items each with three possible response categories, hereafter known as the spectacle adaptation questionnaire (SAQ - see appendix E). The corresponding Rasch logit transformed person / item map is shown in

Figure 6.9 (Umean=50.089 Uscale=9.918) with the separation between item mean and person mean reduced to 1.25 logit units (11.0 units when scaled 0-100) from an initial value of 2.06 logit units (prior to category collapse) and 1.43 logit units (after category collapse). Patient separation was still very good at 2.23; reliability 0.83; root mean square measurement error 6.22, person mean square infit 0.99 +/- 0.37, outfit 1.01 +/- 0.56. All items fitted within a range of infit from 0.74 to 1.16 and outfit measurement 0.72 to 1.31 (Table 6.2). Therefore the variance within items extended from 26% (infit) and 28% (outfit) less than expected to 16% (infit) and 31% (outfit) more than expected. The item (pilot question 3 - new spectacles just not feeling “right”) was the only question that just exceeded the previously defined fit parameters by exhibiting an outfit of 1.31 (1.30 limit).

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adaptation problems>|<rarer problems>

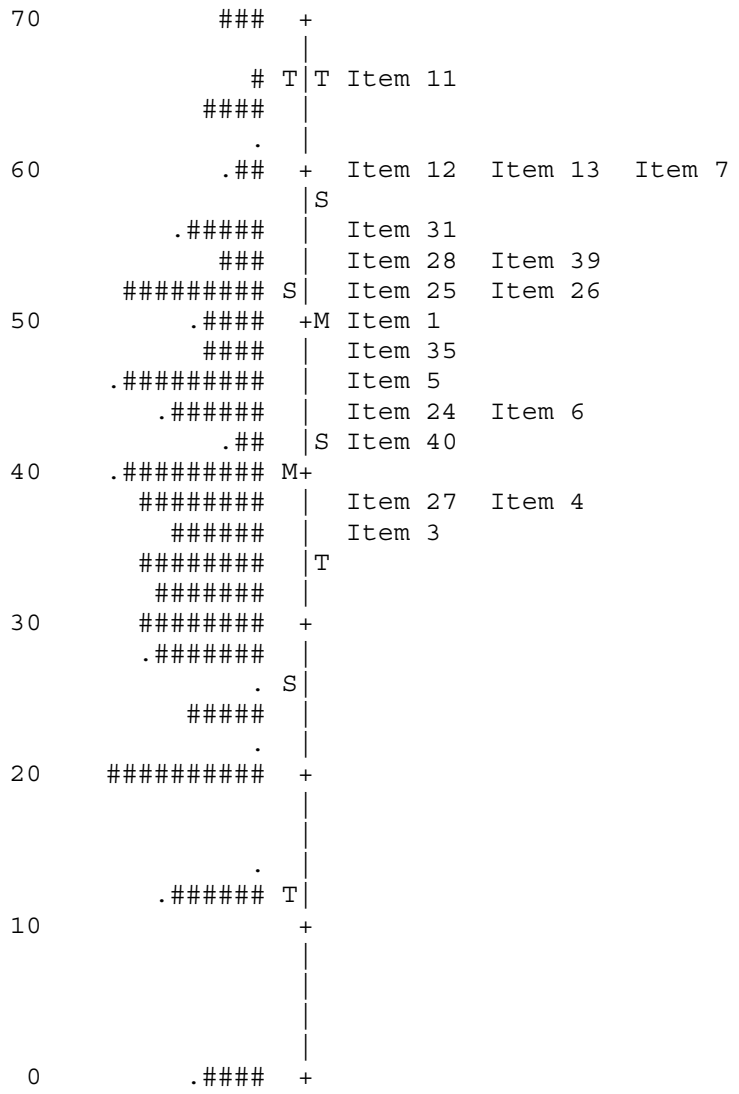

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Figure 6.9 Person-item map for pilot questionnaire of 18 items and 274 respondents, with three response categories.

Table 6.2 Infit / outfit values of 18 item spectacle adaptation questionnaire (28 items deleted from original 46 items), 3 response categories.

Retained Items		**Infit 0.8-1.2**	**Outfit 0.7-1.30**
Q1	Distorted vision; e.g. straight edges appear to droop at their ends	1.13	1.24
Q3	New spectacles just not feeling 'right'	0.92	1.31
Q4	Vision appears different but difficult to say why	0.74	0.72
Q5	Problems with blurred distance vision	1.00	0.95
Q6	Problems with blurred near vision	1.03	1.09
Q7	Words running together when reading	1.01	0.83
Q11	Objects appearing smaller than expected	1.07	1.11
Q12	Objects appearing further away	1.02	1.06
Q13	Objects appearing 'tilted' ; e.g. door/window frames slope	1.04	1.03
Q24	A feeling that your spectacles were 'too strong' or 'too powerful'	0.96	0.92
Q25	A 'pulling' or 'drawing' sensation in your eyes	1.10	1.01
Q26	A need to blink a lot more than with your old spectacles	1.16	1.00
Q27	Your eyes feeling tired or strained or 'heavy'	0.85	0.86
Q28	A 'swimmy' sensation or general feeling of motion-sickness	0.95	0.91
Q31	A 'motion-sickness' feeling when moving around but your vision felt okay when seated	1.05	1.04
Q35	Concern about walking or moving around	0.96	0.90
Q39	Concern about being unsteady on your feet when standing	1.00	0.96
Q40	Concern about going up or down steps/stairs or kerbs	1.04	1.10

6.3.4 Unidimensionality and differential item functioning

Unidimensionality and consistency were assessed by both Rasch unrotated PCA (as discussed in 6.1.3) and Cronbach's alpha. The PCA results indicated that the variance explained by the measures was 70.3% and the unexplained variance in the first contrast was 2.2 eigenvalue units. Using the previously defined criteria for unidimensionality, this would suggest a unitary dimension to the questionnaire as the value of the biggest residual contrast was 2.2 or less than the strength of 3 items.

Internal consistency was also assessed using Cronbach's alpha, a traditional statistical method widely used in vision related quality of life questionnaires (Massof, 2002). Items were randomly split into two groups and the degree of agreement between these scores and the total score were calculated (Cronbach, 1951). A Cronbach value of 0.90 was obtained which supported the unidimensional nature of the questionnaire as it is generally agreed that a value of 0.70 – 0.90 is desirable (Pesudovs *et al*., 2007). Higher values may indicate that too large a number of items are found in the questionnaire or that a high level of item redundancy is present. Conversely low values of Cronbach's alpha suggest that some items measure something different, contradicting the unidimensionality assumption demanded by the Rasch model (Massof, 2002).

Analysis for differential item functioning (DIF) on the basis of gender revealed no significant difference for any item ($p>0.002$ Bonferroni

corrected p value of t test as recommended by Lineacre, 2009). However one item (item 40 - w*ith your new spectacles, how much concern did you have about going up or down steps/stairs or kerbs?)* was selected more by the older patient (46yrs+) p=0.0003 (t test).

6.4 Assessment of the performance of the 18 item SAQ

6.4.1 Introduction

The foregoing discussion has focussed on the development of SAQ with Rasch fit statistics being used to aid item identification, selection and response scale category collapse. However in order to further assess the performance of SAQ, validity and reliability must also be considered (Pesudovs *et al*., 2007). More specifically, construct validity may be thought of as an umbrella term which refers in this case to whether SAQ measures the unobservable construct it purports to measure. Although construct validity may be demonstrated by the different facets of criterion, discriminative and concurrent validity, comparison with other constructs in this instance is difficult. Since SAQ was the first instrument of its kind to try and assess spectacle adaptation issues, related constructs are not available. Thus the traditional measure of criterion validity, whereby an instrument is correlated with an existing standard of the same thing is not possible. For instance, visual acuity has been used to assess convergent validity in some vision related questionnaires (Pesudovs *et al*., 2007) but is an unsuitable related construct as spectacle adaption issues can occur despite the improvement in visual acuity (see chapter 1). Similarly,

discriminant validity in which the degree of divergence from other specifically dissimilar instruments was also not readily calculable.

The incorporation of modifications to the instrument prior to the redistribution of SAQ was considered to facilitate concurrent validity assessment. Concurrent validity refers to SAQ's ability to differentiate between respondents having significant spectacle adaptation difficulties and those for whom any symptoms were only a minor issue. An initial question such as "have you experienced such difficulty with your new spectacles that you had to return to your optometrist" was considered for incorporation. However our experience of including such a global question in our prescribing questionnaire described in chapter 3 (section 3.3) was not very encouraging as the results were very contradictory. It was also felt that the inclusion of such a question may elicit subconscious bias by encouraging some respondents to exaggerate their answers to some items, especially in the case of respondents who had returned to their prescriber. Therefore the original format of SAQ was retained and its performance was assessed using the following reliability indices.

As previously mentioned in section 6.3.4 Cronbach's alpha is a traditional measure of the internal consistency of an instrument, however values greater than 0.9 can indicate redundancy. Other performance indices generated by the Rasch analysis include person and item separation reliability indices. These are the ratios of the true variance to the observed

variance in the estimated measure (Mallinson, 2007). Person and item separation reliability can range from 0 to 1 and according to Pesudovs *et al*. (2007) “0.8 is the minimum cut-off for both in terms of acceptability”.

6.4.2 Distribution

The 18 item instrument (appendix E) was again distributed over a 3 month period in several settings using both a conventional paper copy and also an internet based questionnaire hosted by Wufoo (www.wufoo.com). As far as possible, distribution and publicity for the questionnaire were aimed at different geographic locations in the UK than used formerly in the development phase of the questionnaire. Paper copies of the instrument and posters inviting spectacle wearers to complete the online version were displayed in numerous health centres, doctor’s surgeries and optometry practices throughout Lancashire and Greater Manchester.

6.4.3 Results

A total of 384 completed questionnaires were received. The previous exclusion criteria were applied, so that 58 were excluded due to respondents selecting “never” for all items, 29 were removed due to respondents indicating that they only used reading spectacles or had changed lens type and 3 excluded due to greater than 33% missing data. Rasch patient fit statistics were used to identify 25 possible rogue responders but after review only 4 were discarded. The age distribution of the remaining 290 questionnaire respondents is depicted graphically in

Figure 6.10 with females (n=160) outweighing male respondents (n=130). Kolmogorov-Smirnov tests confirmed the non-parametric nature of the data with a median age of 62yrs (range 18-87yrs).

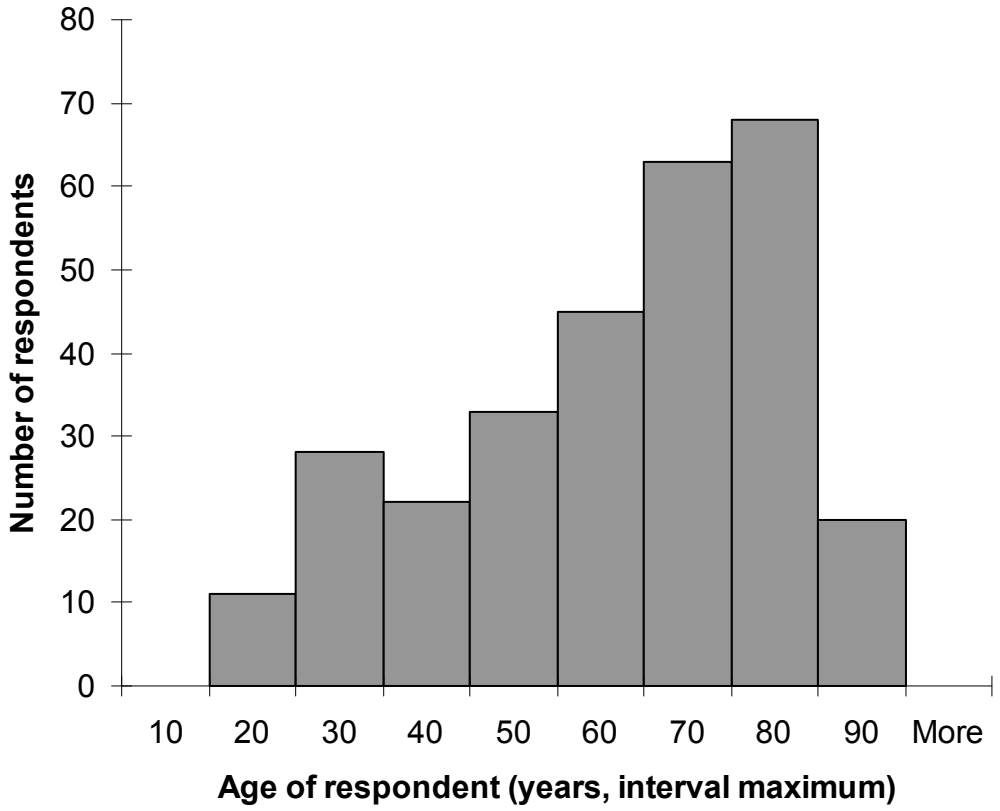

Figure 6.10 Age distribution of the 290 respondents to the spectacle adaptation questionnaire (18 items).

Rasch analysis generated the item-person map shown in Figure 6.11 which was a linear transformation of the logit scale to fit a 0-100 scale (Umean=49.945, Uscale= 9.637). The separation between item mean and

person mean was 1.35 logit units or 12.9 units when scaled 0-100. The person separation index was still very good at 2.24, reliability 0.83, root mean square measurement error 5.35, person mean square infit 0.98 +/- 0.35 and mean square outfit 1.02 +/-0.70. Individual item fit statistics are shown in Table 6.3 with all items fitting a range of infit from 0.74 to 1.20 and outfit measurement 0.72 to 1.25. Therefore the variance within items extended from 26% (infit) and 28% (outfit) less than expected to 20% (infit) and 25% (outfit) more than expected. Only one item (question 3 in appendix E – vision appears different, but difficult to say why) exceeded either of the previously defined item fit criteria (infit range 0.8-1.2 and outfit range 0.7-1.3) by exhibiting an infit of 0.74.

The Rasch prerequisite of unidimensionality was supported with a value of variance explained by the measures of 67.8% and the unexplained variance in the first contrast was only 2.1 eigenvalue units (or approximately 2 items). Internal consistency as assessed by Cronbach's alpha was 0.89. Person and item separation reliability were also excellent at 0.83 and 0.98 respectively.

Differential item functioning (DIF) analysis revealed similar results to those obtained previously. No DIF on the basis of gender was found ($p>0.002$) and only one item (question 18 - w*ith your new spectacles, how much concern did you have about going up or down steps/stairs or kerbs*?) was chosen more by the older patient (46yrs+) $p=0.0002$ (t test).

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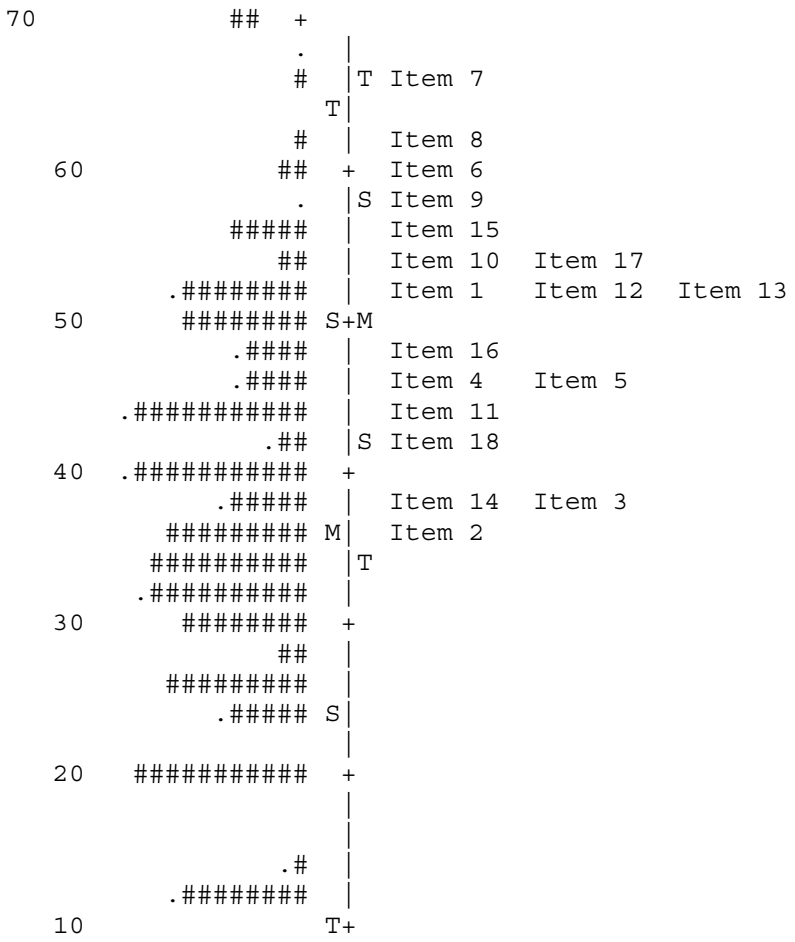

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Figure 6.11 Person-item map for final questionnaire of 18 items with three response categories completed by 290 spectacle wearing respondents.

Table 6.3 Rasch fit statistics and responses within each category for spectacle adaptation questionnaire.

		Response category (%)				0.8-1.2	0.7-1.3
	Item	**Missing data**	***Never***	***Occasionally***	***Most/all time***	**Infit**	**Outfit**
Q1	Distorted vision; e.g. straight edges appear to droop at their ends	3	59	32	10	1.12	1.21
Q2	New spectacles just not feeling 'right'	1	25	43	32	0.91	1.21
Q3	Vision appears different but difficult to say why	2	30	45	25	0.74	0.72
Q4	Problems with blurred distance vision	2	55	24	21	0.99	0.94
Q5	Problems with blurred near vision	4	47	35	17	1.03	1.08
Q6	Words running together when reading	4	77	19	4	1.06	0.93
Q7	Objects appearing smaller than expected	4	84	15	1	1.07	1.25
Q8	Objects appearing further away	3	80	17	4	0.96	0.99
Q9	Objects appearing 'tilted' ; e.g. door/window frames slope	4	73	21	6	0.99	0.98
Q10	A feeling that your spectacles were 'too strong' or 'too powerful'	2	68	21	11	0.96	0.86
Q11	A 'pulling' or 'drawing' sensation in your eyes	1	45	35	20	0.99	0.94
Q12	A need to blink a lot more than with your old spectacles	2	61	27	12	0.98	0.90
Q13	Your eyes feeling tired or strained or 'heavy'	2	62	27	11	1.20	0.99
Q14	A 'swimmy' sensation or general feeling of motion-sickness	2	26	51	24	0.87	0.92
Q15	A 'motion-sickness' feeling when moving around but your vision felt okay when seated	3	71	19	10	1.06	0.93
Q16	Concern about walking or moving around	2	53	31	16	0.99	0.97
Q17	Concern about being unsteady on your feet when standing	3	64	29	7	0.97	0.89
Q18	Concern about going up or down steps/stairs or kerbs	3	41	39	21	1.06	1.14

6.5 General discussion

The spectacle adaptation questionnaire (SAQ) (appendix E) is the first questionnaire developed specifically to investigate the problems that patients experience when adapting to new spectacles following a change in their prescription. As stated earlier, the inherent variability and subjective nature of these adaptational difficulties may mean that quantification is extremely difficult. Indirectly it could be argued that this inherent variability also helps to substantiate the view held by Walsh (2009) that spectacle prescribing is more of an art rather than a science. In other words if the symptoms noticed by patients when adapting to new spectacles are so widely variable and problematic to quantify, then it is almost impossible to define a protocol for the clinician to follow when prescribing spectacles to avoid eliciting symptoms in at least some patients. As previously discussed in Chapter 1 it is possible that as a practitioner gains experience of dealing with spectacle dissatisfaction cases, it may influence their future spectacle prescribing decisions and thus help explain “the art” aspect of spectacle prescribing.

Nevertheless the proposed questionnaire represents a first step in the investigation of spectacle adaptation issues. The patient separation index of 2.24 obtained with SAQ is very good when compared to other vision related questionnaires. For instance, the Rasch refined Activities of Daily Vision Scale (ADVS) proposed by Pesudovs *et al*. (2003) obtained a comparable person separation of 2.22 when distributed to patients having

undergone cataract surgery. However this Rasch refined ADVS still contained 4 misfitting items (infit or outfit lie outside the acceptable range 0.7-1.3) out of its total 15 items. Conversely the proposed SAQ maintains a similar level of patient separation but all of its 18 items lie within an acceptable range of infit/outfit (0.72-1.25 as depicted in Table 6.3). The Quality of Life Impact of Refractive Correction (QIRC) contained 20 items with an infit/outfit range of 0.78 to 1.32 but with a lower person separation of 2.03 (Pesudovs *et al*., 2004) which was only marginally above the minimum of 2.0 suggested by Bond and Fox (2007). More recently, the Quality of Vision (QoV) questionnaire designed for spectacle wearers, contact lens patients and refractive surgery patients used 10 symptoms rated in three scales (frequency, severity and bothersome). Relatively low patient separation indices of 2.08, 2.10 2.01 were obtained respectively, although infit/outfit statistics were all within an acceptable 0.70-1.30 (McAlinden *et al*., 2010). Thus in comparison to these previous questionnaires the Rasch indices obtained by using SAQ appear very reasonable.

The gender excess of female respondents and age distribution of respondents to both the pilot questionnaire and SAQ are very similar with one peak at 30 and a larger peak at 80 years interval maximum. Intuitively this compares well to a typical optometric population, although the relative size of the two peaks was reversed in an earlier report by Pointer (2000). It is possible that the mode of participant recruitment (posters asking

spectacle wearers if they had ever experienced issues when adapting to new spectacles) may have self-selected individuals for whom spectacle adaptation had previously been an issue. Thus as most texts suggest that older patients may have more difficulty in adapting to new spectacles (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007), this may be reflected in the age distribution of SAQ respondents. Conversely the preponderance of older respondents may simply be reflective of individuals with more free time to complete a questionnaire.

It is accepted that some of the items that make up the questionnaire eg. items 2 and 3 (new spectacles just not feeling "right" and vision appears "different" but difficult to say why) are somewhat vague but these epitomise the ambiguous nature of some of the symptoms experienced by patients. Despite this ambiguity, these two items were the most frequently endorsed items in the "occasional" and "most/all of the time" response categories (see Table 6.3). Yet these items also exhibited the greatest variability in item fit statistics with "new spectacles not feeling right" having an outfit of 1.31 in the pilot questionnaire and "vision appears different but difficult to say why" having an infit of 0.73 in the redistribution of SAQ. Perhaps these items indicate that the visual symptoms observed by spectacle wearers when adapting to a change in prescription are very difficult to describe and manifest themselves in an individual way.

The proposed SAQ comprises 18 items and this compares favourably with the 15 item Rasch refined ADVS (Pesudovs *et al*., 2003) and the 20 item QIRC (Pesudovs *et al*., 2004). Although respondent burden is low by having only 18 items, it is possible that some of the rarer issues experienced by some patients may have been lost in the item reduction phase. From the initial pilot questionnaire, items relating to symptoms were the most common to be retained with 6 out of the possible 11 items represented in the final SAQ. Items from the domain of activity limitations were the least retained, with only 3 out of 12 items being chosen in the SAQ. The remaining 9 items were selected from the domain termed "problems seeing with your new spectacles". Although item reduction was driven primarily by Rasch analysis, it also seems reasonable from a clinical viewpoint to expect that spectacle adaptation issues will predominantly be symptom related. It could be argued that the only item to exhibit DIF (pilot question 40 - concern about going up or down steps/stairs or kerbs) should have been excluded from the final questionnaire as clearly older people will experience more problems with steps and kerbs as increasing age reduces mobility. However we felt that this item warranted inclusion as it represented 1 of only 3 items related to activity limitations and its removal adversely affected patient separation in the pilot development (2.36 reduced to 2.10). In addition changes in spectacle magnification have been implicated in the patient's judgment of the position of kerbs and stairs (Elliott & Chapman, 2010; Chapman *et al*., 2011). Ultimately it is possible that when the item reduction phase was

combined with the category collapse into three response categories, patient separation may be compromised when the questionnaire is distributed to a very large population of spectacle wearers. However the Rasch indices, Cronbach's alpha (0.89) and patient/item separation reliability (0.83 and 0.98 respectively) from the second distribution of SAQ to 290 respondents would seem to support its reliability.

The wording of items 35, 39 and 40 started with "how much concern did you have" and it is accepted that the response category is frequency related (e.g. never, occasionally, all the time) when it could be argued that responses such as "none", "a bit" or "unable" would have been more appropriate. However in the lay focus group of questionnaire development, this potential distinction had previously been explored by activity limitations having a question about difficulty (e.g. how much difficulty do you have….none, a little, quite a bit, a lot, unable to do task), followed by a frequency question (e.g. how often do you experience…never, occasionally, fairly often, very often, all the time). This subtle distinction was not readily understood by the lay focus group and it was felt that these questions were merely duplicates of one another. Therefore in terms of simplification the activity limitation items were prefixed with "concern" and the same frequency response categories were used throughout the questionnaire. It is also readily accepted that no attempt was made to exclude patients with significant ocular pathology or other comorbidity that may have influenced the responses to some items. Given that the median

age of respondent was 62 years then this issue may be a significant limitation of the developed SAQ.

6.6 Conclusion

As far as we know, this questionnaire represents the first attempt at quantifying the spectacle adaptation problems experienced by patients when they change the power of their spectacles. The initial pilot questionnaire of 46 items was refined using Rasch analysis to improve response categorisation, item selection and identify misfitting items and respondents. The resultant 18 item SAQ was then distributed to 290 respondents and yielded good reliability indices. When weighted with Rasch scoring SAQ allows a single-value that reflects the spectacle adaptation issues experienced by the respondent to be calculable.

Chapter 7

Use of the spectacle adaptation questionnaire (SAQ) to investigate whether spectacle adaptation symptoms are related to the age of the patient.

7.1 Introduction

As previously discussed some texts suggest that presbyopic patients account for the majority of spectacle dissatisfaction cases (Constantine-Smith, 2002; Freeman & Evans, 2010). Consequently this group of optometric patients are either more acutely aware of spectacle adaption symptoms (and thus more likely to return to their optometrist) or alternatively they experience more difficulty in adapting to the visual disturbances elicited by the new prescription. Certainly many texts support this latter explanation as spectacle adaptation has been reported to be more difficult in the older patient (e.g. Wick, 1960; Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007).

Accordingly, the aim of this study was to use the spectacle adaptation questionnaire (SAQ) developed in the preceding chapter to establish whether any link could be found between respondent age and SAQ Rasch weighted scores. As far as we know this research represents the first investigation into spectacle adaptation symptoms experienced when adapting to new spectacles as opposed to the analysis of rates of

spectacle dissatisfaction (presumably as occurs when patient symptoms are so intolerable that a recheck eye examination is required).

7.2 Methods

In order to appeal to the widest possible spectrum of spectacle wearers, it was decided that it would be easier to provide an internet only based version of SAQ (using www.wufoo.com) and distribute details of this website in as many ways possible nationwide. Links were placed on general discussion forums at universities, the Open University, various community support groups, sports clubs and further social groups aimed at the older individual. In this publicity, it was deliberately emphasized that any spectacle wearer could complete the questionnaire on the basis that it was easier to discard unsuitable entries (respondents using only reading spectacles or changing spectacle lens types), rather than stipulate specific exclusion criteria from the outset. The website was active for 3 months to maximise data collection.

7.3 Results

In total 422 entries were received over the 3 month data collection period. In contrast to Chapter 6, the only exclusion criteria applied was those respondents using solely reading spectacles (N=20), changing lens types (N=25) or entries with significant missing data>33% (N=2). In particular, completed questionnaires in which “never” was selected for all items were included in all subsequent analyses. The results from each questionnaire

were converted into a weighted interval measure of spectacle adaptation using the Rasch scoring table as generated by the analysis in the preceding chapter (see table 7.1). The higher the SAQ score obtained, the more spectacle adaptation symptoms had been experienced by the respondent.

Table 7.1 Weighted Rasch scoring table. The final questionnaire score is calculated from the addition of each response category value divided by the number of questions answered.

		Response category		
	Item	***Never***	***Occasionally***	***Most/all time***
Q1	Distorted vision; e.g. straight edges appear to droop at their ends	31.9	51.0	70.1
Q2	New spectacles just not feeling 'right'	16.1	35.1	54.2
Q3	Vision appears different but difficult to say why	19.2	38.3	57.4
Q4	Problems with blurred distance vision	27.0	46.1	65.2
Q5	Problems with blurred near vision	25.9	45.0	64.1
Q6	Words running together when reading	40.8	59.9	79.0
Q7	Objects appearing smaller than expected	47.5	66.6	85.7
Q8	Objects appearing further away	43.1	62.2	81.3
Q9	Objects appearing 'tilted' ; e.g. door/window frames slope	38.9	58.0	77.1
Q10	A feeling that your spectacles were 'too strong' or 'too powerful'	34.5	53.6	72.7
Q11	A 'pulling' or 'drawing' sensation in your eyes	24.8	43.9	63.0
Q12	A need to blink a lot more than with your old spectacles	32.0	51.1	70.2
Q13	Your eyes feeling tired or strained or 'heavy'	32.6	51.7	70.8
Q14	A 'swimmy' sensation or general feeling of motion-sickness	18.4	37.5	56.6
Q15	A 'motion-sickness' feeling when moving around but your vision felt okay when seated	36.0	55.1	74.2
Q16	Concern about walking or moving around	28.3	47.4	66.5
Q17	Concern about being unsteady on your feet when standing	35.0	54.1	73.2
Q18	Concern about going up or down steps/stairs or kerbs	23.4	42.5	61.6

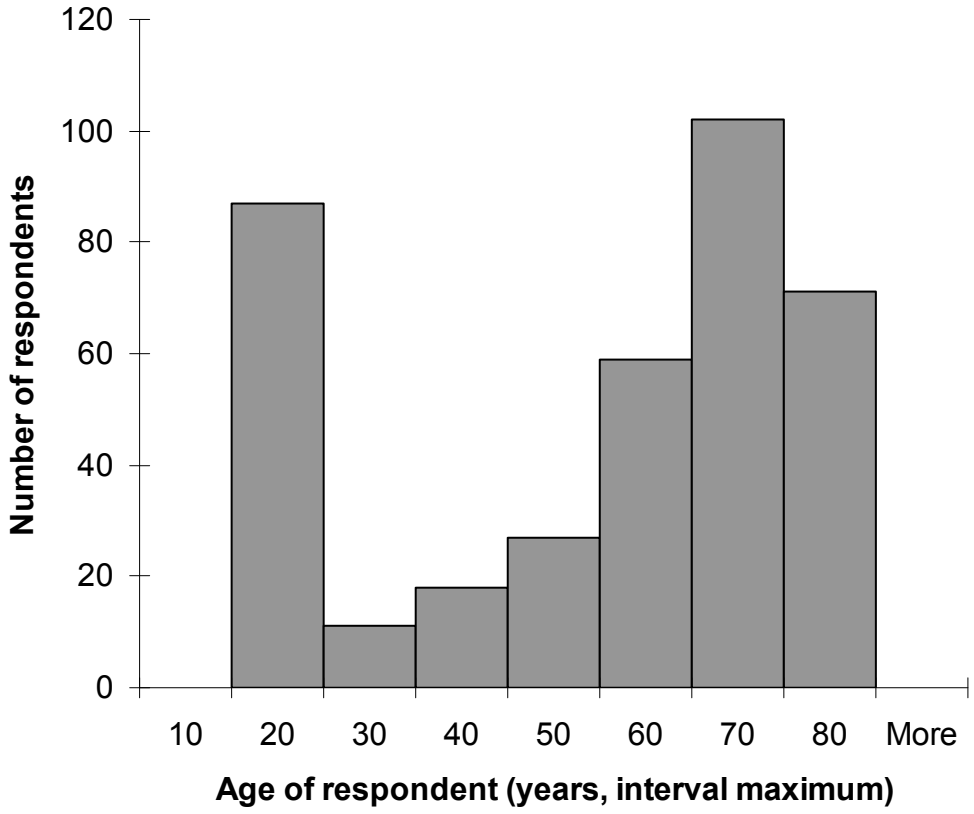

Figure 7.1 Age distribution of the 375 respondents to the spectacle adaptation questionnaire.

The age distribution of respondents is shown in figure 7.1, with a median age of 59 years (range 16-80 years) and 212 males and 163 females completing the questionnaire. The peak at 20 years interval maximum was due to the questionnaire being publicised on university student forums. There was no significant difference between Rasch SAQ scores based on gender (logistic regression p=0.61). A scatterplot of respondent age and Rasch weighted SAQ scores are shown in figure 7.2 with no significant

correlation being found between age and SAQ scores (Spearman's rank correlation p= 0.67).

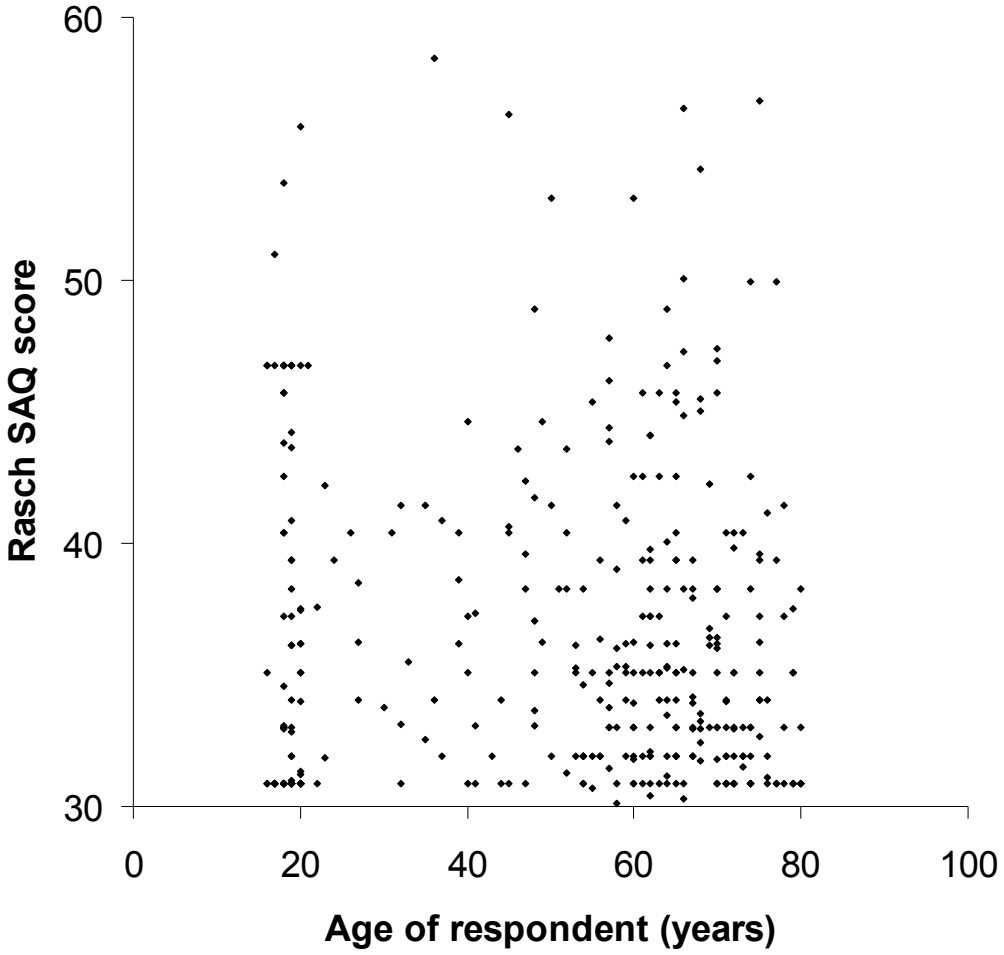

Figure 7.2 Scatterplot of Rasch derived SAQ score and patient age for 375 spectacle wearing respondents.

7.4 Discussion

With regard to the age distribution of respondents, this was broadly similar to that previously reported in an optometric population by Pointer (2000). The lack of difference between SAQ scores and the gender of

respondent is in concordance with the differential item functioning analyses obtained in chapter 6. The lack of significant correlation of respondent age and SAQ score would seem to suggest that spectacle adaptation symptoms are noticed equally by all age groups. However spectacle dissatisfaction rates (discussed in chapter 1) suggest that presbyopic patients are more likely to return to their optometrist to express their dissatisfaction with their new spectacles. These two potentially opposing findings can be reconciled in the following way: It seems likely that younger spectacle wearers are less concerned by the visual disturbances of a new spectacle prescription and more readily accept that they will adapt to them in time. It is also possible that this process of adaptation occurs much more rapidly in the younger patient and this reasoning is to some extent supported (albeit indirectly) by the literature. For instance, in the treatment of amblyopia children are often prescribed their full cycloplegic refraction result and adapt quite easily (Mitchell, Freeman, Millodot & Haegerstrom, 1973; Dobson, Fulton & Lawson-Sebris, 1984) although it is accepted that visual cortex plasticity is maximal at this early age. It is also recognised from visual rehabilitation studies following brain injury that neuroplasticity is easier in the younger brain (Kleim & Jones, 2008). In contrast, the older patient may experience similar spectacle adaptation symptoms but take longer to adapt (Marcus & Rubin, 2006) and experience more difficulty in adapting (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Newman, 2006; Elliott, 2007; Eperjesi *et al*., 2007) and thus be more affected by the visual

disturbances afforded by the new prescription. Certainly, in terms of the gain component of the vestibulo-ocular reflex (VOR), this has been demonstrated to be lower in the elderly population (Ura, Pfaltz & Allum, 1991). Therefore it is possible that this reduced VOR gain accounts at least in part for the longer adaptation period to new spectacles and therefore the increased likelihood of spectacle dissatisfaction in the presbyopic patient.

7.4.1 Limitations

The lack of correlation of age and SAQ scores was unexpected and suggests that the SAQ questionnaire could be improved by modifications allowing the respondent to grade their symptoms according to how long they had been experienced.

7.5 Conclusion

The first use of SAQ yielded an unexpected finding in that spectacle adaptation difficulties were noticed similarly by both the younger and older patient. It is possible that the spectacle adaptation process occurs more rapidly in the younger patient and also that any symptoms experienced are more likely to be accepted as transitory in nature. More research is needed to quantify the duration of symptoms experienced by spectacle wearers following a change in the power of their prescription in order to clarify this issue.

Chapter 8

Unifying discussion and suggestions for future research

The overall aim of this thesis was to investigate what scientific evidence could be collected to support the statement made by Walsh (2009) that "although many practitioners may wish it to be a science, prescribing spectacles is essentially an art". Thus in Chapter 1, the complex issues and potential problems and difficulties that can be encountered by practitioners when prescribing new spectacles were examined. In essence, successful spectacle prescribing does not solely rely on improving the visual acuity of the patient as spectacle adaptation problems may occur due to either magnification, minification or distortion effects and/or changes to the gain of the patient's vestibulo-ocular reflex (Elliott, 2008). Spectacle dissatisfaction rates in the UK due to incorrect prescribing or failure of the patient to adapt were estimated to be in the range of 1-3% of all spectacles dispensed, although the true figure is likely to be higher due to non-complaints in some cases. Given the inherent variability of refraction (Goss & Grosvenor, 1996; MacKenzie, 2008; Shah *et al*., 2009) and that the process of refraction encompass a myriad of complex sensory and motor functions, neurological, psychological and cultural factors (Safir, 1975), it was suggested in chapter 1 that perhaps a low level of spectacle dissatisfaction was inevitable. However it is equally possible that some optometrists may be more adept at modifying the spectacle prescription rather than relying on the subjective refraction result

alone. In other words the “art” aspect of spectacle prescribing was due to the experience gained by a practitioner when managing and solving their own cases of spectacle dissatisfaction.

Although experiential prescribing maxims are quoted in some optometric texts (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007) their content varies significantly and no direct research evidence was available to support their use. Accordingly in chapters 2 and 3, the uses of several potential prescribing rules were investigated in the UK optometric profession. Our results indicated that the subjective refraction result exerted a strong hold on the prescribing outcome with ~85 % of optometrists prescribing the subjective result in scenarios involving moderate (10º axis shift of 2.50D cylinder) and larger changes of cylinder axis (40º axis shift of 2.50D cylinder). This low level of partial prescribing particularly in the scenario involving large changes of oblique cylinder axis was unexpected as some authors have highlighted that these changes should be partially prescribed, (Obstfeld, 1988; Brookman, 1996; Newman, 2006). It is possible that these refractive changes do not produce as many visual problems as suggested or perhaps more likely, they are seldom encountered in UK optometric practice resulting in practitioners having little experience in these changes.

Conversely, significant cylinder power changes triggered the highest level of partial prescribing with 30% (average 0.88DC increase), 49% (1.25DC

increase) and 59% (2.00DC increase) of practitioners electing to reduce the cylindrical change. These practitioners often employed a wide variation in techniques with many (53% of 350) seemingly to view the cylindrical lens in isolation without consideration of the overall spherical equivalent. This approach is at odds with conventionally optometric practice in which changes to the cylindrical lens are combined with spherical changes to maintain the mean sphere equivalent of the refraction result.

The most common clinical maxim described in its various guises in the literature “if it ain’t broke, don’t fix it” was (dependent on scenario) broadly speaking used by the same number of practitioners (~40%) as those electing to prescribe the subjective refraction result (~40%). This habitual : subjective prescribing ratio of approximately 1:1 (range 1:0.7-1.4) was found across five different clinical scenarios. Although these figures may suggest that it is not as frequently used by optometrists as the partial prescribing of cylindrical power changes, it is possible that this maxim is the more widely used clinically as it is more universally applicable across different prescribing situations. It would also appear from the results of the retrospective evaluation of the “if it ain’t broke, don’t fix it” clinical maxim in Chapter 4 that spectacle dissatisfaction rates could be reduced by between 22 to 42% depending on how strictly the maxim is interpreted by the practitioner. However it should be noted that in the majority of these cases, the spectacle prescription following the recheck eye examination was not returned exactly to the habitual prescription but to within 0.25D of

its mean sphere equivalent. Consequently, it is perhaps more appropriate for the practitioner to interpret this clinical maxim as guidance to minimise the refractive change experienced by the patient especially when no symptoms and good visual acuities are recorded in the eye examination ("if it ain't broke, don't fix it much"). Financial implications aside, it could also be argued that small incremental changes in prescription are more beneficial to the patient, especially given that poor adaptation to large refractive corrective changes may increase the risk of falls in older patients (Cumming *et al*., 2007). Nevertheless an important caveat to any application of this maxim is that a full and complete case history is essential together with accurate focimetry of the patient's habitual spectacles.

The finding that experienced optometrists are more likely to suggest a partial prescription (3 times more likely after 40 years qualified) is an important finding that provides significant support for the prescribing rules suggested by various authors (Brookman, 1996; Werner & Press, 2002; Milder & Rubin, 2004; Elliott, 2007). The alternative explanation of a cohort effect seems unlikely. It could also be argued that this substantiates the "art" aspect of spectacle prescribing by practitioners adopting a more conservative approach after gaining experience when dealing with their own recheck eye examinations. No other differences between partial prescribing behaviour and type of practice or gender were evident and any differences in partial prescribing between practice type e.g. independent

versus multiple practice were merely reflective of the different number of years practitioners had been qualified.

Future research in this area could include other forms of clinical evaluation, such as clinical vignettes (Shah *et al*., 2010) and standardised patients (Shah *et al*., 2009; Shah *et al*., 2010). Both are likely to be more closely related to what actually occurs in clinical practice, particularly the standardised patient approach (Shah, Edgar & Evans, 2009; Shah *et al*., 2010; Theodossiades, Myint, Murdoch, Edgar *et al*., 2012). The questionnaire survey approach used here plus the clinical vignette assessment could also be used via the internet to determine how prescribing rules are used across the world. In addition, further assessment of whether optometrists fully understand the link between spherical and cylindrical powers during prescribing could be determined. This could be done using a multiple choice question (MCQ) format at continuing education conferences, where “wi-fi” technology can provide immediate answers and feedback to MCQ questions.

Chapter 5 included the reanalysis of previously published data (McGwin *et al*., 2006) that surprisingly found no change in falls rate after cataract surgery. The potential influences of change in power of refractive correction and/or visual acuity were investigated but unfortunately these data were not sufficiently powered to provide significant results. Future research should explore this issue using accurate determinations of

spectacle type worn (Lord, Dayhew & Howland, 2002) and spectacle power changes after surgery (Cummings *et al*., 2007) plus an indication of whether glasses were worn (and what type of lens) when a patient suffered a fall.

In chapter 6, a questionnaire was developed that identified and quantified the symptoms experienced by patients when they adapted to new spectacles. In particular, it was hoped that this instrument would then provide an avenue for further research by allowing patient reported spectacle adaptation problems to be related to other factors such as the magnitude of prescription change or the age of the patient. The SAQ (spectacle adaptation questionnaire) was developed using Rasch analysis and showed very good psychometric properties and highlighted the wide range of symptoms experienced by patients when having difficulty adapting to new spectacles. Symptoms included in SAQ related to blur (distance blur, near blur), magnification effects (smaller, tilted), motion sickness (feeling “swimmy”, motion-sickness), mobility issues related to vision (unsteady, difficulties walking) and feelings of visual unease (not “feeling right”, appearing different but not sure why). However, analysis of SAQ data from 380 patients across a wide age range showed no correlation of SAQ score with age, despite the greater prevalence of spectacle dissatisfaction with older patients. This suggests that some indication of severity and/or duration of symptoms may need to be incorporated into the questionnaire. This would require further piloting and

validation and should be developed in any future research. Subsequently this could potentially be used to determine whether greater adaptation difficulties occur with increasing age and/or increasing change in refractive error and whether some refractive changes, such as oblique cylinder, elicit more problems for patients than others.

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Appendix A

Initial questionnaire to investigate whether prescribing maxims are widely used in UK optometry.

We are two students at Bradford University doing a questionnaire based dissertation on prescribing trends within UK High Street practices. We would be very grateful if you could spend a few minutes answering the following questions, taking into consideration what you would actually do in practice. Please select the most appropriate option or select other with a reason for your answer.

In order to determine how representative our sample is, when compared to the optometric profession across the UK, we have asked questions about gender and practice type/location you work in.

The information provided will be treated confidentially and the presentation of any data will be anonymous.

1. What is your gender?

o Male

o Female

2. How many years have you been qualified for?

o Less than 1 year

o 1-2 years

o 3-5 years

o 6-10 years

o 11-20 years

o 20+ years

3. Where do you work?

o Large Multiple

o Small Multiple (up to 10 branches)

o Independent

o University Eye Clinic

o Other (please state below)

4. Where do you work?

o East England
o South-West England
o West Midlands
o London and surrounding areas
o North-East England
o North-West England
o South-East England
o South-England
o East Midlands
o Northern Ireland
o Scotland
o Wales

5. What type of Optometrist are you?

o Resident
o Locum

Patient A. Case History and Clinical Findings

A 38 year old teacher comes in for annual check up. He is not having any problems with current spectacles, which he wears all the time. No other history. Hobbies and Interests are: Reading, Tennis and Computers.

Habitual Rx:

RE: -6.00DS

LE: -7.00DS

Distance Habitual VA RE: 6/5 LE: 6/5

Near Habitual VA RE: N5 LE: N5

Retinoscopy:

RE: -6.00/-0.50 x 115

LE: -7.25/-0.25 x 70

Subjective:

RE: -5.75/-0.50 x 125----Distance VA: 6/5----Near VA: N5

LE: -7.00/-0.25 x 85------Distance VA: 6/5----Near VA: N5

All other assessments within normal limits for age and refractive error.

6. What would you prescribe for Patient A and why?

o RE: -5.75/-0.50 x 125

LE: -7.00/-0.25 X 85 (Subjective Rx)

o RE:-6.00DS

LE:-7.00DS (Habitual Rx)

o Other (please state below)

……

……

Reason for Answer:

.....

……

Patient B. Case History and Clinical Findings

A 15 year old girl comes in for annual check-up. No-one in family wears glasses, she has no visual symptoms and is progressing well in school. She tells us that she loves to read and is doing well at school and wears her glasses when doing near work. No other pertinent history.

Habitual Rx:

RE: +0.75DS

LE: +0.75DS

Distance Habitual VA: RE: 6/5 LE: 6/5

Near Habitual VA: RE: N5 LE: N5

Retinoscopy:

RE: +2.00/-0.25 x 5

LE: +1.75/-0.25 x 165

Subjective:

RE: +1.50DS-----Distance VA: 6/5---Near VA: N5

LE: +1.50DS -----Distance VA: 6/5---Near VA :N5

All other assessments within normal limits for age and refractive error.

7. What would you prescribe for Patient B and why?

o RE: +0.75DS

LE: +0.75DS (Habitual Rx)

o RE: +1.50DS

LE: +1.50DS (Subjective Rx)

o Other (please state below)

……

……

Reason for Answer:

……

……

Patient C. Case History and Clinical Findings

A 71 year old retired woman comes in complaining of headaches and eyestrain both with and without her current Rx. She wears her Rx all the time. She is otherwise generally fit and healthy. No medications/allergies. No other pertinent history.

Habitual Rx:

RE: +0.75DS

LE: +1.00DS ADD + 2.50

Distance Habitual VA: RE: 6/9 LE: 6/12

Near Habitual VA: RE: N8 LE: N10

Vision (with pinhole): RE: 6/5 LE: 6/5

Retinoscopy:

RE: +1.00/-0.75 x 35

LE: +1.50/-1.00 x 60

Subjective:

RE: +0.75/-0.75 x 35--- VA:6/5 ----- Near VA: N5

LE: +1.25/-1.00 x 55---- VA: 6/5 ----- Near VA: N5 (ADD +2.50)

Ocular Health Assessment: Cortical lens opacities visible in infero-nasal quadrants of both eyes.

All other assessments within normal limits for age and refractive error.

8. What would you prescribe for Patient C and why?

o RE: +0.75DS

LE: +1.00DS (ADD + 2.50) (Habitual Rx)

o RE: +0.75/-0.75 x 35

LE: +1.25/-1.00 x 55 (ADD +2.50) (Subjective Rx)

o Other (please state below)

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……

Reason for Answer:

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Patient D. Case History and Clinical Findings

A 36 year old technician came in for a routine check up. He explains that he has recently had to squint to see things more clearly and doing that gave him headaches and eyestrain. He wears his Rx all the time.
His general health is fine, no medications or allergies.

Habitual Rx:

RE: +0.50/-1.75 x 90

LE: -0.25/-1.25 x 90

Distance Habitual VA: RE: 6/12 LE: 6/12

Near Habitual VA: RE: N6 LE: N6

Retinoscopy:

RE: +0.50/-3.00 x 90

LE: Plano/-2.75 x 90

Subjective:

RE: +0.75/-3.00 x 90--- Distance VA: 6/6---Near VA: N5

LE: Plano/-2.50 x 90-----Distance VA: 6/6---Near VA: N5

All other assessments within normal limits for age and refractive error.

9. What would you prescribe for Patient D and why?

o RE: +0.50/-1.75 x 90

LE: -0.25/-1.25 x 90 (Habitual Rx)

o RE: +0.75/-3.00 x 90

LE: Plano/-2.50 x 90 (Subjective Rx)

o Other (please state below)

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Reason for Answer:

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Patient E. Case History and Clinical Findings

A 33 year old Taxi Driver comes in for a routine eye exam and wants a new frame. Distant Vision and Near Vision are good with Rx, which he wears all the time. Drives with no problems. VDU user with no problems. First wore spectacles at age of 18. No change in Rx at last visit 2 years ago. No other pertinent history.

Habitual Rx:

RE: -2.75/ -0.75 x 175

LE: -2.50/ -0.75 x 10

Distance Habitual VA: RE: 6/5 LE: 6/5

Near Habitual VA: RE: N5 LE: N5

Retinoscopy:

RE: -2.75/ -0.50 x 10

LE: -2.00/ -0.50 x 15

Subjective Rx:

RE: -2.25/ -0.75 x 180 VA 6/5----Near VA: N5

LE: -2.25/ -0.75 x 5 VA 6/5 ------ Near VA: N5

All other assessments within normal limits for age and refractive error.

10. What would you prescribe for Patient E and why?

o RE: -2.75/ -0.75 x 175

LE: -2.50/ -0.75 x 10 (Habitual Rx)

o RE: -2.25/ -0.75 x 180

LE: -2.25/ -0.75 x 5 (Subjective Rx)

o Other (please state below)

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Reason for Answer:

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Patient F. Case History and Clinical Findings.

A 46 year old shop owner is experiencing difficulty with his near vision. His distance vision is fine with Rx which is worn all the time. No other history or symptoms, no meds or allergies. No other pertinent history.

Habitual Rx:

RE: +1.00/-0.50 x 50

LE: +1.50/-0.50 x 65

Distance Habitual VA: RE: 6/5 LE: 6/5

Near Habitual VA: RE: N12 LE: N12

Retinoscopy:

RE: +1.75/-0.50 x 55

LE: +2.25/-0.50 x 60

Subjective:

RE: +1.50/-1.00 x 50 ------ Distance VA: 6/5----- Near VA: N5

LE: +2.00/-0.50 x 65 ------- Distance VA: 6/5----- Near VA: N5

(ADD +1.00)

All other assessments within normal limits for age and refractive error.

11. What would you prescribe for Patient F and why?

o RE: +1.00/-0.50 x 50

LE: +1.50/-0.50 x 65 (Habitual Rx)

o RE: +1.50/-1.00 x 50

LE: +2.00/-0.50 x 65 (ADD +1.00) (Subjective Rx)

o Other (please state below)

……

……

Reason for Answer:

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Patient G. Case History and Clinical Findings

A 33 year old builder experiencing his vision to be 'not as good as it used to be'. He wears his Rx all the time. Is generally fit and healthy, no medications or allergies. No other pertinent history.

Habitual Rx:

RE: -1.00/-2.00 x 45

LE: -1.25/-2.50 x 140

Distance Habitual VA: RE: 6/9 LE: 6/9

Near Habitual VA: RE: N5 (with difficulty) LE: N6

Retinoscopy:

RE: -1.25/-2.00 x 50

LE: -1.25/-2.50 x 130

Subjective:

RE: -1.25/-2.25 x 55 ------Distance VA: 6/5-----Near VA: N5

LE: -1.25/-2.75 x 130 -----Distance VA 6/5------Near VA: N5

All other assessments within normal limits for age and refractive error.

12. What would you prescribe for Patient G and why?

o RE: -1.00/-2.00 x 45

LE: -1.25/-2.50 x 140 (Habitual Rx)

o RE: -1.25/-2.25 x 55

LE: -1.25/-2.75 x 130 (Subjective Rx)

o Other (please state below)

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Reason for Answer:

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Patient H. Case History and Clinical Findings

Routine eye exam. A 75 year old retired female has early cataract.

Reports no problems with distance or near vision. Px can see TV and do shopping fine etc, with Rx (worn all the time). Px does not drive.

No other pertinent history.

Habitual Rx:

RE: -1.50/ -0.75 x 40

LE: -1.25/ -1.00 x 150

(ADD +2.75)

Distance Habitual VA: RE: 6/9(-1) LE: 6/9(+1)

Near Habitual VA: RE: N6 LE: N6

Retinoscopy:

RE: -2.00/ -1.25 x 30

LE: -1.50/ -1.50 x 155

Subjective Rx:

RE: -1.75/ -1.00 x 35------Distance VA 6/9----------Near VA: N6

LE: -1.25/ -1.50 x 145------Distance VA 6/9(+1)----------Near VA: N6

(ADD +2.75)

Ocular health assessment: early nuclear cataract with cortical spokes in RE and LE (RE > LE)

13. What would you prescribe for Patient H and why?

o RE: -1.50/-0.75 x 40

LE: -1.25/-1.00 x 150 ADD +2.75 (Habitual Rx)

o RE: -1.75/-1.00 x 35

LE: -1.25/-1.50 x 145 ADD +2.75 (Subjective Rx)

o Other (please state below)

……

……

Reason for Answer:

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……

Appendix B

UNIVERSITY OF BRADFORD
MAKING KNOWLEDGE WORK

APPLICANT'S ETHICS CHECKLIST

This checklist is designed to help you to decide whether or not ethics approval is required and, if required, to decide on the appropriate ethics review procedure

Who should use the checklist?
The Principal Investigator [PI] or the Principal Supervisor [PS] in the case of a supervised student research project.

Guidance on the 2 different ethics review procedures that together make up the University's Ethics Review System (i.e. 'University' and 'NHS') is available at http://www.bradford.ac.uk/rkts/researchsupp.php?content=UniversityorNHSApproval

****

Project Title: ……The science of prescribing spectacles……

Name of Principal Investigator / Principal Supervisor: …Prof David Elliott..

Name of Student (if applicable): ……Chris Howell-Duffy…… ……..

Summary of Project (max 150 words):

How many optometrists make adjustments to the subjective refraction result prior to prescribing? When and what types of adjustments are made?
A questionnaire has been developed that attempts to determine what refractive correction optometrists would prescribe for five selected cases, which are relevant for several prescribing rules that have been recommended in the optometric literature.[2-10] A multiple choice answer format is used to make completion of the questionnaire as simple as possible. The questionnaire will be made available via the internet,[12] e.mailed and posted to optometrists throughout the UK. These data will be analysed to determine the way that optometrists adapt the results of subjective refraction, if they do so at all, for these five selected cases and whether this varies with various demographic variables such as years of experience. The questionnaire is attached.

The following 5 questions should be answered *in order* 'Yes' or 'No':

Q1 **Is the proposed project a research project?** **YES**

i.e. will it constitute an 'investigation undertaken in order to gain knowledge and understanding'? (this includes work of educational value designed to improve understanding of the research process) A more detailed definition is available at: http://www.bradford.ac.uk/rkts/researchsupp.php?content=Guidance

If you answer 'Yes' to Q1 ethical approval may be required, move to Q2.
If you answer 'No' to Q1 then a research ethics review is not required.

Note: there may be occasions where a project is not defined as research but still raises ethical issues – please submit for review.

Q2 **Will the research project involve the NHS?** See guidelines **NO**

http://www.bradford.ac.uk/rkts/researchsupp.php?content niversityorNHSApproval

If you answer 'No' to Q2 move on to Q3

Q3 **Will the research project involve any of the following in the UK:** **NO**

- Testing a medicinal product
- Investigating a medical device
- Taking samples of human biological material (e.g. blood, tissue)
- Prisoners or others in custodial care (e.g. young offenders) as participants
- Adults with mental incapacity as participants
- Other vulnerable groups (e.g. vulnerable children) as participants

If you answer 'Yes' to Q3 ethical approval will *usually* be required by NHS Research Ethics Committee (REC).

See guidelines at:
http://www.bradford.ac.uk/rkts/researchsupp.php?content=UniversityorNHSApproval

If you answer 'No' to Q3 move on to Q4

Q4 **Will the research project involve <u>human participants and/or human data (but not accessed through the NHS)</u>?** **YES**

If you answer 'Yes' to Q4 University ethical approval is required
If you answer 'No' to Q4 move on to Q5

Please give brief explanation of type of data/participation in cases which could be defined as uncontentious.

The research involves simple uncontentious questionnaires.

Q5 **Will the research project involve <u>human tissue (but not requiring NHS approval – see Q3)</u>?** **NO**

If you answer 'Yes' to Q5 University ethical approval is required

If you require advice on human biological material please contact Human Tissue Act (HTA) Designated Individual: Professor Diana Anderson on ext 3569 or email: d.anderson1@bradford.ac.uk

If you answer 'No' to Q5 and have answered 'No' to Q2, Q3 and Q4 ethical approval is <u>not</u> required.

Approval for the above named proposal is granted:

I confirm that there are **<u>no ethical issues</u>** requiring further consideration.
(Any subsequent changes to the nature of the project will require a review of the ethical considerations)

Name (Principal Investigator/Principal Supervisor): Prof David Elliott

Signature: **Date:**

Name (Student): Chris Howell-Duffy

Signature: **Date:**

Approval for the above named proposal is not granted:

I confirm that there are **ethical issues** requiring further consideration and will refer the proposal to the appropriate Research Ethics Panel.

Name (Principal Investigator/Principal Supervisor):

Signature: **Date:**

****
****

Checked:

Signature of Senior Academic Manager:

Print Name: **Date:**

Ethical Scrutiny by a University Research Ethics Panel is not required if:

- **The project is NOT a research project.**

- **The research project will only involve unlinked or aggregated human data which was collected and which was, at the time, subject to relevant research ethics panel approval.**
  However, where this is the case the researcher should at least confirm this in an email to the Research Support Unit's Ethics Administrator so that the Ethics Administrator has a record and can inform the Chair of the appropriate Research Ethics Panel that the researcher plans to go ahead without ethics approval. The email should confirm that the research project does not require ethics approval because it only involves unlinked or aggregated data, which when originally obtained from people was obtained in accordance with the protocol as approved at the time by an appropriate research ethics panel. The email should also briefly explain how the researcher now plans to use the unlinked or aggregated data.

- **The research is Public Domain Data:**
  The Economic and Social Research Council's (ESRC) Research Ethics Framework states that ethics approval may not be required for data sets that exist in the public domain (e.g. datasets that are available from the Office for National Statistics or from the ESRC's Data Archive) so long as the appropriate permissions from individuals have already been obtained (i.e. informed consent) and where it is not possible to identify the individuals from the information provided. It must be remembered that public domain data is still covered by the laws of copyright.

- **The research involves Simple Uncontentious Questionnaires:**
  If a research project's only involvement with human subjects is a simple brief questionnaire with uncontroversial content it may not require ethical approval. It is the Principal Investigator or Principal Supervisor's responsibility to decide whether a project comes under this category and must indicate this on the form and attach the document for information.

Please return Checklist to:

Lynda Nuttall, Ethics Administrator, Research Support Unit [RSU],

RKTS ext. 3170, [l.d.nuttall@bradford.ac.uk]

Ethics Approval for Science of Prescribing Spectacles

>X-Sieve: CMU Sieve 2.3
>From: "TL Holt" <T.L.Holt@Bradford.ac.uk>
>To: "DB Elliott" <D.Elliott1@Bradford.ac.uk>
>Cc: <m.h.brinkworth@Bradford.ac.uk>,
> "'Lynda Nuttall'" <L.D.Nuttall@Bradford.ac.uk>
>Subject: Science of Prescribing Spectacles
>Date: Fri, 14 Aug 2009 08:49:10 +0100
>Thread-Index: Acocs7TuLDzuoDmmQCK5DBLDos1mww==
>
>Hi Dave
>
>I've had a look over your Ethics Checklist for the above project and agree that it does not require further ethical scrutiny.
>
>Thanks
>
>Tamsin
>
>Tamsin Holt, Head of Research Support, Research and Knowledge
>Transfer Support, The University of Bradford, Bradford BD7 1DP
>
>T: 01274 235911 * E: t.l.holt@bradford.ac.uk * F: 01274 236090
>

--
David B Elliott, PhD; Bradford School of Optometry & Vision Science,
University of Bradford, Bradford, BD7 1DP.
Ph: 01274-235224 Fax: 01274-235570
http://www.brad.ac.uk/optometry/our-staff/academic-staff/David_B._Elliott/

Appendix C

Further prescribing questionnaire to investigate whether any particular demographic of the UK optometric profession utilised clinical maxims more than another.

The purpose of this questionnaire is to further investigate the prescribing decisions made by UK Optometrists. Although you may have previously completed such a questionnaire I would be grateful if you could spare a few minutes to complete this shorter version (only 5 cases).

This research is supported by the College of Optometrists.

Please tick the most appropriate decision that you would make in practice. All information provided will be treated confidentially and the subsequent presentation of any data will be anonymous.

After consideration of patient history, signs, symptoms and the results of all tests performed during the eye examination, in what circumstances would you prescribe your full subjective refraction result?

- O Always (go to last page for demographic questions - although you may wish to look through the case scenarios presented in questions 1 to 5 before selecting this option).

- O Sometimes (continue to question 1 on next page)

1. Patient A. Case History and Clinical Findings

A 30 year old taxi driver comes in for his bi-annual check up. He is not having any problems with his current spectacles (approx 3 years old) which are worn all the time, but he would like a new frame. He reports that his distance and near vision are good and he is not having any headaches or other visual related problems. Spectacles were first worn at age 18. No other pertinent history.

Hobbies and interests are: reading and computers.

Habitual Rx:

RE: -2.25DS 6/5 N5 **LE**: -2.00DS 6/5 N5

Subjective:

RE: -1.75DS (duochrome balanced, +1.00 test 6/12) VA: 6/5 N5

LE: -1.50DS (duochrome balanced, +1.00 test 6/12) VA: 6/5 N5

Retinoscopy was similar to the subjective refraction result.

All other assessments were within normal limits for age and refractive error.

Question: What would you prescribe for Patient A and why?

- **Subjective Rx** (RE: -1.75DS LE: -1.50DS)
- **Habitual Rx** (RE: -2.25DS LE: -2.00DS)

O Other (please state below)

……

……

Reason for Answer:

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……

2. Patient B. Case History and Clinical Findings

A 68 year old retired bricklayer reports that his distance vision in particular has deteriorated and he would like his spectacles updating. His last eye examination was approximately 3 years ago. He wears his spectacles all the time and is generally fit and healthy. No medication is taken apart from simvastatin for his raised cholesterol level. He doesn't drive but is a keen walker and enjoys bird watching. No other pertinent history.

Habitual Rx:

RE: -1.50/-2.00x80	VA 6/18+1	Add +2.25	N6
LE: -1.50/-2.25x85	VA 6/18	Add +2.25	N6

Subjective:

RE: -1.25/-2.50x40 VA 6/7.5+2 Add +2.50 N5

LE: -1.25/-2.75x45 VA 6/7.5 Add +2.50 N5

Retinoscopy was similar to the subjective refraction result.

Ophthalmological examination was unremarkable apart from cortical spoke opacification in both eyes.

Question : What would you prescribe for Patient B and why?

- **Habitual Rx** (RE: -1.50/-2.00x80 LE: -1.50/-2.25x85 Add +2.25)
- **Subjective Rx** (RE: -1.25/-2.50x40 LE: -1.25/-2.75x45 Add +2.50)
- **Other** (please state below)

……

……

Reason for Answer:

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3. Patient C. Case History and Clinical Findings

A 22 year old woman comes in for her first "proper" eye examination having never worn spectacles. Her vision was tested 10 yrs ago at school and no problem was found. In the last 6 months she has started her own business, a sandwich shop and although no visual problems are reported whilst at work, she has now started to use a computer in the evening for the business accounts. She reports that her eyes feel "tired" after using the computer for about an hour and sometimes she gets a frontal headache. The headaches happen 2-3 times a week generally after doing the accounts. OTC paracetamol generally solves the problem and she has not consulted her GP.

No-one in her family wears spectacles or suffers from any ocular problem.

She has never had any ocular problems and all other pertinent history is negative.

Vision

R 6/6+2 N5 **L** 6/5 N5

Subjective:

RE: +2.00/-1.00x135 VA: 6/5 N5

LE: +1.50DS VA: 6/5 N5

Retinoscopy was similar to the subjective refraction result.

All other assessments are within normal limits for age and refractive error.

Question: What would you prescribe for Patient C and why?

- **No prescription issued**.
- **Subjective Rx** (RE: +2.00/-1.00x135 LE: +1.50DS)
- **Other** (please state below)

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Reason for Answer:

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4. Patient D. Case History and Clinical Findings

An 85 year old retired woman comes in complaining that her vision is not as good as it used to be. Her last eye examination was approximately 18 months ago and she was told both eyes had cataracts. She doesn't want referral for cataract surgery because her general health is not good. She now feels that she has to read a little bit too close for comfort, saying that it "makes my arms hurt". Used to drive but licence surrendered a few years ago.

Various tablets being taken for blood pressure, heart and cholesterol (exact details not known). No other pertinent history.

Habitual Rx:

RE: +4.75DS	VA 6/12	Add +2.50	N5 at approx 20cm
LE: +6.50DS	VA 6/24	Add +2.50	N6 at approx 20cm

Subjective:

RE: +2.75DS	VA 6/7.5+1	Add +3.00	N5 at approx 30cm
LE: +4.50DS	VA 6/12	Add +3.00	N6 just at approx 30cm

Retinoscopy was similar to the subjective refraction result.

Ocular Health Assessment: nuclear lens opacification L>R.

All other assessments within normal limits for age and refractive error.

Question: What would you prescribe for Patient D and why?

O	**Habitual Rx**	(RE: +4.75DS	LE: +6.50DS ADD + 2.50)
O	**Subjective Rx**	(RE: +2.75DS	LE: +4.50DS ADD +3.00)
O	**Other**	(please state below)	

……

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Reason for Answer:

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5. Patient E. Case History and Clinical Findings

A 75 year old retired man came for his routine check up. He feels that his vision has deteriorated for both distance and near. His last eye exam was approx 2 years ago. He is generally fit and healthy for his age and apart from 75mg aspirin daily takes no regular medication. He has never learned to drive and still uses his bicycle to travel to the shops. He has worn spectacles for as long as he can remember and always had separate pairs for distance and reading.

Doesn't read much, his main hobby is gardening.

Habitual Rx:

RE: -4.00/-1.00x160	VA 6/18+1	Add +2.50	N6
LE: -3.50/-1.25x40	VA 6/18	Add +2.50	N6

Subjective:

RE: -4.50/-3.00 x 160	VA 6/7.5-1	Add +3.00	N5
LE: -4.00/-3.25 x 40	VA 6/7.5-2	Add +3.00	N5

Retinoscopy was similar to the subjective refraction result.

Ophthalmological examination is unremarkable except for marked bilateral cortical lens changes and some nuclear haze. Patient informed of cataract but doesn't want referral, would prefer new spectacles.

Question: What would you prescribe for Patient E and why?

- **Habitual Rx**
  (RE: -4.00/-1.00x160 LE: -3.50/-1.25x40 Add +2.50)
- **Subjective Rx**
  (RE: -4.50/-3.00x160 LE: -4.00/-3.25x40 Add +3.00)
- **Other**
  (please state below)

……

……

Reason for Answer:

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……

Practitioner demographics

(I) Approximately how long have you been qualified | **years** |

(II) Where do you work?

- Large Multiple
- Small Multiple (up to 10 branches)
- Independent
- University Eye Clinic
- Other (please state below)

……

……

(III) In what capacity is the majority of your Optometric work carried out ?

- Resident
- Locum

(IV) Approximately how many CET points (to the nearest 10) will you have accumulated by the end of the current CET cycle (31 Dec 2009)

| **points** |

Many thanks for completing this questionnaire.

Appendix D

Pilot questionnaire of the measurement of problems adapting to new spectacles.

This is a pilot questionnaire designed to measure the symptoms and difficulties experienced by people who obtain new spectacles following a change in the power of their spectacles. Although some of the questions may seem very similar we are trying to find the “best” ones to use so that we are able to determine the type of spectacle power changes that cause the most problems. The questionnaire is not intended to investigate adaptation problems when changing to different spectacle lens types (such as when you wear varifocal or bifocal lenses for the first time).

This research is supported by the College of Optometrists.

Important

Please only complete this questionnaire if your new spectacles were of the same lens type (distance, bifocal or varifocal) as your previously worn spectacle correction. Do not complete this questionnaire if you were trying bifocal or varifocal type lenses for the first time or if you only wear spectacles for reading.

This questionnaire is also available for online completion at:

http://newspecs.wufoo.com/forms/questionnaire/

If you have any questions on any part of the questionnaire, please contact either:

Chris Howell-Duffy MSc, MCOptom, Dept of Optometry, University of Bradford, Bradford, BD7 1DP.

Email: c.j.howell-duffy1@bradford.ac.uk

Prof. David B. Elliott PhD, MCOptom FAAO

Email: d.elliott1@bradford.ac.uk

Demographic information

This information is provided anonymously. Please do not give your name.

1. What type of spectacles do you use ?
(please tick all that apply)

Distance spectacles	
Reading spectacles	
Bifocal spectacles	
Varifocal spectacles	

2. Did your new spectacles have the same type of lenses as previously worn; e.g. distance, bifocal, varifocal ?

Yes	
No	

3. Please enter your age to the nearest year ?

	Years

4. Please select your gender ?

Female	
Male	

Instructions

Please complete pages 2-10 using a tick as in the example below.	✓

Example:
With your new spectacles, did you experience…?

……*the new spectacles just not feeling "right"* ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time
		✓			

Section I: Problems seeing with new spectacles

We are going to ask you about any visual issues that you may have encountered in the days and first few weeks when wearing your new spectacles. For all these questions we want you to think about any visual difficulties experienced when using your new spectacles in normal everyday life.

With your new spectacles, how often did you experience...?

1. … your vision being distorted; e.g. straight edges appeared to droop at their ends, steps appeared to curve or newspaper or paperwork looked curved/tapered or the wrong shape ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

2. … your vision being “too clear” or that you could see “too much detail” ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

3. … the new spectacles just not feeling “right” ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

4. … your vision appearing different but it was difficult to say why ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

5. … problems with blurred distance vision; e.g. difficulty reading teletext pages or sub-titles on the TV ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

6. … problems with blurry near vision; e.g. reading a newspaper ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

7. … words running together when reading ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

8. … the tendency to miss or skip lines when reading ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

9. … objects appearing closer ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

10. … objects appearing bigger than expected ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

11. … objects appearing smaller than expected ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

12. … objects appearing further away ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

13. … objects appearing "tilted"; e.g. your desktop seemed to slope toward/away from you, door/window frames or your computer screen appeared to slope or tilt ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

14. … circular objects appearing oval; e.g. dinner plates looked oval or clock faces seemed oval ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

15. … the floor feeling too close ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

16. … the floor appearing not to be level; e.g. sloping toward or away from you?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

17. … the floor feeling further away ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

18. … the world appearing to "swim"; e.g. as though looking through water ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

19. … your vision being worse through the edges of your spectacle lenses ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

20. … the need to move your head around more often ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

21. … feeling taller ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

22. … frequently having to adjust the position of your spectacles ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

23. … feeling shorter ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

Section II: Symptoms

We are only interested in knowing about symptoms experienced in the first few days and weeks with your new spectacles and not problems that were also present when wearing older spectacles.

With your new spectacles, how often did you experience...?

24. … a feeling that your spectacles were “too strong” or “too powerful” ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

25. … a “pulling” or “drawing” sensation in your eyes; e.g. a sensation that your eyes were being pulled forward ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

26. … a need to blink a lot more than with your old spectacles ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

27. … your eyes feeling tired or strained or “heavy” ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

28. … a “swimmy” sensation or general feeling of motion sickness; e.g. like car or sea-sickness ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

29. … headaches when wearing your new spectacles; e.g. headaches above the eyes, in the eyes, after reading, at the end of the day ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

30. … itchy / burning / sore / uncomfortable / or dry eyes ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

31. … a “motion-sickness” type feeling on moving around but your vision felt okay when seated ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

32. … problems with quick head movements causing discomfort; e.g. rapid head movements made your feeling of motion-sickness worse ?

Don’t know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

With your new spectacles, how often did you experience...?

33. … your eyes feeling watery or runny ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

34. … a need "to stare" or concentrate "too much" through your new spectacles ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

Section III: Activity limitations

We are going to ask you about things that you might have found troublesome in the first few days and weeks when wearing new spectacles and that might have caused some concern or worry at the time (these concerns have likely disappeared by now). We only want you to think about concerns that occurred when you started wearing your new spectacles.

When wearing your new spectacles, how much concern did you have…?

35. … about walking or moving around ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

36. … judging the speed of vehicles either when driving or as a pedestrian ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

37. … about driving and your awareness of objects or other potential hazards;
    e.g. did other cars seem to appear quicker than expected ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

When wearing your new spectacles, how much concern did you have…?

38. … accurately judging distances when parking your car; e.g. did you leave a wider or narrower gap than you intended either to a kerb or other vehicle ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

39. … about being unsteady on your feet when standing ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

40. … about going up or down steps/stairs or kerbs ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

41. … regarding stumbling or tripping over ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

42. … with hand-eye coordination; e.g. finding it difficult to put down a cup of tea or difficult reaching for a door knob ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

When wearing your new spectacles, how much concern did you have…?

43. … regarding specific work related visual problems; e.g a bricklayer may have experienced worries about laying bricks in a straight line or a builder may have felt a little unsteady and unsafe on scaffolding etc ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

44. … adequately seeing your dinner plate or using your knife and fork at meal times ?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

45. … that you were lifting your feet higher than usual when walking?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time

46. … that you simply couldn't wear your new spectacles and instead reverted back to a more satisfactory older pair of spectacles?

Don't know / Not applicable	Never	Occasionally	Fairly often	Very often	All the time
		✓			

This is the end of the questionnaire

Thank you for assistance !

Please return it to the University of Bradford in the attached pre-paid envelope.

……
…….

Appendix E

The measurement of problems adapting to new spectacles.

This is a questionnaire designed to measure the symptoms and difficulties experienced by people who obtain new spectacles following a change in the power of their spectacles. The questionnaire is not intended to investigate adaptation problems when changing to different spectacle lens types (such as when you wear varifocal or bifocal lenses for the first time).

This research is supported by the College of Optometrists.

This questionnaire is also available for online completion at:

https://newspecs.wufoo.com/forms/spectacles/

If you have any questions on any part of the questionnaire, please contact either:
Chris Howell-Duffy MSc, MCOptom, Dept of Optometry, University of Bradford, Bradford, BD7 1DP.
Email: c.j.howell-duffy1@bradford.ac.uk

Prof. David B. Elliott PhD, MCOptom FAAO
Email: d.elliott1@bradford.ac.uk

Demographic information

This information is provided anonymously. Please do not give your name.

1. What type of spectacles do you use ?
(please tick all that apply)

Distance spectacles	
Reading spectacles	
Bifocal spectacles	
Varifocal spectacles	

2. Did your new spectacles have the same type of lenses as previously worn; e.g. distance, bifocal, varifocal ?

Yes	
No	

3. Please enter your age to the nearest year ?

	Years

4. Please select your gender ?

Female	
Male	

Instructions

Please complete pages 2-10 using a tick as in the example below.	✓

Example:
With your new spectacles, did you experience…?

……*the new spectacles just not feeling "right"* ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time
		✓	

With your new spectacles, how often did you experience...?

1. … your vision being distorted; e.g. straight edges appeared to droop at their ends, steps appeared to curve or newspaper or paperwork looked curved/tapered or the wrong shape ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

2. … the new spectacles just not feeling "right" ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

3. … your vision appearing different but it was difficult to say why ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

4. … problems with blurred distance vision; e.g. difficulty reading teletext pages or sub-titles on the TV ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

5. … problems with blurry near vision; e.g. reading a newspaper ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

With your new spectacles, how often did you experience...?

6. … words running together when reading ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

7. … objects appearing smaller than expected ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

8. … objects appearing further away ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

9. … objects appearing "tilted"; e.g. your desktop seemed to slope toward/away from you, door/window frames or your computer screen appeared to slope or tilt ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

Section II: Symptoms

We are only interested in knowing about symptoms experienced in the first few days and weeks with your new spectacles and not problems that were also present when wearing older spectacles.

With your new spectacles, how often did you experience...?

10. … a “swimmy” sensation or general feeling of motion sickness; e.g. like car or sea-sickness ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

11. … a feeling that your spectacles were “too strong” or “too powerful” ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

12. … a “pulling” or “drawing” sensation in your eyes; e.g. a sensation that your eyes were being pulled forward ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

13. … a need to blink a lot more than with your old spectacles ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

14. … your eyes feeling tired or strained or “heavy” ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

15. … a “motion-sickness” type feeling on moving around but your vision felt okay when seated ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

Section III: Activity limitations

We are going to ask you about things that you might have found troublesome in the first few days and weeks when wearing new spectacles and that might have caused some concern or worry at the time (these concerns have likely disappeared by now). We only want you to think about concerns that occurred when you started wearing your new spectacles.

When wearing your new spectacles, how much concern did you have…?

16. … about walking or moving around ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

17. … about being unsteady on your feet when standing ?

Don’t know / Not applicable	Never	Occasionally	Most/all of the time

When wearing your new spectacles, how much concern did you have…?

18. … about going up or down steps/stairs or kerbs ?

Don't know / Not applicable	Never	Occasionally	Most/all of the time

This is the end of the questionnaire

Thank you for assistance !

Please return it to the University of Bradford in the attached pre-paid envelope.

……
…….