Development of a Questionnaire to Measure Spectacle Dependence

A Thesis

Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of The Ohio State University

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The Ohio State University
2009

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Abstract

There have been numerous attempts in vision science to ascertain information through the use of a survey or questionnaire. Questionnaires need to be accurate and efficient in order to gather reliable information. In the present study, 31 subjects were recruited to take two surveys (the National Eye Institute Refractive Error Quality of Life (NEI-RQL-42) questionnaire and an original spectacle use and dependence questionnaire) at their first visit, then again at their second visit two weeks later. Between visits, subjects had their spectacles fitted with a temperature sensor to monitor spectacle wear. Data from the surveys for the two visits and data from the temperature sensors were compared using Bland-Altman analyses for repeatability and agreement. Analyses were performed to also assess the effect that the comfort or awareness of the temperature sensor strap had on the responses to the spectacle use and dependence questionnaire. When the responses to the spectacle use and dependence questionnaire from both visits were compared, some subjects provided inconsistent responses regarding how many hours they wear their spectacles. In addition, some subjects’ responses did not agree well with the data gathered from the temperature sensors. It was unclear if the comfort of the temperature sensor strap impacted the responses to the survey. Although spectacle dependence is a very important measurement, obtaining accurate data may be more difficult than anticipated.
Dedication

For Sheri: Eventually I hope to write something you’ll enjoy. I’ll dedicate that to you too.
Acknowledgements

Thank you to Dr. Melissa Bailey for all her hard work, patience, guidance and understanding. Thanks to Dr. Mark Bullimore for showing me that it’s possible to be laid back and pay attention to details. Thanks to all those involved in the Opt 7 program at The Ohio State University College of Optometry, I’ve loved learning here.
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FIELDS OF STUDY

Major Field: Vision Science
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Chapter 1: Introduction

1.0 Survey Use

All too often in health sciences, clinicians and researchers find a need in their respective fields of expertise to develop a new research tool. This pursuit can be carried out by experimentation, observation, or in some cases, by means of a survey or questionnaire.

A survey can obtain data from a sample of people representing a larger population by asking carefully targeted questions. The subjects’ answers can then be quantified for analysis, which will hopefully lead to the discovery of an unknown truth. Once this truth is discovered, there exists potential for its application. In the case of the present study, a survey was developed, administered, and validated to measure spectacle dependence and usage. This is an outcome not often measured in other vision science surveys. Surveys are familiar instruments and used often to find information. In ideal cases, they are simple, articulate, or easy to understand, and targeted for obtaining specific information. But not all surveys are ideal. Because of the appearance of simplicity in creating the instrument, a survey developer may be naïve as to what is necessary to make the survey simple, articulate, and accurate. This is a disadvantage of using questionnaires.
Surveys depend largely on the quality, not quantity, of the sample used to project the attitude of the larger population. If a sample of subjects is skewed in one way, the application of the information to the public may not give the desired result. Surveys are also vulnerable to quality of the questions. They need to be consistent; meaning that one person taking the same survey twice will be able to provide similar responses both times. They also need to direct the subject into answering the questions so that the responses provided will be helpful in unearthing the hidden truth[1].

1.1 Previous surveys used in vision science research

In the field of vision science many surveys have been developed. They are commonly created to investigate the quality of life after surgical procedures, with various eye diseases, or when corrected with various modes of refractive error correction. To address this need for evaluating quality of life, several surveys have been developed by the National Eye Institute; however, other surveys, such as the Refractive Status and Vision Profile (RSVP) and the Quality of Life Impact of Refractive Correction (QIRC) questionnaire have been developed by other independent groups. Although quality of life has been heavily assessed, none of these surveys have tried to determine how much time subjects have worn their glasses, which could be interpreted as their spectacle dependence. Another interpretation of spectacle dependence would be to determine which tasks require a subject to use his or her spectacles.
1.2 National Eye Institute Visual Function Questionnaire

Perhaps one of the older and most commonly used surveys is The National Eye Institute Visual Function Questionnaire (NEI-VFQ-25), which was designed to assess the effects on quality of life caused by the eye diseases most responsible for causing blindness in the United States[2]. It was also designed to determine if different common eye diseases produced similar problems with visual function. This list of diseases included macular degeneration, diabetic retinopathy, cataracts, glaucoma, and cytomegalovirus retinitis.

1.2.1 NEI-VFQ-25 design and development

A group of 246 participants were recruited for the development of the NEI-VFQ. They were divided up into twenty-six, condition-specific focus groups that were arranged geographically into five regions. These participants stated 2623 different problems related to their visual function. The most commonly noted problems were reading problems, followed by driving, then general problems with seeing clearly and mental health complaints caused by their vision. Problems were then carefully categorized and developed into well-worded questions. Questions allowed the patient to divulge the status of their quality of life in regards to his or her current ocular health condition. Subscales were developed and were scaled 0 to 100, with a score of 100 indicating the highest level of function. These subscales contained categories such as general vision, distance activities, and dependency on others.

As mentioned above, in the present study, questions concerning tasks performed which require glasses were used to evaluate spectacle dependence. Some tasks
specifically mentioned in the NEI-VFQ-25 were considered for the survey use in the present study. These tasks included: 1) watch a movie in a theater, 2) watch television, 3) play sports, 4) attend a sports event, 5) read a newspaper or magazine, 6) sewing, 7) use hand tools, 8) cook a meal, 9) use a telephone book, 10) read a street sign, and 11) recognize someone the subject knows across a street or large room. While the NEI-VFQ-25 was developed to measure the difficulty in performing these tasks, the present study targeted the necessity of glasses while performing these tasks. Instead of rating how difficult these things were due to quality of vision, subjects were asked how often they needed their glasses to complete the tasks.

1.2.2 Use of the NEI-VFQ-25 in vision science research

After using the NEI-VFQ-25 to study the effects of low vision due to any cause [3] or glaucoma [4, 5] on health-related quality of life in patients, this same survey was used to determine the effect on the quality of life years after subjects had episodes of optic neuritis[6]. It has been noted that many patients can recover from attacks of optic neuritis regaining 20/20 vision but may still experience changes in contrast sensitivity, color vision and other visual abilities[7]. This disparity between the commonly-measured visual acuity and other visual abilities warranted a further look into these patients’ quality of life.

During the Optic Neuritis Treatment Trial (ONTT), patients were given the NEI-VFQ-25 five to eight years after they entered the study. This study reported quality of life, as measured by the NEI-VFQ-25, and the manner in which the survey was related to clinical measurements of these patients. When compared to a group of disease-free
subjects, the ONTT subjects scored lower (less functioning) in most NEI-VFQ-25 subscales. A significant difference between the two groups was found in the subscales of distance activities, mental health, driving and peripheral vision. The correlations between clinical measurements and visual function were “moderate at best” ($r = -0.31$)[7].

In 2003, The Submacular Surgery Trials (SST) Research Group administered the NEI-VFQ-25 over the phone to over 200 people 12 and 24 months after they had enrolled in the study. These subjects had suffered loss of vision from choroidal neovascularization associated with age-related macular degeneration, oculohistoplasmosis, or any idiopathic cause. This research group was trying to determine if the NEI-VFQ-42 was capable of detecting changes in vision within individuals. Their findings indicate that it is sufficiently responsive to do this, as scores went down by 3.6 to 16.2 points (worse functioning) when associated with a 3-line decrease in visual acuity in the better seeing eye[8].

While this survey has been useful in assessing a variety of the diseases mentioned above, it was not used the present study. Walline [9] and co-workers published a study which indicated that the NEI-VFQ-25 would not be appropriate for the present study due to the fact that the participants in the present study had excellent vision with their refractive error corrected by glasses and/or contact lenses. In the study by Walline and co-workers, 218 subjects free of any ocular disease were given the NEI-VFQ-25 to see if it was sensitive enough to detect differences in quality of life based on method of refractive error correction. These subjects were corrected by rigid contact lenses, soft contact lenses, or spectacles. The researchers found that the NEI-VFQ-25 was not sensitive enough to distinguish significant differences in quality of life between the
refractive error correction groups. This was attributed largely to the fact that at least fifty percent of the subjects gave the highest score possible for six of the eleven subscales[9]. In addition to considering Walline and co-worker’s results, the NEI-VFQ-25 was also not used in the present study because it does not specifically address how often subjects wear a correction.

1.3 The Index of Visual Functioning (VF-14)

In 1994, before the NEI-VFQ-25 was created, a survey was developed to measure functional impairment caused by cataracts. This was called the VF-14[10]. The developers of this survey cited two studies [11, 12] when they reported that, “[Visual acuity] is an imperfect measure of visual impairment caused by cataract and hence is an inadequate measure alone of either the need for or outcome of cataract surgery.” They also mentioned the importance of assessing visual function through means more than through a simple measure of visual acuity. This idea of accessing information beyond what is typically clinically measured should apply as well to spectacle dependence.

While a correlation between best-corrected visual acuity or uncorrected visual acuity and the dependence of an individual on spectacles has not yet been shown, it is a relationship most clinicians formulate readily. Recently, factors such as a subject’s personality [13] have been associated with blur tolerance. While there are clear relationships between refractive error and visual acuity [14], these data on personality and blur tolerance suggest that spectacle dependence should be measured along with visual acuity in studies of refractive error correction, just as quality of life is measured along with objective measurements of vision and eye health in studies of eye disease.
1.3.1 VF-14 design and development

To develop the VF-14, three ophthalmologists were asked to identify all the activities doctors ask their patients when they are considering that patient for cataract surgery. The research group also used information from previous studies of functional assessment [11],[15, 16] and asked the ophthalmologists to review those studies for visual-function-related activities that could be affected by cataracts that they may have overlooked. Those items suggested by the ophthalmologists were then included in their initial list. This list was sent to a different panel of ophthalmologists and optometrists. These eye care professionals edited the list until the final set of activities was determined and questions assessing these activities were written. They included: (1) reading small print, (2) reading a newspaper or book, (3) reading large print, (4) recognizing people when they are close, (5) seeing steps, stairs or curbs, (6) reading traffic and other signs, (7) doing fine handwork, (8) writing checks, (9) playing games, (10) taking part in sports, (11) cooking, (12) watching television, (13) daytime driving, and (14) nighttime driving. Once again, the VF-14 is more appropriate for assessing quality of life in subjects with a particular disease; it does not assess spectacle dependence.

Two aspects of the design and development of the VF-14 are, however, relevant to the present study. First, we considered the list of activities in the VF-14 when selecting which tasks to include in the questionnaire designed for the present study. Second, the aspect of having knowledgeable experts review the content of the questionnaire for face validity purposes is an accepted [17] as described above, this technique was used to design the VF-14, and as described below, this technique was used in the present study.
A specific scoring scale was developed for the VF-14. For each question asked, a range of scores were possible. A score of four was given if the patient had no difficulty performing the task, then fewer points were rewarded if difficulty increased until finally a zero was given if they were unable to perform the task due to their vision. Their answers were averaged and then multiplied by 25 to give a total score between 0 (not able to do task because of vision) or 100 (no difficulty at all doing tasks).

An additional cataract symptom scale was developed where subjects were asked to quantify how much they were bothered by any of five symptoms common to cataract patients (double or distorted vision, seeing glare or halos around light, blurry vision, colors changes, vision worsening). They were asked to report if they were “very bothered” for whom a score of 3 was assigned, “somewhat bothered” received a score of 2, “a little bothered” was scored as 1 point, and if they weren’t bothered at all by that particular symptom, they received a score of 0 points. A total cataract symptom score of 0 on this scale indicated that the patient did not suffer from common cataract symptoms and a score of 15 was interpreted as the patient being very symptomatic. In the present study, we will trial several different scales/methods for having a subject estimate the amount of time he or she wears glasses. Once the best method for estimating spectacle use is determined, scales may be created. For example, one question asks subjects to report specific time frames spectacles are worn. Another question asks subjects to report the percentage of time they were spectacles.

In an assessment of the VF-14, the research group obtained responses from 766 patients and the scores on the VF-14 ranged from 12.5 to 100 (mean 75). Some patients (107) reported being affected in all activities, but they were not representative of the
entire patient sample. The researchers were able to determine that the VF-14 was better correlated with the patient’s self reported amount of trouble with vision \((r = -0.45)\) and satisfaction with their vision \((r = 0.34)\) than the Sickness Impact Profile \((r = 0.14\) and \(-0.9\) respectively), which is an instrument used for the assessment of a subject’s general health. The cataract symptom score was also highly correlated with VF-14 \((p<.0001)\)[10]. In conclusion, the VF-14 was found to be a reliable and valid instrument to measure the function of vision in relation to cataracts. Thus, the comparison of the VF-14 to other scales served to validate the survey. In the present study, because there are no other scales with which to compare, we will validate spectacle use survey data with data from a temperature sensor that will tell us when subjects are and are not wearing their spectacles.

1.4 National Eye Institute Refractive Error Quality of Life Questionnaire

Another questionnaire designed by the National Eye Institute (NEI) is called the Refractive Quality of Life (NEI-RQL-42)[18]. The need to study the effect of refractive error on quality of life was made apparent when it was discovered that the NEI-VFQ-25’s measures were unable to distinguish between an emmetrope not currently using refractive error correction and those who do need some type of refractive error correction, be it spectacles, contact lenses, or refractive surgery [19]. This was a significant deficit in the NEI-VFQ-14 because clinically important refractive error affects half of the United States population[20].
1.4.1 NEI-RQL-42 design and development

In order to determine the feasibility of developing a quality of life survey for issues related to refractive error correction, 52 focus groups in five geographically diverse regions were held for 414 patients. These patients wrote 9262 comments about their refractive error. These comments were then simplified into a number of constructs from which questions could be written. The constructs included topics such as near vision, distance vision, dark adaptation comfort, and ease of use, cost, and others. In the present study, we used experts and previous questionnaires to assist in the development of the questionnaire content, however, focus groups are also frequently used in the development phase.

 Eventually, the questionnaire developed into a 42-item survey specifying 13 subscales. These subscales are (1) clarity of vision, (2) expectations, (3) near vision, (4) far vision, (5) diurnal fluctuations, (6) activity limitations, (7) glare, (8) symptoms, (9) dependence on correction, (10) worry, (11) suboptimal correction, (12) appearance and (13) satisfaction with correction. Similar to the NEI-VFQ-25, a high score indicates no problems or a high quality of life and a low score indicates a very difficult problem or low quality of life. Although the developers of this survey did discuss and try to assess dependence on refractive error correction in one subscale with questions 13-16, the responses were qualitative. In the end there is no real measurable scale to determine how much an individual relies on their glasses, or another method to correct their vision. The questions only ask if spectacles are required for specific tasks. The duration of wear is not addressed.
1.4.2 Use of the NEI-RQL-42 in vision science research

McDonnell and co-workers (2003) used the NEI-RQL42 when they administered the survey before and after refractive-error-correcting surgery[21]. For this study the NEI-RQL-42 was administered to 175 myopes and 69 hyperopes at different sites. Subjects took the questionnaire at least 3 months before surgery and no more than 3 months after surgery. Higher scores were noted after surgery in 11 of 13 subscales. The most significant improvement seen in this sample of subjects was seen by both hyperopes and myopes in the categories that measure expectations of the patient, activity limitations, dependence on correction, appearance and satisfaction with correction. Improvement in clarity of vision was the same before and after surgery, but glare seemed to be worse after surgery[21]. All in all, the researchers were satisfied with the results of the NEI-RQL-42 and its measurement of change.

The NEI-RQL-42 has been used to assess many things since its creation. It was again used by McDonnell and co-workers [22] to evaluate presbyopia and its corrections, specifically monovision correction. Results were compared in two populations both older than 45 years old: one, an ametropic group which had their refractive error corrected by monovision contact lenses or surgery and the other, a group which was also ametropic not corrected with monovision but by other means. The monovision patients reported higher scores, improved quality of life, on 3 subscales (expectations, dependence on correction, and appearance) than those with single vision correction. Interestingly when compared to a group of emmetropes less than 45 years old, the quality of life in emmetropic patients older than 45 (with presbyopia) was worse. The emmetropes with presbyopia had reduced scores (lower quality of life) in 7 out of 13 subscales. These
lower scores were in the subscales such as near vision, dependence on correction, and vision satisfaction[22].

Although the investigators did try to assess refractive quality of life, if one wants to compare groups of patients based on how much time spectacles or other corrections are worn, the NEI-RQL-42 does not assess spectacle dependence in terms of time used in a day. The NEI-RQL-42 dependence questions address the need for glasses, bifocals, or magnifiers while reading something brief (like directions, a menu, or a recipe) or while reading something long (like a book, a magazine article, or the newspaper). But these questions may or may not be sensitive enough for to compare subjects for something like a cost/benefit analysis. More direct questions, like the ones used in the present study, such as “When I watch television I…always, often, occasionally, rarely, never…wear my glasses” is more applicable to the experience of patients and therefore more indicative of the level of a subject’s spectacle dependence.

1.5 The Refractive Status and Vision Profile

The Refractive Status and Vision Profile (RSVP) was developed to measure functional status and quality of life in individuals with refractive errors[23]. In this survey, forty-five questions are asked. The answers to these questions are used to calculate subscale scores in 8 categories. These subscales are then rescaled to a 100-point scale and higher scores indicate a larger problem/reduced quality of life. The subscales are: 1) concern, 2) expectations, 3) physical and social functioning, 4) symptoms, 5) driving, 6) optical problems, 7) glare, and 8) problems with corrective lenses.
1.5.1 RSVP design and development

Initially, items for the survey were gathered from a review of questions found in previously published questionnaires. These items were then taken to focus groups of eye care professions and individuals with refractive error, and then the questions were revised. In developing an instrument to measure spectacle dependence, a similar starting point would be necessary. Using questions that were previously written to investigate correction type and usage, and then taking them to professionals to ensure that the question is able to capture the relevant information, is a commonly-used strategy for developing a survey. The RSVP questionnaire was given before and 2-6 months after surgery, subjects were also asked to rate their satisfaction with vision, concern about their vision and overall health on a 5 point scale. For each item, subjects were to respond and rate the subject presented according to difficulty, bother, or frequency. All items had five possible responses. They were coded 1 through 5, and 5 represented the greatest or most frequent trouble. Again, the sum was then taken and rescaled to a 0 to 100 scale for scoring.

1.5.2 Use of the RSVP in vision science research

The RSVP’s performance was evaluated by its developers when they assessed patient outcomes after refractive surgery[24]. The results of this study showed that an 33% of patients reported to be dissatisfied or very dissatisfied with their vision preoperatively, and only 15% reported the same level of dissatisfaction after surgery. Also, 68% of those dissatisfied or very dissatisfied before surgery were satisfied or very satisfied after surgery. Interestingly, although individuals had good Snellen acuity
outcomes, lower scores on the subscales driving (29.5%), glare (16.3%) and others were found after refractive surgery[24]. The questionnaire was self-administered before and after bilateral refractive surgery. The results of this study showed that the RSVP score correlated with a change in vision and was very sensitive to the change produced by the refractive surgery. The developers also claimed that low scores on the subscales of physical functioning and optical problems before surgery were indications of a poor outcome after surgery[24].

To assess the reliability and validity of the instrument, the RSVP was used in a comparison study with the NEI-RQL-42[25]. Nichols et al, recruited 81 subjects and gave them both the NEI-RQL-42 and the RSVP on 2 occasions. The internal consistency differed between the two surveys as did the test-retest reliability. The authors’ ultimate conclusion was that both surveys were adequately reliable and valid, but in choosing one over the other, an individual must consider the content of the survey. Prior to his comparison study of the NEI-RQL-42 and RSVP, Nichols[25, 26] and colleagues assessed the performance of the RSVP in a contact lens clinical trial. When the RSVP was given 3 times, to 50 contact lens wearing subjects, scores much lower than those reported by the developers of the survey were found on five out eight subscales, including the overall score. In conclusion, Nichols and co-workers state that the RSVP may not be the ideal quality of life instrument to use in a population of contact lens wearers. This is likely due to the fact that the questionnaire was developed largely on a population that had undergone refractive surgery. This outcome illustrates an important detail in developing surveys. It is important to remember that when assessing refractive
error status and dependence on its correction, the instrument used to do so should be sensitive towards all refractive error correction types.

The RSVP did make an attempt to measure spectacle dependence directly by asking the patients how many hours glasses were used for looking at distance or for reading (if a different pair was used for reading). A similar approach to capture the amount of spectacle use was made in the present study. Other than these two RSVP questions, a quantitative measurement of spectacle dependence was overlooked. The investigators focused most questions on difficulty with common tasks or bother from common symptoms. The survey did pursue an avenue of spectacle dependence when subjects were asked “How bothered are you by losing/looking for glasses?” Unfortunately the answer to this question is probably not solely determined by need for glasses, but by personality, refractive error, and visual acuity.

1.6. The Activities of Daily Vision Scale (ADVS)

Developed in 1992, the Activities of Daily Vision Scale (ADVS)[27] was one of the first surveys developed. It was designed as a method for the evaluation of visual function in subjects with cataracts.

1.6.1. ADVS design and development

The researchers selected 20 activities and categorized them into five subscales. These subscales included: 1) distance vision, 2) near vision, 3) glare disability, 4) night driving and 5) daytime driving. The activities selected such as recognizing friends and reading newspapers are activities not unique to the cataract population. These can also be
performed by those in spectacles, or other methods of refractive error correction. The relationship of these activities to spectacle usage may provide information on the subject’s dependence on their refractive error correction. Each subscale in the ADVS was scored from 100 (no difficulty) to 0. The researchers found a correlation between vision loss and the ADVS (-0.37) when it was administered in person and a correlation of -0.39 when the survey was given over the phone. The authors concluded that their instrument was reliable and valid enough to measure a patient’s perception of impairment.

This ADVS Scale was assessed again by Pesudovs et al. This time the analysis was done using the Rasch method[28]. Using this form of analysis for the ADVS, the author noted that although the ADVS had undergone careful validation previously using widely accepted methods, the survey showed signs of inadequacy when assessed by Rasch analysis. The data from the ADVS showed that the questions were not distributed normally, some contained ceiling effects and others had empty response categories. Pesudovs then shortened the ADVS trying to shape it to fit the analyses and provide better precision and decrease the disparity between patient ability and item difficulty, but this version was still not ideal. To improve the problems found in the ADVS, more questions would need to be included. Pesudovs then went on to create his own questionnaire to measure quality of life, the QIRC.

1.7. The Quality of Life Impact of Refractive Correction questionnaire

The Quality of Life Impact of Refractive Correction (QIRC) questionnaire was created to quantify quality of life in patients with refractive error corrected by spectacles, contact lenses, or refractive surgery[29].
1.7.1. QIRC design and development

Through literature review with both professional and lay focus groups the author and his colleagues developed a 90-item questionnaire that was then whittled down to a 20-item quality of life survey from pilot data gathered from 306 subjects. The 20 questions developed for the survey discussed subjects such as vision, safety, health concerns and also appearance and/or aesthetics of their method of correction. After using traditional methods accompanied by Rasch analysis to develop the questionnaire, Pesudovs concluded that the QIRC questionnaire, which quantifies people with refractive error according to their mode of correction, was shown to be valid and reliable for those subjects in pre-presbyopic age group. Although the QIRC is reliable and valid, the survey does not address spectacle dependence as a separate entity that may influence quality of life. It does ask the patient to report the amount of time of correction usage and asks patients to consider separately contact lenses and spectacles. The QIRC does go into more particular detail when asking subjects to report spectacle usage including questions addressing self-image; however, it addresses activities in a manner similar to that of previous surveys mentioned. The QIRC asks the subject to report difficulty and trouble performing certain tasks and not their need for using spectacles while performing those tasks. Thus, spectacle dependence is not fully addressed.

1.8. The Quality of Vision (QOV) Questionnaire

Brunette and co-workers set out to develop a “valid, reliable and easy-to-administer instrument to assess patient satisfaction and perceived outcome after bilateral excimer laser photorefractive keratectomy”[30, 31].
1.8.1. QOV design and development

To create the QOV, the developers selected questions used in the Prospective Evaluation of Radial Keratotomy (PERK) and the Index of Visual Functioning (VF-14). From the samples of these two instruments, seven scales were created which included: 1) global satisfaction, 2) quality of uncorrected vision, 3) quality of corrected vision, 4) quality of night vision, 5) glare, 6) daytime driving and 7) night driving. Once the survey was validated and deemed reliable, with a Cronbach’s $\alpha$ coefficient greater than or equal to 0.83, this instrument was self administered to 690 patients to measure patient satisfaction in myopic post bilateral PRK. The vast majority (91.8%) of patients were satisfied or very satisfied with their surgery, and 96.3% felt their main goal had been reached. Through the use of this instrument, the researchers found that the degree of satisfaction was proportional to the postoperative uncorrected LogMAR visual acuity in the best eye ($r = -0.18$) and negatively correlated with the importance of corneal haze ($r = -0.23$). Most patients noted an increase in daytime glare (55.1% of 690 patients), and close to $1/3$ reported a decrease in night vision and increased difficulty driving at night because of their vision [30]. Like many other surveys discussed above, spectacle use was not measured in this survey.

1.9 Are some surveys not validated in development?

At times, there are surveys that are not validated. One example is the study of Castanon Holguin [32] done in Mexico where children were given free glasses. Between 4 and 18 months after the initial visit, the children were observed by
researchers to see if they complied with wearing their glasses. This survey was a simple two question survey. If they did not wear them, they were asked if they had them and to identify 1 of 13 reasons for not wearing the spectacles. The list of 13 reasons came from pilot data showing most common causes of noncompliance. Perhaps a validated survey could be more useful in determining the amount of non compliance, or trends in decreasing non compliance, rather than simply categorizing patients in wear/non-wear categories based on researchers observation of that specific day.

Another survey in which validation of the questions was overlooked was used in a study of quality of life in patients who received bilateral implantation of asymmetrical diffractive multifocal intraocular lenses (IOLs)[33]. Patients were given modified monovision refractive error correction with multifocal IOLs and then asked about post-surgery spectacle usage. Frequency of spectacle usage was 20% (5 patients) for distance. Eighty percent reported no use of spectacles at all, and that included spectacle use for reading vision. Again, it may have been beneficial to have a validated survey available to measure the amount of spectacle usage. There may be a relationship between amount of time glasses are used after surgery and overall quality of life or patient satisfaction that due to the lack of investigation of spectacle dependence, was overlooked.

1.10 Why is it necessary to develop another survey?

Patterns in human behavior are difficult to discover. Currently there is no validated survey that addresses quantitatively the amount of spectacle dependence and
the tasks that require spectacle wear. With an instrument developed to obtain a measurement of hours per day of spectacle usage, one could accurately determine the amount, not just the quality of dependence. An instrument designed to capture the amount of spectacle dependence would need to undergo a process of development and validation much like other surveys before it.

1.10.1 Methods for questionnaire development

Before the survey is administered to study subjects, a group of eye care professionals must assess the questions for face validity. Once the questions are deemed as practical and have the appearance of accuracy, the test may then be administered to a sample of individuals that fit specific inclusion criteria. Answers from these questions may then undergo a variety of statistical analyses to determine the repeatability, correlation, or the agreement of the survey’s questions.

1.10.2 Statistical analyses

Many studies propose correlation as a method to measure agreement. In 1986, however, Bland and Altman suggested a more accurate method citing that “correlation (r) measures the strength of a relation between two variables, not the agreement between them.” They also wrote that “repeatability is relevant” to agreement because “if one method has poor repeatability—i.e., there is considerable variation in repeated measurements on the same subject—the agreement between the two methods is bound to be poor too.” [33]
1.11 Uses for a spectacle dependence survey

An instrument of this kind would be useful in many areas of vision science. With current advancements in the development of intraocular lens implants, the goal in cataract surgery is not only to remove a cataract and restore vision, but to restore vision to such a degree that patients once obligated to glasses no longer need them. A survey designed to measure spectacle dependence would tell if this surgical goal has been achieved, and it could be administered annually or biannually to assess the longevity and/or perhaps the quality of the treatment.

The same could be said for successes in post-LASIK patients. Again, the goal of LASIK is to have the patient discontinue use of their current refractive error correction. Understandably, the patients that fail to achieve absolute emmetropia may not feel that the surgery was indeed successful. For these patients, knowledge of how many of them are wearing glasses, for how long, how often, and for what type of activities would be valuable to evaluate the patients’ quality of life and the cost-effectiveness of the surgical procedure. Results from a study designed to obtain quantitative measurements for spectacle dependence may further support the importance of absolute accuracy and long-term stability in LASIK surgery.

Refractive error correction by spectacles is the standard of care for treating amblyogenic anisometropia. Often, a full time wear schedule is prescribed. Compliance is often monitored solely by the improvement in visual acuity during a certain period of time[35]. With a valid survey that measures spectacle dependence and usage, compliance with glasses wear schedule may be measured to determine if the patient is following the doctor’s treatment plan.
Similar to that of amblyopia, glasses with bifocals are needed for accommodative problems. The clinician could monitor spectacle usage throughout the lengthy process involved with vision therapy as patients with binocular vision problems improve. Finally, with the measurements obtained from a spectacle dependence survey, a doctor might be able to see if more hours of spectacle use lead to a decrease in quality of life with one of the many quality of life surveys like the NEI-RQL-42 or QIRC.

In addition, a severe amount of dependence on glasses may be an indication to change the modality of refractive error correction. For example, if the first thing a patient does when he or she wakes up is put their glasses on and the last thing he or she does when he or she goes to sleep is take them off, perhaps an eye care provider should consider a change to contact lenses or refractive surgery. Still, one also might consider the appropriateness of refractive error correcting surgeries in some patients if postoperatively they return to preoperative levels of spectacle usage.

The Aims of this study were to develop a questionnaire to measure spectacle usage/dependence then assess it for repeatability and validity with face validity and other statistical tests comparing it to a standard of wear obtained by a temperature sensor.

The need for such an instrument is apparent. In the following sections, the development, methods of application, and analysis of a survey designed to measure spectacle usage and dependence will be discussed.
Chapter 2: Methods

2.0 Methods

For this study, 31 subjects, 5 male and 26 female were recruited at The Ohio State University College of Optometry and were either faculty, staff, students or their dependents. Subjects were recruited through mass email and flyers located in patient/clinic areas in between the fall of 2006 and spring of 2008. To be included in the study, patients needed to be willing and have the ability to complete a survey on two separate occasions and wear a temperature sensor for two weeks on their glasses. The subject’s glasses needed to be made from a prescription that was written within the last year. Subjects must have worn their glasses for at least one hour on at least three days per week. Other grounds for exclusion from the study included: any current ocular disease, previous ocular surgery, or best-corrected visual acuity worse than 20/40.

At the beginning of the initial appointment, patients were reminded of exclusion and inclusion criteria, and the researcher verified that all these requirements were satisfied. Patients were given a privacy policy pamphlet regarding the HIPAA standards adhered to by The Ohio State University. Patients were informed that they would be able to withdraw from the study at any time. Tenants of the declaration of Helsinki were
followed in recruiting, research, and data analysis. Approval was given by the Institutional Review Board at The Ohio State University. Patients gave their informed consent to participate in the study. Identification numbers were used instead of patient names to protect subject privacy.

Distance visual acuities were measured for each eye using a high-contrast Bailey-Lovie visual acuity chart at 20 feet. Non-cycloplegic autorefraction was performed on each eye using a Grand Seiko WR-5100K binocular autorefractor. The mean of ten measurements was used as a starting point for a subjective refraction. Subjective refraction was performed by the same individual (AB) using a Marco RT-300(-) phoropter. After the subjective refraction, patients completed two surveys, the National Eye Institute Refractive Error Quality of Life questionnaire (NEI-RQL-42) self-administered format July 2001; Version 1.0 and our original survey (see appendix A).

Subjects completed the original survey on a desktop computer using the software program Ultimate Survey Enterprise (Edition Version 3.09 Copyright, 2006. Prezza Technologies, Inc). The questions were developed by three researchers who are also eye care practitioners. Questions were investigated and assembled from previously published surveys concerning activities performed with glasses and the amount of time wearing glasses. These questions were then evaluated by the three eye care professionals/researchers to assess the face validity of the questions.

Prior to leaving the first appointment, patients had their spectacles fitted with a SL51 I-sensor temperature monitoring device purchased from signatrol.com. The sensor was a round disk (17 mm in diameter and 6 mm thick), and weighed 4 grams. This sensor had a temperature range of −40° Celsius to 85° Celsius, and it was programmed to take a
temperature reading every three minutes until reaching maximum data storage capacity (2048 measurements). Then the sensor would cease measuring temperatures. The sensor was capable of making a measurement every three minutes for 17 days, more than enough time for a subject to complete the study. One sensor was placed inside a small nylon sleeve which was then glued on to a Hilco elastic strap used to secure spectacles in place. When the strap was in place the sensor rested on the skin over the mastoid process of the skull. Before the study, the apparatus was worn by the researcher and others to determine if it would be sensitive enough to detect a change from ambient temperature to skin temperature. This was done for both inside and outside, during summer, conditions. It was shown that the peaking of the temperature had a distinct appearance (as seen in figure 2) and that these peaks differed from the temperature produced by the subject’s surrounding environment.

Figure 1. Picture of Sensor Apparatus
Subjects were told to have the sensor in contact with their skin, but not to have the strap on too tightly to avoid discomfort. They were instructed to wear this device whenever they were wearing their glasses. If a subject had two pairs of glasses, they were told to put the apparatus on the pair of spectacles that they would be wearing. Once a good, comfortable fit was established and the patient educated on how to use the sensor/strap apparatus, each subject was given a one page log on which they could record their spectacle usage and a brief description of their activities. Patients were required to keep the apparatus on their glasses for a period of two weeks, after which they returned for their second appointment. At the end of the two week period, the patient returned the sensor and took the same two surveys again. This time, when the subjects completed the Spectacle Use and Dependence survey, they answered two additional questions regarding the comfort of the strap and changes in the awareness of their spectacle usage.
2.1 Preparation of sensor and questionnaire data for statistical analyses

Data from the temperature sensors was used as the control in some of our agreement tests with estimators received from the spectacle dependence questionnaire. In 5 subjects the graph data showed temperature peaks which physiologically impossible. These peaks had a unique appearance much more different than those seen during times of wear. This data was removed in order to not confound the estimation of spectacle usage with the temperature sensors. Also, due to the fact that we were not able to extrapolate a full day of wear time from a part day wear time, half days, such as when the subjects began and terminated the study, were removed. A common temperature needed to be determined as the initiation of the on time with the sensors. This temperature was
29 degrees Celsius or 84 degrees. The researchers felt this was an appropriate
temperature and would not cut off a significant amount of time as the sensors warmed
from ambient temperature to achieve peak skin temperature. With these adjustments a
total time in hours of spectacle wear was gathered from the temperature sensors

Questions 4 through 7 required the subjects to submit a time that they either put
their glasses on or took them off on weekdays and days during the weekend. They were
instructed to enter an AM or PM time indicator. For subjects who took their glasses off at
midnight, we received times of both 12:00 AM and 12:00 PM on the questionnaire. The
data from the sensors clearly indicated that these subjects did not sleep all night with their
glasses on. So for subjects who said they put on their glasses at 8:00 PM, for example,
and removed them at 12:00 PM, the response was changed to 12:00 AM. Future
researchers who use these questions should consider providing instructions to the subjects
about using “AM” to indicate 12:00 midnight and “PM” to indicate 12:00 noon. After
these changes were made, to further promote ease in the statistical analysis process, time
values were changed to military time with 24:00 representing 12:00 AM.

Certain subjects were excluded from analysis due to discontinuity of responses.
Three subjects (1817, 1818 and 1830) did not answer question number 3 which asked,
“Do you wear your glasses: a) all day long, b) just part of the day” the same way at both
visits. The survey was designed to skip questions 4-7 based on how they responded to
question number 3. If the subject answered “all day long,” to question number 3, then
they moved onto question number 8. The answer, “just part of the day,” allowed them to
answer the questions concerning what time they had their spectacles on/off during days
of the week/weekend. These three subjects answered question 3 differently on their
second visit, and therefore they could not be included in the analyses related to the repeatability or agreement of question 3 or questions 4-7. Also because of this question a subject which answered “all day long” and was not able to answer questions 4-7 were not available for the analyses of Total Reported Time.

2.2 Statistical Analyses

2.2.1 Between-visit repeatability for questions regarding spectacle use

In order to assess the between-visit repeatability of the questions regarding how many hours a subject wears his or her glasses for one week, there were two ways to estimate total time of spectacle wear. They were: 1) Total Reported Time and 2) Percent time. These estimates are configured using the responses to the following survey questions:

Total Reported Time = Q1 X (ΔQ4 and Q5) + Q2 (ΔQ6 and Q7)
Percent Time = (Q12/100) X 24 X 7

For each of the two estimates of total time, a Bland Altman (BA) analysis of repeatability was performed to compare the data from the two visits. The difference between the two responses from each session was calculated with the above formulas for each subject. The mean of the differences between the repeated measurements (i.e., the difference between visits) characterizes the bias of the measurement method. This mean of the differences was compared to zero using a one-sample t-test to determine whether the bias was statistically significant. The mean of the differences and the standard deviation of the differences were used to construct 95% limits of agreement (LoA) (mean ± [1.96 times
the SD). The LoA characterize the expected difference between repeated measurements. The breadths of these LoA indicated the repeatability of the technique. The closer the LoA are to the zero, the more repeatable the technique.

These data were plotted on difference vs. mean plots. The relationship between the mean of the values being compared and the difference between those values is a useful one. The value of the mean cannot stand alone and sustain significance. One must know the values from whence the mean came in order to determine validity or in this case repeatability. For example if one student scored a 100% on test and a 68% on another, the final grade for that student (or the mean) is 84%. But another student may obtain the same final grade by receiving an 85% and an 83% on the same two tests. This example illustrates the importance of knowing not only the mean, but the difference between the values used to obtain that mean, in determining consistency.

2.3 Validity of questions regarding spectacle use

A Bland Altman analysis of agreement was performed to compare the values of Total Reported Time and Percent Time from the second study visit to the data from the temperature sensors. The breadth of the 95% LoA indicates the agreement between instruments. The narrower the limits of agreement are, the better the two measures agree.

For each subject, 14 days of his or her sensor information were used after removing the first and last day of data because those days were partial days of data. These partial days occurred because on the first day of data collection, only data after the study visit were available and on the last day of data collection, only data before the study visit were available. If more than 14 days of data were available, because of how a
subject’s visits were scheduled, only the last 14 days were used. Only the last 14 days of sensor data were used in such cases because the data from the temperature sensors was compared to the questionnaire data from the second visit, and some questions ask the subjects about their behavior over the course of the last two weeks.

The mean number of hours of spectacle use per day for a weekday was computed using the temperature sensor data as obtained by the methods explained previously, as were the mean number of hours per day for the weekend. The subject’s average hours per week were calculated to be:

A) Sensor Total Weekend Hours = 2 X (Avg. hours/day during weekend)
B) Sensor Total Weekday Hours = 5 X (Avg. hours/day during week)
Total Week hours = A + B

2.4 Between-visit repeatability for task-specific spectacle dependence

There are 29 questions in the questionnaire that ask for the level of spectacle dependence for certain tasks on a five point scale. These are questions Q13-A to Q13-Z, and Q16-18. There are 2 questions, Q10 and Q11, that ask for near and far quality of vision without glasses which also use a five point scale. We performed analyses which focus on these 30 questions and the repeatability of responses to these questions across the two visits. In some cases, there are missing data because subjects reported doing an activity at one of the visits, but did not report doing that activity at the other visit. The analyses are limited to questions that had responses from at least 25 subjects at both visits. The repeatability of the questions was assessed by a correlation of responses given at visit 1 and responses given at visit 2. Between-visit repeatability is indicated by a Spearman rank order correlation coefficient. The Spearman is analogous to the more
common Pearson correlation coefficient, but is more appropriate for ordinal responses [36]. The p-value was from a test of the hypothesis that the correlation is 0. Based on the size of the correlations, the null hypothesis was rejected for each of the questions. A Bland Altman analysis wouldn’t be used in this case because of the ordinal nature of the data. A Bland Altman test for repeatability requires continuous data.

2.5 Analyses of the effects of the study itself on responses to the questionnaire

Two questions in the survey were designed for use only during the development of the questionnaire. Question 19 asks the subject “How comfortable/uncomfortable was the strap and sensor you wore on your glasses for the last two weeks? Very comfortable, comfortable, neither comfortable nor uncomfortable, uncomfortable, very uncomfortable.” Question 20 asks the subject to state how much more/less they noticed their glasses in the last two weeks. Their options were much more, slightly more, the same as before the study, slightly less, much less. Total Reported Time was used to investigate the possibility of subjects changing their behavior because it was found to have the best between-visit repeatability and to agree the most with the temperature sensor data. The change in time is defined as the Total Reported Time from visit 1 subtracted from the Total Reported Time from visit 2. We also fitted multiple regression models of change in Total Reported Time at visit 1 with comfort and awareness as predictors. We controlled for Total Reported Time at Visit 1. We checked for the possibility of an interaction between comfort and awareness and looked at models with only comfort or only awareness as predictors.
Chapter 3: Results

3.0 Summary Statistics

Of the 31 subjects recruited for the study, 5 were male and 26 female. The mean age of the sample was 25.5 years old with a SD of 3.9 years with an age range from 22 years old to 42 years old. Multiple ethnicities were represented in the study. Of all 31 subjects, 23 were Caucasian, two were Asian, two were Hispanic, two were African American, one Middle Eastern, and one Asian Indian. Of all subjects, 93% were myopic with ranges of refractive error from −0.25 D to −10.00 D. One subject was hyperopic, and another subject had antimetropia (one eye being hyperopic and the other myopic).

Table 1 summarizes the values captured for spectacle use by the three methods used in this study. As mentioned above some subjects were removed from the sample due to inconsistent answers as to whether they wore their glasses part of the day or all day. Percent time and Total Reported Time had very similar means and ranges. These values give us an estimate that subjects wore their glasses about 2 hours a day according to the sensors and about 4 to 4.5 hours a day according to the spectacle dependence questionnaire.
Table 1. Time measurements of weekly spectacle usage

<table>
<thead>
<tr>
<th>Measurement</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensors (hours/week)</td>
<td>27</td>
<td>14.9</td>
<td>15.1</td>
<td>1.0</td>
<td>67.3</td>
</tr>
<tr>
<td>Total Reported Time (hours/week)</td>
<td>27</td>
<td>30.6</td>
<td>30.3</td>
<td>1.0</td>
<td>114.8</td>
</tr>
<tr>
<td>Percent Time (hours/week)</td>
<td>27</td>
<td>33.8</td>
<td>25.0</td>
<td>6.7</td>
<td>100.8</td>
</tr>
</tbody>
</table>

3.1 Between-visits repeatability analysis of total time variables

The repeatability of Total Reported Time and Percent Time are reported in Table 2. The values for coefficient of repeatability and mean of the differences for the two methods are similar. It is important to address the fact that our third measurement technique, the temperature sensors, is absent from table 2. This is due to the fact that we only obtained one series of measurements from the sensors. An interesting artifact of this process is seen in the column of mean of the differences. All values are a negative value; this indicates that many subjects gave a larger value for either Total Reported Time or Percent Time on the first visit. Due to the variability of answers we can conclude that the mean of the differences between the two methods may be zero (t value=−0.56, p value 0.581).
<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean of the Differences</th>
<th>Standard Deviation of the Differences</th>
<th>95% Limits of Agreement</th>
<th>Coefficient of Repeatability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td>Lower Bound</td>
<td>Upper Bound</td>
</tr>
<tr>
<td>Total Reported Time</td>
<td>25</td>
<td>−4.2</td>
<td>−15.9</td>
<td>+7.4</td>
<td>28.2</td>
</tr>
<tr>
<td>Percent Time</td>
<td>31</td>
<td>−11.8</td>
<td>−22.6</td>
<td>−0.9</td>
<td>29.6</td>
</tr>
</tbody>
</table>

**Table 2.** Bland-Altman analysis of the two estimates of total time of spectacle use

Figure 2 is a difference versus mean plot for Total Reported Time. Visual inspection of the graph shows that as the mean of total reported time from the two visits increases, the difference between the two values also increases. This trend in the graph shows the potential for a possible relationship; that as people wear their glasses more, they may be less accurate at reporting the amount of time they wear them.
A similar trend is noted for the value of Percent Time in Figure 3. Those who wear their spectacles less often seem to have provided more repeatable estimates of spectacle use. Also the value of the mean of the difference is negative, which means that the subjects reported a greater amount of time and visit 1 then changed that amount at visit 2. This could be due to the fact that more people were paying attention. Although the estimates at Visit 2 do not agree with the temperature sensor data as will be shown, it is possible that they are getting closer to the actual amount after two weeks of paying closer attention to their spectacle usage.
Table 3. Agreement of spectacle use estimates with data from temperature sensors
3.2 Agreement between measures of total time and temperature sensor data

Table 3 shows the results of a Bland-Altman analysis of agreement between Total Reported Time or Percent Time and the temperature sensor data. Subjects tended to overestimate their reported time compared to spectacle usage as measured by the temperature sensors. The level of agreement with the temperature sensor data and Percent Time or Total Reported Time was similar.

Table 4 shows that the values of Total Reported Time and Percent Time are moderately correlated. The highest correlation ($R^2 = 0.5$) was found between Total Reported Time and the temperature sensor data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total Reported Time</th>
<th>Percent Time</th>
<th>Sensor Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Reported Time</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Time</td>
<td>0.45 *</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sensor Hours</td>
<td>0.51 **</td>
<td>0.38 *</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4. Correlation table for estimators of spectacle usage

Sample size=27: Key: * $p$ $\leq 0.05$; ** $p$ $\leq 0.01$

We compared the estimates Total Reported Time and Percent Time from the report at the second visit to the data from the temperature sensors to determine the validity of the questionnaire responses. The analyses are limited to the 27 subjects with sufficient data from Q1, Q2, and Q4-7 to compute Total Reported Time. Figure 4 illustrates the within-subject variability for the difference between Total Reported Time, Percent Time and the temperature sensor data. There were a number of subjects with
questionnaire responses that agreed well with temperature sensor data, for example subjects 2 and 10. In contrast, some subjects reported values for Total Reported Time or Percent Time that differed from the temperature sensor data by 80 hours or more, i.e., subjects 24 and 1. This variability may be due to things such as non-compliance to the required tasks. It’s also possible that some subjects removed the strap because of comfort and thought a small amount of time would not be noticeable by the study. That our standard of temperature sensors has a degree of measurement error, and 29 degrees removed more data than though is a possibility as well.

![Graph]

**Figure 5.** Summary of individual subject’s values for Total Reported Time from Visit 2, Percent Time from Visit 2 and Temperature Sensor Data
Figures 5 and 6 are difference versus mean plots comparing Total Reported Time and Percent Time to temperature sensor data. These two illustrations demonstrate yet again, that some subjects’ responses agreed well with temperature sensor data, and other subjects’ responses did not agree well.

**Figure 6.** Bland Altman Difference versus Mean Plot: Total Reported Time vs. Temperature Sensor Data
Figure 7. Bland Altman Difference versus Mean Plot: Percent Time versus Temperature Sensor Data

Table 5. weekday and weekend hours for Total Reported Time and Temperature Sensors

<table>
<thead>
<tr>
<th>Variable Hours</th>
<th>Sample Size</th>
<th>Mean</th>
<th>STD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Sensors: weekday hours</td>
<td>27</td>
<td>11.3</td>
<td>11.0</td>
<td>0.8</td>
<td>44.6</td>
</tr>
<tr>
<td>Temperature Sensors: weekend hours</td>
<td>27</td>
<td>3.7</td>
<td>5.0</td>
<td>0.0</td>
<td>22.7</td>
</tr>
<tr>
<td>Total Reported Time: weekday hours</td>
<td>27</td>
<td>22.2</td>
<td>23.6</td>
<td>0.8</td>
<td>83.8</td>
</tr>
<tr>
<td>Total Reported Time: weekend hours</td>
<td>26</td>
<td>8.8</td>
<td>10.1</td>
<td>0.3</td>
<td>32.5</td>
</tr>
</tbody>
</table>

3.3 Weekday hours compared to weekend hours and temperature sensor data

Below, Tables 5 and 6 report values that will aid in the analysis of agreement between two methods of estimating spectacle use, but at different times during the week.
<table>
<thead>
<tr>
<th>Analysis</th>
<th>N</th>
<th>Mean of the Differences</th>
<th>95% confidence interval</th>
<th>Standard Deviation of the Differences</th>
<th>95% Limits of Agreement</th>
<th>Coefficient of Repeatability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Weekday vs. Sensors</td>
<td>27</td>
<td>10.9</td>
<td>2.7</td>
<td>19.1</td>
<td>20.6</td>
<td>−29.6</td>
</tr>
<tr>
<td>Weekend vs. Sensors</td>
<td>26</td>
<td>5.3</td>
<td>1.4</td>
<td>9.21</td>
<td>9.7</td>
<td>−13.7</td>
</tr>
</tbody>
</table>

Table 6. Bland Altman analysis of agreement between Total Reported Time for weekday hours or weekend hours and temperature sensor data

Table 5 shows the mean of the value for Total Reported Time for weekdays or weekends is nearly double the amount reported by the temperature sensor for the same time period. A trend similar to that discussed earlier is found again in Figures 7 and 9. It appears that those subjects that had the greatest difference between their reported values on the survey and the sensor data were the ones that self-reported a large amount of weekday wear. These subjects, as noted in Figure 8, included subjects five, six, nine, 11, and 24. Interestingly, among these subjects, all but number six reported a greater amount of spectacle usage on the survey than was recorded with the temperature sensor. Conversely, subject six underreported spectacle usage.
Figure 8: Bland Altman Difference vs. Mean Plot: Total Reported Time for weekday Hours vs. weekday Temperature Sensor Data
Figure 9: Summary of individual subject’s values for Total Reported Time for weekday hours and Temperature Sensor Data

Previously, it was mentioned that there was one subject, number six, who reported no values when asked about weekend wear, i.e., questions 6 and 7. This is the reason for a sample size of 26 in Figure 10. Also, Figure 9 shows the trend of over reporting by some subjects. Twenty out of the 27 subjects had higher Total Reported Time for weekend hours compared to that measured by the temperature sensors.
Figure 10: Bland Altman Difference Versus Mean Plot: Total Reported Time for weekend hours vs. Temperature Sensor Data
3.4 Between-visit repeatability of questions related to spectacle dependence for specific tasks

Table 7 provides the repeatability as indicated by the Spearman rank-order correlation coefficient. For all 13 questions, correlations between visit 1 and 2 were generally high and statistically significant. With the exception of one of the questions, which was: “Have you looked at an alarm clock within the last two weeks,” the correlations for these activity questions were greater than 0.8. Descriptive summaries of repeatability for individual subjects are provided in Tables 8 through 19. For each question, a table details the distribution of the responses for Visits 1 and 2. For example, the table for Calculator Agreement, Table 8, indicates that 11 subjects responded with a 1
or that they always need to wear glasses at both visits, while one subject responded with a 4 (rarely) at Visit 1 and a 2 (often) at Visit 2.

<table>
<thead>
<tr>
<th>Activity performed in last two weeks</th>
<th>Spearman Correlation Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used a calculator</td>
<td>0.89</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Looked at an alarm clock</td>
<td>0.62</td>
<td>0.0005</td>
</tr>
<tr>
<td>Used a computer</td>
<td>0.81</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Cooked a meal</td>
<td>0.90</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Distance vision without glasses</td>
<td>0.84</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Drive during the day</td>
<td>0.88</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Drive at dusk</td>
<td>0.99</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Use glasses for looking at far away</td>
<td>0.92</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Up close vision without glasses</td>
<td>0.81</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Drive at night</td>
<td>0.90</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>See a street sign</td>
<td>0.83</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Watch TV</td>
<td>0.99</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Table 7: Spearman correlation coefficients for task-specific questions related to spectacle dependence. A significant p-value means that there was agreement between visit one and visit two.

Table 9 is an example of a question where one can see a wide distribution of responses that is responsible for a lesser correlation (0.62). Eleven subjects at the initial visit responded in as always needing their glasses, yet at the second visit only six gave the same response. Three subjects selected as “never” needing to wear glasses at visit 1 and again at visit 2.
<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>11</td>
</tr>
<tr>
<td>Often</td>
<td>.</td>
</tr>
<tr>
<td>Occasionally</td>
<td>1</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

Table 8: Calculator Agreement (N = 27)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>14</td>
</tr>
<tr>
<td>Often</td>
<td>2</td>
</tr>
<tr>
<td>Occasionally</td>
<td>1</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

Table 11: Cook a Meal Agreement (N = 29)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>6</td>
</tr>
<tr>
<td>Often</td>
<td>2</td>
</tr>
<tr>
<td>Occasionally</td>
<td>2</td>
</tr>
<tr>
<td>Rarely</td>
<td>4</td>
</tr>
<tr>
<td>Never</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 9: See Alarm Clock Agreement (N = 28)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>22</td>
</tr>
<tr>
<td>Often</td>
<td>2</td>
</tr>
<tr>
<td>Occasionally</td>
<td>1</td>
</tr>
<tr>
<td>Rarely</td>
<td>2</td>
</tr>
<tr>
<td>Never</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 12: Day Driving Agreement (N = 31)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>11</td>
</tr>
<tr>
<td>Often</td>
<td>4</td>
</tr>
<tr>
<td>Occasionally</td>
<td>4</td>
</tr>
<tr>
<td>Rarely</td>
<td>1</td>
</tr>
<tr>
<td>Never</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 10: Computer Use Agreement (N = 30)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>25</td>
</tr>
<tr>
<td>Often</td>
<td>.</td>
</tr>
<tr>
<td>Occasionally</td>
<td>1</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

Table 13: Dusk Driving Agreement (N = 31)
<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>17</td>
</tr>
<tr>
<td>Often</td>
<td>3</td>
</tr>
<tr>
<td>Occasionally</td>
<td>.</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

**Table 14:** Distance Vision w/o Spectacles Agreement (N = 31)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>24</td>
</tr>
<tr>
<td>Often</td>
<td>1</td>
</tr>
<tr>
<td>Occasionally</td>
<td>.</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

**Table 15:** Distance Spectacle Use Agreement (N = 31)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>26</td>
</tr>
<tr>
<td>Often</td>
<td>.</td>
</tr>
<tr>
<td>Occasionally</td>
<td>.</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

**Table 16:** Night Driving Agreement (N = 31)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>3</td>
</tr>
<tr>
<td>Often</td>
<td>1</td>
</tr>
<tr>
<td>Occasionally</td>
<td>.</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

**Table 17:** Near Vision w/o Spectacles Agreement (N = 31)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>20</td>
</tr>
<tr>
<td>Often</td>
<td>1</td>
</tr>
<tr>
<td>Occasionally</td>
<td>.</td>
</tr>
<tr>
<td>Rarely</td>
<td>1</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

**Table 18:** See a Street Sign Agreement (N = 28)

<table>
<thead>
<tr>
<th>Visit 1</th>
<th>Visit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>21</td>
</tr>
<tr>
<td>Often</td>
<td>.</td>
</tr>
<tr>
<td>Occasionally</td>
<td>.</td>
</tr>
<tr>
<td>Rarely</td>
<td>.</td>
</tr>
<tr>
<td>Never</td>
<td>.</td>
</tr>
</tbody>
</table>

**Table 19:** Watch TV Agreement (N = 27)
Contrasting the results from the alarm clock question to the results of another with a higher correlation shows how repeatable some questions are compared to others. Table 13 shows the responses for the question “When I drive my car at dusk I ____ need to wear my glasses.” Again a response of 1 indicates always, and 5 indicates never having to need them. The only inconsistency with this question shows that on visit 1, one subject responded with answer 4, or that they “rarely need to wear their glasses” for driving their car at dusk. The graph shows that this subject changed from rarely needing to wear their glasses, to never having to wear them.

3.5 The effect of strap comfort and spectacle awareness on subjects’ responses to questions regarding spectacle use

Two questions, Q19-20, asked about the comfort of the elastic strap and temperature sensor. The purpose of these questions was to investigate if comfort was related to a change in the amount of time wearing glasses between the first and second visits. For this analysis, time of spectacle wear is estimated by Total Reported Time. Change in time is defined as the Total Reported Time from Visit 1 subtracted from the Total Reported Time from Visit 2. The distribution of changes in scores is given in Figure 11. Nearly 80% of the patients either did not change their Total Reported Time between visit 1 and visit 2 or the change in Total Reported Time was 10 hours or less. The remaining 20% were different by a large amount, 30 to 60 hours. Sixty hours during this study represented 17.8% of the total 2 week period, or 2.5 days.
Figure 11: Distribution of the difference in Total Reported Time between visit 1 and visit 2

Table 15 provides the distribution of responses to the two questions, as well as the average value of change in Total Reported Time for each response level. The table is limited to subjects with complete data. There does not appear to be a trend in change in Total Reported Time as a function of comfort level. With question 19 and 20, patients were to indicate which level of comfort or awareness they had experienced within the last two weeks. One point on the comfort scale indicated that the strap was very uncomfortable, and a 5 indicated that it was very comfortable.
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td>1 – Very Uncomfortable</td>
<td>1</td>
<td>−3.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 – Uncomfortable</td>
<td>12</td>
<td>−0.1</td>
<td>40.1</td>
</tr>
<tr>
<td></td>
<td>3 – Neither</td>
<td>7</td>
<td>−10.6</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>4 – Comfortable</td>
<td>5</td>
<td>−5.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Awareness</td>
<td>3 – Same as before</td>
<td>2</td>
<td>−12.8</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>4 – Slightly more than before</td>
<td>16</td>
<td>−2.2</td>
<td>27.9</td>
</tr>
<tr>
<td></td>
<td>5 – Much more than before</td>
<td>7</td>
<td>−6.6</td>
<td>34.5</td>
</tr>
</tbody>
</table>

**Table 20:** The mean change in Total Reported Time for the various responses to the comfort and awareness questions

Table 21 summarizes the regression model p-values and estimates for Total Reported Time at visit 1, comfort and awareness. Only Total Reported time at visit 1 is statistically significant. When a potential interaction between comfort and awareness was investigated it was found to be not statistically significant (p=0.9). Models with only comfort or only awareness showed no predictors and found no statistically significant comfort or awareness effects.

<table>
<thead>
<tr>
<th>Effect</th>
<th>p Value</th>
<th>Parameter Estimate</th>
<th>Lower CL</th>
<th>Upper CL</th>
<th>R Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td></td>
<td>46.9</td>
<td>−79.3</td>
<td>173.1</td>
<td>0.32</td>
</tr>
<tr>
<td>Total Reported Time: Visit</td>
<td>0.006</td>
<td>−0.6</td>
<td>−1.0</td>
<td>−0.2</td>
<td></td>
</tr>
<tr>
<td>Comfort</td>
<td>0.2</td>
<td>−8.9</td>
<td>−24.6</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Awareness</td>
<td>0.9</td>
<td>−1.9</td>
<td>−24.9</td>
<td>21.0</td>
<td></td>
</tr>
</tbody>
</table>

**Table 21:** Multiple regression results for change in Total Reported Time for comfort of the sensor and strap

52
4.0 Discussion

The role of spectacle dependence in the quality of life and care of patients is becoming increasingly more interesting to the vision science community. In January 2008, George O. Waring commented on the long-awaited, 10-year long-term safety data on Laser in Situ Keratomileusis (LASIK) surgery[37]. He sighted multiple studies published by Jorge Alió in the same issue of the *American Journal of Ophthalmology* in his editorial[38-41]. These studies discussed the 10-year follow up for patients treated with LASIK who had up to −10 D of myopia, and it also discussed those with high myopia. Photorefractive keratectomy (PRK) 10-year follow up reports were also published for those patients who had more or less than −6 D. Alió and his associates reported that after LASIK in patients with less than 10 D of myopia, 73% of 97 eyes were within ± 1.00D and 89% were within ±2.00 D[40]. For those patients with less than 6 D of myopia treated with PRK (225 eyes) 75% were ±1.00 D and 92% were ±2.00D[38]. After citing that 55% of eyes that had less than 10D and treated with LASIK or less than 6 D and treated with PRK, were within ± 0.50 D[38, 40], Waring closed his editorial by stating, “Unfortunately, Alió and associates did not report the use of optical correction after surgery—a most important outcome[37].”
Surely with the refractive ranges reported by Alió, there would have been some subjects that would have to return to spectacle or contact lens wear to obtain adequate visual acuities after LASIK or PRK. Although spectacle dependence truly is “a most important outcome,” it may be harder to obtain an accurate measurement than initially thought. Evidence for this difficulty comes from the results from the present study. In Table 2, the coefficients of repeatability were 55.2 hours and 58 hours for Total Reported Time and Percent Time, respectively. If we assume that subjects sleep for seven hours in a 24 hour period, this coefficient of repeatability represents 3.2 days of daytime spectacle wear or 23% to 24% of the total time. The question then arises; why are the responses to these questions so variable for some subjects?

4.1 Memory

Recall definitely has an impact on the questionnaire responses from a subject. An event such as putting on your glasses in the morning or taking them off at night is not monumental. People are capable of recording seemingly frivolous details before or during important events. This is why people often talk about what they were doing when Pearl Harbor was attacked, or when the World Trade Center fell. Because of the significance of these events, precision is common. In contrast, the regular morning hygiene routine is just that, routine. In order to recall events, as mentioned by Ross and Conway [42], we can see things differently as time goes on, always “reinterpreting and re-explaining our pasts.” We also forget. “We forget, and we fill in the gaps in memory by inferring what probably happened.” [42]
Memory is not only influenced by the significance of an event, but as Ross and Conway explain, it is also influenced by the attitude of the individual, routines, beliefs, personality, desired self-perception, and desired perception by others. It’s difficult to know if two weeks is too short of a time for all these variables to have an effect on an individual’s memory, but one can assume that it is likely.

4.2 Question Type

Another potential cause for obtaining poor coefficients of repeatability is due to the type of questions asked. Commonly, the decision to wear spectacles is based on the activity performed and not on the time at which it will be performed. This would likely influence the quality of subject recall on glasses use. For example, a patient might find it easier to answer the question “What kind of things do you use your glasses for?” as opposed to a question like “What time do you put your glasses on in the morning?” If we are to assess quantitatively the amount of spectacle dependence, a repeatable time value is needed. Perhaps one way around this problem is to ask a logical progressive series of questions such as: 1) What activities do you always wear your glasses for 2) How long does this activity usually take? Support for this approach may come from the data in Table 7 which shows the between-visit correlation of activity questions. Correlations for similar questions used in the NEI-RQL-42 also support this approach[19]. These questions are much more repeatable than the questions 1, 2, 4-7 or questions 12 on the questionnaire, based on the statistical analyses.
4.3 Spectacle awareness and comfort of the strap and temperature sensor

As Table 20 shows, 23 out of 25 subjects reported being more aware of their glasses during the two weeks that they wore the sensor apparatus. Although the data do not support this, it is possible that awareness may have had influenced a decrease in the amount of spectacle wear, and therefore inaccurate sensor data. It is easy to believe that those who typically wear glasses more often would be more likely to switch to contact lenses during the two weeks while the strap was attached to their glasses, if they had a problem with the comfort of the sensor and strap.

Another possibility is that discomfort from the strap influenced wear time and produced skewed sensor values which did not compare well to survey data. In the present study, 13 subjects out of 25 (52%) reported the strap to be uncomfortable (12), or very uncomfortable (1). It is possible that some subjects simply removed the strap and did not comply with study protocol. Shortly after each subject finished the two week session, they were asked casually by the researcher how the strap felt, most replied kindly and indifferently. About a year later, when the comfort of the strap was mentioned again to some of the subjects, most subjects’ memories of the strap were negative and unpleasant. It would be worth repeating an investigation of the repeatability of the Spectacle Use and Dependence Questionnaire in another sample of subjects who take the survey, do not have a sensor attached to their glasses, and then return in two weeks and complete the survey again. This may aid in ultimately deciding if the strap’s presence interfered with the subjects’ reports of the time they put their glasses on or took them off, what percentage of the day they wear them, and/or compliance with the temperature sensor and strap.
4.4 Similar approaches in health care.

This approach of monitoring device usage through sensors is not novel to this study. Headgear is a device often used to correct overbite and/or crooked teeth. In 1976, a “timing headgear” was designed with a watch battery and small circuit to record the amount of time that a patient wore their device. Northcutt, the original publisher, also made efforts to create a predicted rate of progression based on his device[43]. This idea has been extrapolated to other orthodontic devices including, most recently, “Smart Retainer”[44] which has a sensor embedded in the plastic to record various oral ambient measurements and then produce a graph that the doctor may use to illustrate compliance to the patient as well as prescribe further usage.

4.5 Limitations of Study

A significant limitation in investigating spectacle usage in our sample was the concurrent use of contact lenses with spectacles. Because of subjects such as these it is important to not confuse the results of the hourly estimator analyses with dependence on refractive error correction. Eventually with a valid and repeatable method for measuring spectacle usage we could find out more about subjects that use glasses with contact lenses, but that’s for another time. Also, when considering agreement we were limited to the accuracy of our temperature sensor data which was deemed as the standard. Some diary data was available and it may be advantageous to investigate the agreement between sensors and diary data.
Another limitation is that it is difficult with the current set of data to determine if comfort and awareness played a factor, one could expect that to happen based on the pattern between visit 2 reports being lower than visit 1 results. In order to cancel this effect we could administer the spectacle dependence questionnaire again without the use of the sensor strap and test again for repeatability. Changes would need to be made in the wording of the questions as well. In order to obtain complete data sets all patients should answer questions 4 through 7 instead of those that replied that they wore their glasses “just part of the day”. In addition better instructions on AM/PM usage for midnight should be given and even perhaps a pull down menu could be used in selecting times to prevent entry error on the part of the subject. It would also benefit the subjects if we were to specify percentage of waking hours in question 12.

4.6 Conclusion

Because spectacle usage is a “most important measurement,” estimates of the amount of wear time that accurately indicate spectacle dependence are worthy of further pursuit. This measurement would provide invaluable insight into the life of a patient, which a clinician could use to alter treatment plans to make the spectacles fit the patient’s needs. In addition, this measurement will also be very valuable in future studies of the economics of refractive surgery procedures, including LASIK and accommodating intraocular lenses.
References


Appendix A: Spectacle Dependence Questionnaire

1) How many days during the week (Monday through Friday) do you wear your glasses at some point during the day? *(Check one)*
   - 0 days
   - 1 day
   - 2 days
   - 3 days
   - 4 days
   - 5 days

2) How many days during the weekend (Saturday and Sunday) do you wear your glasses at some point during the day? *(Check one)*
   - 0 days
   - 1 day
   - 2 days

3) Do you wear glasses *(check one)*
   - All day long (Skip to question #8)
   - Just part of the day

4) What time do you usually put your glasses on during the week (Monday through Friday)? *(Please enter the time followed by am or pm. For example 6:45 am)*

5) What time do you usually take your glasses off during the week (Monday through Friday)? *(Please enter the time followed by am or pm. For example 6:45 am)*
6) What time do you usually put your glasses on during the week (Saturday and Sunday)?
(Please enter the time followed by am or pm. For example 6:45 am)

7) What time do you usually take your glasses off during the week (Saturday and Sunday)?
(Please enter the time followed by am or pm. For example 6:45 am)

8) In an average day in the last two weeks, how many hours per day do you think you wore your glasses for looking at near?
(Please enter only the number of hours)

9) In an average day in the last two weeks, how many hours per day do you think you wore your glasses for looking far away?
(Please enter only the number of hours)

10) Without my glasses, my vision for looking at near is
(Mark one)

    Very Good
    Good
    Fair
    Poor
    Very Poor

11) Without my glasses, my vision for looking far away is
(Mark one)

    Very Good
    Good
    Fair
    Poor
    Very Poor
12) During an average day, what percentage of time in the day do you wear glasses?
(Please us a number between 0% and 100%. Ex: 
0% = I do not wear glasses, 100% = I wear glasses all day)
13) From the following list of activities, please place a check mark in the box next to the activities you have done in the last two weeks

- Watched a movie in the theater
- Watched television
- Played sports
- Attended a sports event
- Played a musical instrument
- Read a newspaper or magazine
- Read a book or novel
- Played video games (either on a video system or computer)
- Played/worked outside
- Sewing
- Used hand tools
- Cooked a meal
- Used a telephone book
- Checked the time on an alarm clock
- Read a price tag
- Read a street sign
- Read a recipe
- Use a calculator
- Write a check
- Read a menu
- Recognize someone I know across a street or large room
- Used a computer
- Read a spreadsheet on a computer
- Connect electrical wires
- Write a paper or report
- Take a test
13-A to 13-Z) When I *(computer program inserted each task marked from the list above)*, I *(Mark one)*

- Always need to wear my glasses.
- Often need to wear my glasses
- Occasionally need to wear my glasses
- Rarely need to wear my glasses
- Never need to wear my glasses

14) When I am doing activities where I need to look far Away, I *(Mark one)*

- Always need to wear my glasses.
- Often need to wear my glasses
- Occasionally need to wear my glasses
- Rarely need to wear my glasses
- Never need to wear my glasses

15) Have you driven a car in the last two weeks *(Mark one)*

- Yes
- No *(Stop Now)*

16) When I drive my car during the day, I *(Mark one)*

- Always wear my glasses.
- Often wear my glasses
- Occasionally wear my glasses
- Rarely wear my glasses
- Never wear my glasses
- Not applicable, I do not drive a car during the day

17) When I drive my car at dusk, I *(Mark one)*

- Always wear my glasses.
- Often wear my glasses
- Occasionally wear my glasses
- Rarely wear my glasses
- Never wear my glasses
- Not applicable, I do not drive a car during dusk
18) When I drive my car at night (*Mark one*)

Always wear my glasses.
Often wear my glasses
Occasionally wear my glasses
Rarely wear my glasses
Never wear my glasses
Not applicable, I do not drive a car at night

19) How comfortable/uncomfortable was the strap and sensor you wore on your glasses for the last two weeks?

Very Comfortable
Comfortable
Neither comfortable nor uncomfortable
Uncomfortable
Very Uncomfortable

20) In the last two weeks, do you think there is a difference in how much you noticed your glasses compared to before the study?

Yes, I noticed my glasses much more than usual in the last two weeks
Yes, I noticed my glasses slightly more than usual in the last two weeks
No, I think the last two weeks were the same as before the study
Yes, I noticed my glasses slightly less than usual in the last two weeks
Yes, I noticed my glasses much less than usual in the last two weeks