Université de Montréal

Understanding the Use of Head-Mounted Displays by Individuals with Low Vision: The case of eSight

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Thèse présentée en vue de l'obtention du grade de Philosophiae Doctor (Ph.D.)

en sciences de la vision, option basse vision et réadaptation visuelle

Décembre 2019

Université de Montréal

École d'optométrie

Cette thèse intitulée

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Résumé

Les dispositifs permettant d'agrandir les images représentent les formes les plus courantes d'aides en réadaptation visuelle. Grâce à un essor technologique considérable, les lunettes électroniques, qui fonctionnent comme des aides grossissantes électroniques (fournissant un agrandissement variable, amélioration du contraste, utilisables les mains libres), sont devenues d'avantage disponibles, efficaces et utilisées par les personnes malvoyantes. Cependant, il existe un manque de données probantes et de connaissances au regard des taux d'abandon des lunettes électroniques, des facteurs prédictifs de leur utilisation, ainsi que sur les interventions efficaces qui pourraient optimiser leur utilisation.

Afin de mieux comprendre l'utilisation des lunettes électroniques au sein de la population malvoyante, une étude en trois phases a été menée à travers l'exemple des lunettes eSight dans le but de : 1) examiner et synthétiser les facteurs qui influencent l'utilisation d'aides visuelles grossissantes à l'aide d'un examen de la portée afin de guider les études ultérieures; 2) déterminer à travers une étude transversale quelles sont les variables qui prédisent un changement d'utilisation des lunettes électroniques chez leur usager; et 3) élaborer des recommandations fondées sur des données probantes concernant la faisabilité d'une intervention de téléréadaptation auprès des utilisateurs de lunettes électroniques et étudier l'impact de cette modalité sur l'utilisation de leur dispositif et leur qualité de vie.

Les travaux de cette thèse contribuent à soutenir l'idée que le choix d'utiliser des aides visuelles grossissantes dépend de causes multifactorielles. Les facteurs personnels et surtout la motivation représentent des prédicteurs importants. Les difficultés de transport et le manque d'entrainement ont été identifiés comme des obstacles importants à l'utilisation des aides visuelles. D'autre part, l'amélioration de la qualité de vie favorise le maintien de l'utilisation des lunettes électroniques. Compte tenu de ces résultats, un programme de formation personnalisée par téléréadaptation a été mis au point pour répondre aux besoins spécifiques des utilisateurs, offrant une attention individualisée pour optimiser l'utilisation des lunettes électroniques. Cette thèse fournit des preuves sur la faisabilité d'administrer plusieurs sessions d'entrainement en réadaptation de basse vision via la téléréadaptation chez des utilisateurs de lunettes électroniques. Les lunettes électronique eSight améliorent la qualité de vie et la vision fonctionnelle des

utilisateurs, qu'elle soit associée à la téléréadaptation ou au programme d'autoformation du fabricant. Cela indique que les instructions fournies par la téléréadaptation ou par l'autoformation proposée dans un contexte commercial sont tout aussi efficaces pour améliorer la qualité de vie et les capacités visuelles et que la téléréadaptation pourrait être offerte comme une modalité de formation allternative. Afin d'orienter les recommandations de pratiques fondées sur des données probantes en matière de téléréadaptation, et de répondre au mieux aux besoins des personnes avec une basse vision, d'autres études examinant les effets de la pratique et de l'entrainement sont nécessaires.

Mots-clés : basse vision, réadaptation, aide technologique, aide visuelle, lunettes électroniques, téléréadaptation, compliance, adoption, abandon.

Abstract

Magnification devices are among the most common forms of aids in low vision rehabilitation. They are intended to increase the level of independence and function during activities of daily living. Novel head-mounted display magnification devices for low vision that operate as electronic vision enhancements (providing variable magnification, contrast enhancement, hands-free use) have become more and more available, efficient and are increasingly being utilized, thanks to considerable technological development. Nevertheless, there is still a lack of knowledge regarding abandonment rates, factors predicting abandonment of such devices, and efficient intervention characteristics that optimize their use.

To better understand the use of head-mounted displays throughout the low vision population, a three-phase study has been conducted using eSight Eyewear as an example device in order to: 1) investigate and synthesize barriers and facilitators influencing the use of magnifying visual aids, using a scoping review to guide the subsequent cross-sectional and prospective studies; 2) identify which variables best predict a change in device use among current head-mounted display users, using a cross-sectional design; and 3) develop evidence-based recommendations regarding the feasibility of a telerehabilitation intervention on head-mounted display users and study the impact of this modality on their device use and quality of life.

This thesis provides supporting evidence for the multifactorial decision-making process around the use of magnifying visual aids. Device users' low motivation, transportation to rehabilitation services and insufficient training have been identified as important barriers to magnifying low vision aid use. Improving users' quality of life helps to maintain the use of head-mounted displays. Considering these findings, a personalized training regime via telerehabilitation was developed to meet specific users' needs, providing individualizing attention to optimize the use of head-mounted displays. This thesis provides evidence about feasibility of administering several low vision rehabilitation training sessions via telerehabilitation with head-mounted display users. eSight Eyewear, either with telerehabilitation or with the manufacturer self-training standard, improves quality of life and functional vision outcomes. This indicates that instructions provided by telerehabilitation or though the eSight self-training standard are equally successful in improving quality of life and visual abilities outcomes and that telerehabilitation

could be provided as an alternative training modality. To help guide evidence-based practice recommendations for low vision telerehabilitation implementation that meet the unique needs of individuals with low vision, further studies examining benefits of practice and training are needed.

Keywords: visual impairment, rehabilitation, assistive technology, low vision aid, head-mounted display, telerehabilitation, compliance, adherence, abandonment.

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ADL : Activities of daily living

AT : Assistive technology

CCTV : Closed-circuit television

EVES : Electronic Vision Enhancement Systems

HMD : Head-mounted display

ICF : International Classification of Functioning, Disability and Health

LV : Low vision

LVA : Low vision aid

PIADS : Psychosocial Impact of Assistive Devices Scale

QoL : Quality of life

QUEST : Quebec User Evaluation of Satisfaction with Assistive Technology questionnaire

VA LV VFQ-48 : Veterans Affairs Low Vision Visual Functioning Questionnaire 48

WHO : World Health Organization

Au Dr. Jean Martinazzo, mon grand-père,
qui a su cultiver en moi le goût d'apprendre
et qui demeure une source majeure d'inspiration.

« Quel moissonneur de l'éternel été,
Avait, en s'en allant, négligemment jeté
Cette faucille d'or dans le champ des étoiles. »

Victor Hugo.

Remerciements

Ce projet de thèse a été possible grâce au soutien de nombreuses personnes. Je tiens tout d'abord à remercier mon directeur de thèse, Dr. Walter Wittich, pour m'avoir donné l'opportunité de travailler sur ce projet de recherche sous sa supervision. Je le remercie pour sa confiance accordée, sa généreuse disponibilité, et son appui indéfectible qu'il m'a témoigné au cours de mon programme pendant ces quatre dernières années. Ses qualités humaines et son expertise dans le domaine de la réadaptation et de la déficience visuelle ont fait lui un directeur d'exception.

J'ai été chaleureusement accueillie au sein de son laboratoire et remercie chaque membre de cette brillante équipe. Je remercie Natalie, ma camarade de travail et amie, qui a été tout au cours de ce programme une source considérable d'inspiration sur le plan académique et personnel. Je remercie Jonathan, Norman, Karine, Andrea, Anni, Atul et Gabrielle qui ont fait de cette aventure doctorale un moment mémorable. J'ai eu beaucoup d'enthousiasme à travailler avec chacun d'entre eux dans cet environnement privilégié au sein duquel la créativité, la performance et la bienveillance sont indissociables. Je remercie tous celles et ceux qui ont contribué de près ou de loin à ce projet, qui ont croisé mon chemin et qui m'ont encouragée.

Je tiens à remercier les organismes de recherche et de financement qui ont permis la réalisation de ce projet. Notamment, le Centre de Recherche Interdisciplinaire du Montréal Métropolitain, Mitacs, la compagnie eSight, la fondation En Vue de l'Institut Nazareth et Louis-Braille, et la fondation de l'Institut National Canadien pour les Aveugles. Je remercie tout particulièrement Rob Hilkes et le Dr. Brian Mech pour avoir rendu possible ce trait d'union avec l'industrie et joué un rôle essentiel pour le recrutement de nos participants. Je remercie également l'ensemble de nos participants qui nous ont généreusement accordé du temps pour ce projet.

Je remercie chaleureusement le Dr. Aaron Johnson pour sa disponibilité et ses conseils en matière d'analyses statistiques, ainsi que Claire Fréchette qui a embarqué avec enthousiasme dans ce projet et qui a su conquérir la confiance de nos participants. Je remercie vivement Patrice et Nancy pour leur disponibilité et soutien lors de mes recherches bibliographiques. Je remercie le Comité de jury de mon examen de synthèse, les Drs. Julie-Andrée Marinier, Jean-Marie Hanssens et Aaron Johnson, pour leurs conseils qui m'ont permis d'affiner ce projet de recherche dès ses phases initiales. Je remercie par avance le présent Comité de jury de thèse, les Drs. Olga Overbury, Caroline Faucher et Philippe Archambault pour l'évaluation académique de ce projet. Je ne peux oublier les Professeurs Christian Hamel et Yves Matillon qui ont su entretenir ma curiosité pour la recherche au cours de mes années de formation à Lyon et qui m'ont encouragée sans réserve à traverser l'Atlantique pour vivre l'aventure du doctorat.

Je remercie les communautés étudiantes, auxquelles je suis fière d'appartenir et au sein desquelles j'ai grandi tout au long de ce parcours. Leur soutien m'a permis de repousser mes limites pour mon projet de recherche et de vie. Merci, chères associations étudiantes du *CRIR*, et des *Cycles Supérieurs de l'École d'optométrie*. J'ai une pensée particulière pour l'ingénieuse et unique communauté *Thèsez-vous* pour ces innombrables heures de rédaction productives accomplies ensemble lors des retraites urbaines et organisées dans des contrées plus reculées.

Pour terminer, je remercie Mathieu pour son soutien essentiel et l'intérêt qu'il a porté à chaque étape de ce parcours. Merci d'avoir accepté de courir ce marathon à mes côtés et de ne pas t'être échappé en cours de route ! Je remercie mon amie Pauline, une de mes ferventes supportrices depuis mes débuts. Enfin, je remercie mes très chèrs parents, ma famille et mes amis pour leurs encouragements et leur support inconditionnel, reçus depuis les bords de la mer Méditerranée jusqu'aux rives du fleuve Saint-Laurent. Merci.

INTRODUCTION

Low vision - Description of the condition

The World Health Organization (WHO) estimates that approximately 2.2 billion people live with some form of distance or near vision impairment, including blindness and low vision (LV), as it is globally prevalent across the lifespan [1]. The International Classification of Diseases 11th Revision [2] classifies vision impairment into two groups, distance and near presenting vision impairment. It was estimated that 826 million people live with a near vision impairment [3]. With regards to distance vision, 188.5 million have mild vision impairment, 217 million have moderate to severe vision impairment, and 36 million people are blind [4]. The WHO provides definitions of impairment (i.e. loss of psychological, physiological or anatomical structure or function), disability (i.e., restriction or lack of ability to perform an activity) and handicap (i.e., difficulty in fulfilling a normal life role) [5]. On the functional level (disability aspect), there is consensus that LV is defined as mild or moderate visual impairment that is not correctable with glasses, contact lenses, or surgical intervention, and interferes with normal everyday functioning [6]. However, there is no generally accepted definition for LV that combines both functional vision (describes how the patient functions in vision-related activities) and visual function (describes how the eye/visual system functions) dimensions [7]. Most definitions are based on an estimate of visual loss in terms of impairment, using visual function measures (impairment aspect), such as visual acuity or visual field, or in terms of disability (measuring the ability to perform a certain task). The WHO has established criteria for LV which are used in the International Classification of Diseases [2]. LV is defined as a best-corrected visual acuity worse than 0.5 logMAR (Snellen fraction equivalent of 6/18 or 20/60) but equal to or better than 1.3 logMAR (6/120 or 20/400) in the better eye, or visual

field loss corresponding to less than 20 degrees in the horizontal or vertical plane in the better eye with best possible correction. Blindness is defined as a best-corrected visual acuity worse than 1.3 logMAR or a visual field no greater than ten degrees around central fixation in the better eye with best possible correction. In the United States and Canada, the definition of legal blindness is defined as having a visual acuity of 1.0 logMAR (6/60 or 20/200) or worse in the better eye. For example, in Quebec, eligibility for access to LV devices is defined as a best-corrected visual acuity worse or equal to 0.5 logMAR, or central visual field loss corresponding to less than 60 degrees in the horizontal or vertical plane, or loss of a complete half of the visual field [8].

LV is a global concern that is likely to become more meaningful as average lifespans increase in many countries. Population growth and ageing will expand the risk that more people acquire vision impairment. Specifically, with diseases like diabetic retinopathy, the number of individuals with LV is expected to increase significantly by 2030 [9]. In industrialized countries, older adults (75+ age group), constitute the fastest growing segment of the population with LV[10,11], whereby visual impairment has been ranked third, after arthritis and heart disease, among conditions that cause people older than 70 years to require assistance in activities of daily living (ADL) [12]. In the United States, 3.5 million people older than 40 years of age are affected by LV, making it the tenth most prevalent cause of disability [13, 14]. Age-related eye diseases such as age-related macular degeneration, diabetic retinopathy, glaucoma and cataracts are leading causes of visual impairment in the United States [15, 16] and Canada [17]. Degenerative diseases of the retina can lead to deteriorations and dysfunctions of retinal areas and, in particular, of the macula (i.e., the portion of the retina responsible for central vision and the distinction of fine details) causing the perception of visual field defects that can often seriously compromise peripheral and/or central vision [18, 19]. The types of vision impairments associated with LV include reductions in visual

acuity, loss of contrast sensitivity, central scotomas (i.e., profound central field loss), peripheral visual field loss, metamorphopsia (i.e., distorted vision), oscillopsia (i.e., unstable vision), slow glare recovery, photophobia and night blindness. Often, individuals with LV have combinations of these impairments. Given the severity of the symptoms, LV interferes with normal everyday functioning and requires to be supported. LV rehabilitation is the primary intervention for individuals with LV.

Low vision rehabilitation process: provision and training in the use of assistive devices

LV is associated with well identified adverse outcomes including increased challenge with daily activities, an increased likelihood of social isolation and depression and reduced life expectancy [20]. Visual impairment adversely affects educational and employment opportunities, leading to precarious economic situations [21]. More precisely, in degenerative diseases of the retina, scotomas in the central visual field considerably challenge reading performance [22]. In a self-adaptive mechanism, many individuals with a central visual field defect can develop eccentric fixation (i.e., modification of the gaze direction) at a preferred retinal locus (i.e., intact region of the retina) away from the area of dystrophy [23, 24]. However, this new healthy retinal area has lower resolution than a healthy fovea and, therefore, requires magnification to reach the same level of functional ability. One major goal of people with central visual field deficit is to improve their ability to read text [25]. One of the main methods of achieving such improvement can be attained through the provision of and training in the use of low-vision aids (LVAs), a non-therapeutic approach that can attenuate the effects of the visual impairment without correcting the physiological causes of the disease [26].

LV rehabilitation represents the primary intervention for individuals with chronic, disabling visual impairment [27]. The goal is to improve ADL of individuals with reduced visual function by optimizing the use of their remaining sight through the provision of appropriate refractive correction, training in the use of vision assistive equipment and compensatory strategies [28]. The vision rehabilitation process typically includes the prescription of vision assistive equipment and the provision of training in the use of LVAs. Indeed, enhanced LVAs often function best at very close working distances that are perceived as unusual for the users and require education, training, practice, and skill reinforcement. Vision rehabilitation also includes other vision rehabilitation services, such as orientation and mobility training, psychological counseling and/or occupational therapy [28, 29].

Enhanced LVAs are less efficient with individuals with age-related macular degeneration exhibiting large central visual field defects when reading with binocular vision. After a training period, individuals with LV may develop the ability to use their peripheral areas of the retina efficiently [30, 31] while using their LVA. Many people with different types of untreatable eye diseases require visual rehabilitation to assist with various aspects of their daily lives and maintain their independence. Despite its overwhelming presence, age-related vision loss often remains undertreated, with older adults commonly waiting between five and seven years after diagnosis before seeking LV rehabilitation services and assistive technology (AT). Yet, provision of LV rehabilitation services in the early phases following the announcement of the visual impairment diagnosis is fundamental to prevent potential decline in functional ability over time [32, 33].

Traditional vision assistive equipment used to compensate for altaired vision

Mirroring the general definition of assistive devices used in the United States of America Assistive Technology Act 2004 [34], vision assistive equipment (also known as "low vision adaptive devices" or "low vision aids") can be defined as any item, piece of equipment, or product system, whether acquired commercially, modified, or customized that enables individuals with LV to increase, maintain, or improve their functional visual capabilities [35]. Traditional techniques for helping people recruit parafoveal (i.e., close to the center of the retina) and peripheral vision include the employment of magnification and the control of lighting and contrast. LVAs can be classified into optical aids (magnifiers) and electronic ATs. Non-optical aids, such as tinted lenses, filters and coloured overlays) can also be used to enhance vision. Commonly used optical aids include: a) magnifiers: stand and hand magnifiers (with and without illumination). In general, the higher the magnification the greater the restriction of visual field; b) high dioptric power reading glasses or near adds in bifocal glasses (ranged to +4.00 and up to +20.00 diopter sphere); c) distance binoculars or telecopes: a hand-held or spectacle mounted lens system providing magnification at greater distance. In recent years, LVAs have been complemented by 'assistive technologies' mainly based on electronics. AT refers to technology that enables self-managed compensation for disability to achieve independence and increase quality of life (QoL) [36]. In comparison with optical and non-optical devices involving low-tech, they are also known as high-tech devices. These include electronic vision enhancement devices or screen-magnifying such as closed-circuit televisions (CCTV), computer screen reading software, digital audio books, periodicals and text which can be accessed via computers, mobile phones and tablet computers. Recently, mainstream devices, including tablets and smartphones, are more and more used as LVAs by individuals with LV. For users with LV, they contain

accessibility features that enable the user to magnify, invert colour, select a range of filters to differentiate objects or make a text bolder. For blind device users, options such as text-to-speech are available.

Among individuals with LV presenting for rehabilitation, approximately 25% have considerable peripheral field loss, while the remaining 75% have predominantly central vision loss [37]. As such, it is not surprising that magnification devices are among the most common forms of intervention in a LV rehabilitation program [38, 39], specifically for individuals with central vision loss due to macular pathology. Therefore, the majority of research and clinical innovation in LV rehabilitation has been directed toward patients with central visual defects [40]. Commonly prescribed magnifying LVAs for individuals with central visual defect include over-correction with reading spectacles with convex lenses, handheld or stand magnifiers and CCTV [41]. Reading and access to printed information represent the primary motivation for using these devices [25] and the need of recovering or improving a wide range of other activites makes LVAs essential for visually impaired individuals.

Impact of low vision rehabilitation on visual functions and activities of daily living

A 2012 systematic review on the effectiveness of vision rehabilitation services concluded that there was meaningfull evidence that LV rehabilitation services improved clinical and functional abilities [28]. More specifically, there is established evidence that the use of LVAs by individuals with LV can improve functional reading ability [28]. Recent results indicated that use of LVAs can improve visual information processing and visual motor skills among individuals with macular disease [42]. Practice in the use of an electronic vision enhancement system has been shown to increase reading rate more than passive observation of another person's training,

evidenced in a faster reading speed than in those who received no training [43]. Goodrich et al. have shown that practice and supervised training for CCTVs over a 10-day period improved reading speed and duration of use [44].

Two methods have been traditionally advocated to improve the efficacy of LVAs for individuals with central visual defect in many meaningful ADLs: eccentric viewing [44], and the use of prisms to extend the visual fields [45]. The principle of these methods consists of placing the image on a healthy part of the paracentral retina to provide optimal viewing. Training in the use of eccentric viewing (using the preferred retinal locus), considered as a top-down stategy (active participation), can have an effect on the functional status of many meaningful ADLs including mobility, reading, and driving [46]. Many studies have shown beneficial results of reinforcing eccentric fixation with the process of biofeedback using the Microperimeter 1 (Nidek Instruments, Padova, Italy) [47, 48]. In contrast, training in the use of prisms to extend the visual fields is considered as a bottom-up strategy. Expanding a patient's field of vision, however, has challenged clinicians and researchers for half a century. Peli designed and developped glasses with high-power prism segments mounted above and below central fixation [49]. Prisms shift an image and are not a true expansion of the visual field. Prism glasses are difficult to use partly due to image jump and are therefore not widely accepted by LV clients.

Traditionally, magnification has been accomplished using conventional optics; although optical devices are known to be of value, they have notable limitations for certain tasks [12, 50]. One of the main disadvantages is that, as magnification increases, aberrations expand and the useful field of view decreases, causing detrimental effects on visual performance [51]. Further limitations include a fixed level of magnification and close working distance for higher levels of near magnification, which in turn result in limiting use for specific tasks only. To overcome these

limitations and to offer more flexibility of use, high-tech devices have been introduced in LV. These devices utilize sophisticated systems that are electronically based and known as Electronic Vision Enhancement Systems (EVES) such as CCTVs or Head-Mounted Displays (HMDs).

Head-mounted displays within the family of high-tech low vision aids

Electronic LV devices, known as EVES, represent a considerable component of future potential LV rehabilitation solutions. CCTVs and related electronic magnification technologies have been a boon and benefitted a large portion of the LV population, allowing a vast number of people world-wide to maintain the ability to read [52]. Some authors examined whether objective performance of near tasks is improved with EVES compared to the participant's own optical magnifier. The main findings were that EVES allowed reading to be faster and of longer duration than with traditional optical magnifiers, and participants were able to read smaller print sizes [53, 54]. However, many problems, such as glare from the screen, improper contrast settings, and light-sensitivity, cause poor image quality. Another negative point is that most of EVES are frequently limited to performing a single type of task, usually at a specific distance, while people with LV require a number of devices to assist with a variety of tasks [55]. The color quality, sharpness, and high contrast are further important factors and have to be faithfully reproduced for optimized visual experience. Ideally, devices should offer a wide and continuous range of magnification, and the usability to adjust image light intensity and contrast, while maintaining light weight, portability and aesthetic acceptability.

With the massive technology evolution, the rapid miniaturization of cameras, advanced image processing, and improved display electronics in recent decades, novel HMDs have become available and are now a viable alternative to traditional ATs [56, 57] for individuals with vision

impairment. HMDs for individuals with LV includes a display in front of the user's eyes, using a frontal camera to capture live video and incorporate image processing software to present digitally enhanced visual information [58]. This signal is projected in (near) real time to the user, typically through a pair of microdisplays positioned in front of the eyes. Advantages of HMDs are that they enable hands-free magnification for resolution tasks at far, intermediate, and near distances; provide autofocus and variable magnification to facilitate viewing; and offer video inversion as well as contrast and brightness enhancement. Given their features, such ATs have the potentiel to be used for various activities, instantly switching from near vision (reading a book) to intermediate vision (observing the person who enters the room) or far distance (looking out the window), in a wide range of environments. HMDs were initially targeted to military applications but decreased costs have made them accessible to industrial and entertainment (video games) applications. This family of technology has the potential to improve patients' vision through the association of image processing and wearable visual display systems [58]. Interest in HMDs has expanded over the years. The first HMDs designed for individuals with LV were the Low Vision Enhancement System [59, 60] and the Joint Optical Reflective Display (Enhanced Vision Systems, Huntington Beach, CA). They exhibited technical challenges (size, weight, restricted visual field, low resolution, lag time) [55, 59] that limited their full integration into the environment of LV users. Recently, HMDs have made a comeback. Devices currently commercially available include the eSight Eyewear (eSight Corp., Toronto, ON, Canada), NuEyes Pro Smartglasses (NuEyes USA, Newport Beach, CA), CyberTimez Cyber Eyez (Cyber Timez, Winchester, VA), Evergaze seeBOOST (Evergaze, LLC, Richardson, TX), IrisVision (Visionize, L.L.C., Berkeley, CA), and the redesigned Enhanced Vision Systems Jordy (Enhanced Vision Systems, Huntington Beach, CA). These new systems use more modern-color microdisplays or cell phone displays, and higher-resolution color video cameras. HMDs can vary by their positioning to the user's eyes, visual field size, the presence of

stereopsis, type and range of illumination, levels of resolution and user interface options.

This group of technologies can be classified based on how visual information is conveyed, usability, and optical design (i.e., images are magnified with classic lenses in front of eyes or using pupil-forming systems to shift the image directly in the retina) [61, 62]. Based on how visual information is conveyed, HMDs can be classified into monocular, bi-ocular or binocular systems. The simplest solution to implement is a monocular display, presenting images to one eye only. Traditionally this type of system is used as a LVA [57]. Second, bi-ocular displays present the same image to both eyes. This solution is traditionally employed in military applications to improve peripheral vision (movement detection) [62] and also in LV [63]. The third solution is the most ecological one but also the more technically complex, and consists in binocular displays. It is based on retinal disparities (each eye receive its own image that comes from a different field of view) and should require two cameras. However, artificial binocular vision can be created using one camera only and a software shifting images as if they were provided from two different areas of space (such as binocular vision) and provide a smaller visual field than two cameras. Given their high price, binocular displays for LV application remain rare and are mostly used for entertainment. HMDs can also be classified based on usability in virtual reality (also known as immersive reality) devices, whereby the users' eyes are covered by opaque screens and see-through displays. Immersive displays eliminate the direct path between the user's eyes and their real environment and have been traditionally used for entertainment applications (video games), in which users are immersed in a simulated environment. In contrast, augmented reality displays surimpose images, monocularly or binocularly, directly on top of the user's fields of view, without occluding it. Virtual information that does not otherwise exist in the environment is presented to the user.

Visual Performances reached with head-mounted displays and comparison with other low vision aids

Most evaluation studies were conducted with early generations of HMDs addressed at individuals with LV. A comparison of the quality of the image with conventional LVAs, such as CCTVs, showed that HMDs eliminate some of the problems related to reflections and depth of field, improve image quality and provide a way to customize the image output. In CCTVs, the central display of the lens was generally better than the edge display, a factor that negatively influenced both reading speed and comprehension compared with HMDs [64]. Previous research has indicated that HMDs have the potential to improve visual search, nightime travel and dark adaptation deficits in individuals with visual field loss, given the variable magnification, and the ability to magnify/minify portions of the visual field [65]. Their greater magnification range significantly improved utility at far and intermediate distances [55, 66] than traditional optical aids [67]. Considering the functional gain, Peterson et al. [68] documented that reading with a conventional optical aid, such as a hand-held magnifier, was slower than with HMDs. A multi-center randomized controlled trial documented patient-reported functional improvement while they used HMDs [32]. Examining the effectiveness of several types of early-generation HMDs (i.e., the Jordy and the Flipperport HMDs) on visual function, another study concluded that they did not result in better near acuity or contrast sensitivity compared with traditional LVAs [55]. Still, even these early designs were effective for both adults [60, 69] and children [70] with LV; important benefits included improved print reading, contrast sensitivity, and magnification control. Since then, technological advances have made HMDs lighter and smaller, with faster auto-focusing speed, better illumination control, and more processing power. General understanding of the use of new HMD generations remains limited, justifying the objective of the present research to study them using

the example of eSight Eyewear.

eSight Eyewear: a new generation of head-mounted displays

The research litterature has highlighted the importance of improving the processing and perception of an image by enhancing its outline and contrast, beyond what can be achieved with classic LVAs, such as optical magnification currently used to improve visual ability in individuals with LV [65, 71]. With these requirements in mind, eSight Eyewear (see Figure 1 that displays eSight generations 2 and 3) was designed to optimize magnification (1.3 to 12 for eSight 2 and 1.3 to 24 for eSight 3), contrast enhancement, autofocus, portability, hands-free use, and digital image processing, compared to previous systems. The latter feature allows the user to scan through a wide-field image, freeze images for text-to-speech conversion and optical character recognition. eSight Eyewear is a Class I medical device, registered with the the European Database on Medical Devices, in accordance with the European Union directives on medical devices, the U.S. Food and Drug Administration, and Health Canada [72-74]. It was originally launched commercially in 2013 and had approximatively 4000 LV users by October 2019. The device conveys visual information bi-ocularly, meaning that the same image is presented to both eyes. The device is mounted in front of a user's eyes and the images are magnified using classic lenses, traditionally they are near-eye displays. Finally, eSight belong to the VR systems. The eSight 2 device weighs approximately 200 g (104 g for eSight 3) and offers a high-resolution 30-fps (frames per second) video camera, that provides a full-color digital image presented in real time on two near-to-eyes organic light-emitting diode displays (800-600 pixels for eSight 2, 1024-728 for eSight 3) with a display field of view of 28° width (35° diagonal) and maximum magnification of 12.3X for eSight 2, and 24X for eSight 3, associating optical and digital zoom. A handheld controller, connected to the device by a cable (without wire for eSight 3), enables

users to adjust the different parameters. Displays are held by an eyeglasses frame with adjustable headband, provided with adjustable pupil spacing and integrated prescription lenses. eSight Eyewear 2 has a battery life of about four hours and costs approximately $15,000 CA ($9,995 CA for eSight 3). It is possible to connect the device directly to a video stream (bypassing the camera) from television or a computer.

Figure 1. – eSight 2 and eSight 3 head-mounted displays

Currently, when purchasing eSight Eyewear, the users are provided with the eSkills User Guide [75], a self-training program developed by eSight Corporation. It provides instructions and exercises for device users, intended to improve their familiarity and competence with the device, and has been shown to be effective [76]. The manual contains a detailed description of the device, its interface, and user instructions for optimizing headset adjustements and the use of the controller unit. It also provides information on how to control zoom, focus, contrast, color inversion, and the freeze-image mode, as well as safety and maintenance recommendations. The eSkills training module contains a one-month learning calendar with examples and exercises for the user to get to know the device, including modules on near and distance reading, writing, using

computers, and general viewing, followed by sections on optional Web support. Systematic clinical evaluations of such devices remain rare. Recently, a multicenter prospective trial (NCT02616900) investigated the effect of HMDs on 51 novice eSight Eyewear users for three months [76]. Overall, visual abilities (i.e., distance and near visual acuity, contrasts sensibility), ADL and reading showed greatest benefit (both visual function and functional vision) with device use, indicating that the device improves both visual function and functional vision [76]. Another study explored the impact of using eSight Eyewear on functional vision and oculo-motor control in LV users recruited at the *Université de Montréal*. This study replicated previous results and also reported that a 3-months utilization improves distance visual acuity, indicating the benefit of training and/or practice. Regarding the oculomotor-control, the eSight device did not modify fixation location but may improve its stability [77]. Training and practice remain essential such as it is the case for traditional visual aids, because optimal HMDs use requires mastery of its different features depending on the tasks and environment.

Training/practice with head-mounted displays

Previous generations of HMDs have demonstrated benefits in near vision tasks, in general, and reading, in particular, and these tasks were performed just as quickly using optical magnification [78]. Only several minutes were allocated to the "training" on the HMD, thereby not considering the possible benefits of practice and training though rehabilitation strategies and instruction on the use and usability of the device. Other authors compared four HMDs (Jordy, Flipperport, Maxport and NuVision) with conventional optical LVAs, considering the impact of practice [55]. Beneffiting from a 1-week device loan, participants exhibited a significantly better distance and intermediate acuity with the HMDs than the previously prescribed optical LVAs, but near acuity and contrast sensitivity were not consistently better with any of the HMDs. The

authors [55] also highlighted that practice at home provided some improvement in performance with HMDs over time but with limited evidence because the sample was small.

So far, few studies have focused on exposure to and training with HMDs. No evidence exists about the impact of training and practice on HMD use. In order to a gain better understanding of the use of such devices, we need to explore the impact of training provided by a LV therapist on HMD users and follow them for several months. Moreover, although meaningful LV rehabilitation benefits patients in several clinical settings [28, 42], device utilization is rarely taken into account when evaluating LV rehabilitation intervention effectiveness. Providing LVAs to assist people with LV to achieve their goals is a central component of LV rehabilitation, and device non-use may prevent or limit individuals from receiving the maximum benefits of LV rehabilitation.

Adherence in the use of assistive technologies

Medical and intervention adherence

Adherence has been defined as the extent to which an individual's attitude or behaviour follows the treatment recommendations from a health care professional [79] and non-adherence is defined as failure to follow these treatment guidelines. Outcomes from non-adherence or non-compliance have emerged mainly and abundantly from studies on prescribed medications [80]. Patient non-adherence has been studied within various health care-related fields and most often concentrating on medical adherence [81]. There is an extensive literature focusing on adherence because the consequences of non-adherence may induce negative health outcomes (i.e., poor health conditions and decrease of QoL), serious burden to caregivers, and major waste of economic resources to the health care system [82]. Murray et al. [83] proposed a conceptual model specifically related to medication adherence among older adults, composed of environment,

patient characteristics, and medication use system as components and where each of these components encompasses several factors that inform medication adherence. Martin et al [82] proposed another model that defines and explains the underlying factors, such as patient's attitudes, beliefs, emotional challenges, and cultural contexts, not only intended to influence patient adherence to medication use but to treatment regimens overall. Adherence to healthcare treatments or interventions is complex and therefore involves multiple factors that interact and produce individual behaviors. Model-linked medication adherence interventions, such as the Theory of Planned Behavior, the Health Belief Model and the Medication-Taking Behavior Model [84-86] propose four influencing categories of factors related to: the person (e.g., self-efficacy, culture, stress, depression, comorbid conditions); health system (e.g., access to medication, care delivery approach); treatment (e.g., cost, type, treatment duration) and environment (e.g., interpersonal influences, or information from friends, relatives).

Assistive technology adherence

In recent decades, given rapid technological development and advancement, several studies have been conducted in the field of AT (non-)use and have determined that the decision-making process of whether individuals with a disability use or abandon their aids is likely multi-factorial [87, 88]. For example, older adults' AT adoption is influenced by device cost, efficiency and reliability [89-91], limited knowledge of their availability [89], and their appearance [91].

ATs are typically recommended and/or prescribed by a therapist but users do not necessary consistently use them in their home environment. Studies converge on an AT abandonment rate of approximatively 30% one year after device delivery [92, 93], and a 30% rate has been considered as a threshold for defining low and high rates of AT abandonment [94, 95]. However, other studies report divergent data from the typical rate of abandonment [95, 96] where differences in methodology used

may highly contribute to explain this inconsistency. Despite the variability in abandonment rates, similarities have been highlighted among the mechanisms influencing non-use of AT and those influencing non-adherence with other medical interventions [97]. Considering these parallels, adherence to assistive devices may be substantially improved through the application of conceptual frameworks for medical interventions [98]. An overview of the determinants of AT non-use in general has previously been classified into four categories of factors: (1) personal (e.g., age, gender, diagnosis, motivation); (2) device-related (e.g., device weight, size, quality or appearance); (3) environmental (e.g., social support, stigma, physical barriers); and (4) interventional (e.g., instruction, training, follow-up service, technical support) [98, 99]. Although these categories are named differently compared with those that affect adherence with medical interventions, there is large overlap in their content [98, 99].

In order to minimize the risk of device abandonment, all these factors have to be carefully observed, assessed and managed throughout the process of matching the user to the AT device [88,100]. Using the same classification based on the four main identified factors, Federici et al. [99] investigated AT abandonment in users of the Italian National Health Service and documented that, overall, 20% of them abandoned their device. Inappropriate design of the device was the most commonly given reason for not using it and personal factors were more important factors in non-use than the device itself or the associated intervention. Identifying ATs with a higher frequency of non-use, and the reasons given by users for not using them is a major challenge. However, this information is particularly useful to better guide clinicians in selecting and recommending a device suitable for the patient's profile and needs. Investigating the use of ATs in patients with various types of impairment who reported not using them, Forbes et al. [101] reported that the majority of devices owned that were unsatisfactory mainly concerned hearing and visual aids, compared to

cognitive and motor aids.

Low vision aid adherence

The prescription or recommendation of magnification devices, such as over-correction with reading spectacles (high convex lenses), handheld or stand magnifiers and CCTVs systems, is one of the most common forms of intervention [39, 102]. Despite the availability of technologies to support aged-related vision loss, many older adults never obtain LVAs or abandon them early after acquisition [103], thereby never fulfilling the potential of utilizing a device [89]. The variability among reports of LVA abandonment is large. Just like for other ATs, a survey conducted by the Glaskow Eye Infirmary reported that 33% of patients never used their LVAs [104]. Replicating these findings, Elliott et al. [105] surveyed 34 patients in England who had undergone a hospital-based LV program, whereby one third never used their aids at all. There are, however, other LVA abandonment data that diverge from the typical rate of 30% previously mentioned [92, 93] that are also used as a threshold to interpret abandonment. Without distinguishing among LVA types, 15% of devices prescribed were *not still used* (defined by reported as helpful or used in the past year) by individuals with LV in the U.S. Department of Veterans Affairs [50]. In contrast to this comparatively low non-usage rate, and without distinction among LVA types, 80% of the patients engaging in a hospital-based LV program did not use their LVAs *frequently* (a term not defined by authors) [105].

The reasons why patients with LV may or may not choose to utilize their LVAs can vary widely. Little evidence is available in this field because most studies that focus on abandonment are not controlled and/or randomized. Just like other ATs, LVAs non-use is complex because many factors are likely to be involved. Commonly-reported reasons for non-use of prescribed LVA include device-related factors, such as the limited magnification range and the poor

ergonomics of the device [106]. As is the case for persons using ATs in general, a careful evaluation of individuals with LV is a required step in determining their need for assistive devices to enhance or maintain independence and QoL [107]. It is well established that device users require manual dexterity and motivation [104] to gain the maximum benefit from LVAs. The amount and frequency of training in device use is a further important factor that may influence the abandonment rate [108]. For example, a very high compliance rate was observed in a population of LV veterans, where training was considered as greater (average of 32 hours) [12] than was typically available in outpatient settings (only 10% of practitioners provided more than three hours) [106].

Issues related to traditional out-patient rehabilitation and telehealth to deliver services

The strategy of inpatient rehabilitation used in *The Low Vision Intervention Trial* study has indicated benefits of inpatient LV rehabilitation on self-reported visual function [32] but did not reflect standard outpatient LV rehabilitation. The traditional outpatient-based approach for delivering LV rehabilitation exhibits major disadvantages caused by transportation issues and low compliance with visual device training sessions [109]. When patients fail to attend follow-up visits for instructions and training provided and/or do not comply with newly recommended LVAs, LV rehabilitation effectiveness may be seriously compromised [110]. Using magnification devices to their fullest potential involves non-intuitive behaviour, such as adopting a very close working distance. Such strategies require instruction, training, and practice. Moreover, optimal LV device use requires a defined viewing angle, and an adequate eyeglasses correction, as needed. Finally, when patients experience important challenges using their visual aids at home, it may lead to frustration, discouraging them from returning for follow-up appointments [111].

LV rehabilitation providers (e.g., ophthalmologists, optometrists, LV rehabilitation therapists) often anticipate successful outcomes for the patients to whom they prescribe/recommende a magnification aid, yet most of the time they receive little feedback about actual device use by their users [112]. LV rehabilitation services are mainly addressed at older adults, with 73% of patients being aged 65 and older [113]. In addition to their vision impairment, they often exhibit comorbidities including age-related physical, cognitive, and psychological issues. Two-thirds of individuals with LV do not drive [113] and increasingly rely on their relatives for ADL and transportation. Travel to a clinic with LV providers becomes more and more burdensome, expensive, and time consuming for many patients and their relatives [114]. All together, transportation issues and age-related comorbidities represent barriers to attending follow-up appointments that are frequently intended to provide training with visual aids. Given all these challenges, visual aid effectiveness is variable and reported non-use rates are high in some cases [50]. The majority of reports about telemedicine among older adults documented benefits on behavioral outcomes, including compliance, self-efficacy, QoL, and economic outcomes [109]. To the extent that most individuals with LV are older adults, these results are encouraging; yet, few studies have evaluated the potential of a video and audio platform for telehealth with LV clients.

In recent years, telerehabilitation has received intensified interest in health care because it enables people to remain independent at home while receiving rehabilitation services via audio-, video-, and other communication technologies [115]. Clinically, telerehabilitation embraces a range of rehabilitation services including prevention, assessment, monitoring, intervention, education, supervision, and counseling. So far, it has mainly been implemented in physical rehabilitation intended for patients with motor disabilities, most commonly with stroke, joint replacement, or

spinal cord injury [116]. A systematic review focusing on telerehabilitation across various disabilities documented that 71% of the interventions were successful [117], thereby strongly contributing to evidence-based practice recommendations towards implementation of telehealth care intervention. Various benefits of remote on-line rehabilitation have been reported when compared to standard in-office intervention, including resolving transportation issues, optimizing follow-up sessions schedule and assessments of the patients' environment. However, technological [118] and user-centered [118-120] challenges of such approach have also been mentioned. In ophthalmology, telemedicine has mostly found its application in the transfer of patients' ocular images among clinicians for diagnosis and monitoring of ocular disease evolution, while fewer studies have documented telemedicine application to provide LV rehabilitation or to communicate directly with patients with LV [121]. Meanwhile, the U.S. Department of Health and Human Services initiated the Goals of the Healthy People 2020 plan [122] that includes increasing the provision of vision rehabilitation services and the use of assisitive devices by people with a visual impairment. Following the same logic, through the Low Vision and Blindness Rehabilitation - National Plan for Eye and Vision Research [123], the National Eye Institute's strategic plan encourages developing rehabilitation programs and evaluating the most effective interventions for individuals with LV. Considering these recommendations, telerehabilitation addressed at this population needs to be further explored.

Telerehabilitation: an alternative modality for low vision rehabilitation services

Visual aids using video systems (e.g., smartphone, tablet) are widely used by people with a visual impairment, suggesting that they could be used to provide remote, Internet-based services (i.e., telerehabilitation) [124]. Recently, a study on the usage of video systems for LV

documented that nearly half of 132 people with a visual impairment used a tablet device [124]. The majority of these participants used a smartphone and about half used their camera and screen as a magnifier. Another study documented that the large majority of participants resided in the USA had access to a computer or handheld device (e.g., smartphone), and to Internet in their home, which potentially could be used to deliver telerehabilitation services [125]. Given the progress with hardware and videoconference services, as well as the widespread availability of cellular and wireless Internet networks, the environment is favorable for persons with LV to benefit from the technologies, and for rehabilitation professionals to provide remote training on the suitable use of magnifying devices.

Telerehabilitation has the potential to overcome several barriers over traditional in-office services and to generate improvement in visual function and other health-related outcomes [116]. One review specifically pointed out that LV care could potentially be a field that takes advantage of tele-ophthalmology service [126]. The main advantage of telerehabilitation consists in its potential to overcome transportation issues, particularly challenging in rural areas of geographically dispersed countries, such as Australia, the USA and Canada [110, 127]. For people with LV living in rural regions, who have limited access to specialty clinics delivering LV rehabilitation services, therapists could remotely assess patients in their home environment in a more ecological way than the clinical setting, thereby delivering more personalized services. In addition, telerehabilitation has the potential to enhance rehabilitation modalities, developping new ways to interact with patients and designing new tasks and exercices for training in a controlled framework through the use of secure, maintream Internet-based communication technology (e.g., computers, smartphones and tablets). From a health cost-effective perspective, by maximizing the use of time and other LV service resources, this modality also has the

potential to improve efficiency over the expensive and time consuming issues inhenrent in standard in-office care.

A Cochrane systematic review documented very few applications of telerehabilitation with persons living with LV and, at the time, there were no published outcomes [109]. This review did not summarize any evidence on whether the use of telerehabilitation was feasible or a possible viable tool to remotely deliver rehabilitation services to individuals with LV. Several observational studies have highlighted the possible advantages and feasibility of delivering tele-ophthalmology remotely but did not report on any study that specifically addressed remote health services for people with LV. Since then, a pilot study indicated promising outcomes confirming the feasibility and acceptability of training to optimize the use of handheld magnifiers in ten patients with LV via telerehabilitation in their home environment [128]. Telerehabilitation was offered to novice users of handheld magnification devices who self-reported difficulties with reading, and found it challenging to return for follow-up training at their provider's office. Overall, telerehabilitation was successfully adopted by both the providers and older adults with LV in this study. These results are particularly encouraging and support the feasibility, acceptability, and potential value of LV telerehabilitation.

Recently, the transportation cost and times investment using telerehabilitation, as a LV service modality, were investigated in veterans with visual impairment living in rural regions [114]. This study supports LV telerehabilitation as an accepted, time- and cost-saving alternative option to traditional face-to-face (e.g., in-office or at home) sessions with LV providers. This reduction in the visually impaired veteran’s travel distance, time, and cost resulted in a 24% increase in access to LV rehabilitation over five years [129].

All these findings support and demonstrate the need for more focused research on telerehabilitation as a potential modality for LV people. However, among these studies, none have yet investigated the impact of LV telerehabilitation on QoL, few have explored the effect of this modality on functional vision in individuals using LVAs, and no randomized study has yet been conducted in this field. As part of the general understanding of the use of HMDs, the present research project addresses these gaps. The results of his thesis will help guide evidence-based practice recommendations for telerehabilitation as a potential modality for people with LV.

Objectives and hypotheses

The aim of the present thesis is to explore factors that influence HMD use among individuals with LV, using eSight Eyewear as an example, and elplore the extent to which telerehabilitation training can be a feasible modality for LV services in this context. More extensively, the studies in this thesis address some fundamental unanswered questions about efficient training characteristics, and where and by whom the training should be conducted. This information provides us with insight into the factors that influence LVA use when rehabilitation practitioners intervene with patients. The results of this research highlight the unique experience of providing personalized training to HMD users through telerehabilitation, and contribute to the development of evidence-based assessment and training protocols to better meet the unique needs of individuals with LV.

The thesis research is composed of three studies that: 1) investigate and synthesize barriers and facilitators influencing the use of magnifying visual aids through a scoping review to guide the subsequent cross-sectional and prospective studies; 2) identify which variables predict a change in device use among current HMD users using a cross-sectional design; and 3) develop

evidence-based practice recommendations regarding the feasibility of a telerehabilitation intervention on HMD users and study the effect of this modality on their device use and QoL. The different studies of the present research were conducted at the School of Optometry of the *Université de Montréal,* Montreal, Quebec, Canada. The protocol was reviewed and approved by the institutional review board of the *Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain* (CRIR# 1286-1217).

Study 1: Scoping Review (Article 1)

To effectively design studies focused on improving adherence to AT interventions, it is first necessary to gain an understanding of how adherence to AT should be conceptualized. The investigation of the factors predicting non-use of magnifying LVAs is important. Such insights have the potential to help clinicians identify patients at risk of device abandonment, and can provide evidence for interventions designed to improve adherence. As very little research has been conducted in this area, a scoping review functioned as a necessary starting point for synthesizing and reviewing prior research in a systematic and rigorous manner to clarify future research. To the best of our knowledge, no other review has so far focused on factors related to magnifying LVAs use.

The aim of Study 1 was to investigate and synthesize what is already known about the barriers and facilitators that effect the use of HMDs and other magnifying visual aids. This study was the first step in a series of studies exploring factors related to discontinuation of head-mounted displays, a new class of magnifying low vision aid where device (non-)use has not yet been explored**.** An overview of the determinants of non-use of AT has categorized factors related to the person (e.g., depression or anxiety), assistive device (e.g., device weight or size), user's environment (e.g., perception of stigma), and intervention (e.g., absence of technical

support) [98,99]. Using the same paradigm it was hypothesized that some of these factors, common to adherence and the AT field, are also associated with the (non-)use of HMDs and other magnifying visual aids. To summarize the extent, range, and nature of research regarding the categories that are associated with LVA (non-)use, a scoping review was conducted, using the following online databases: Embase, MedLine, Cochrane, ERIC ProQuest CINAHL, Trip Database and NICE Evidence. A combination of key words and MeSH terms was used based upon the identified core concepts of the research question: *low vision*, *assistive technology* and *adherence*. Inter-rater reliability for the selection process was considered acceptable (kappa = .87).

Study 2: Cross-sectional approach (Article 2)

The Study 2 focuses more particularly on the eSight HMD because the changing landscape of AT for LV spurred by mainstream advances in mobile, wearable and virtual technologies has highlighted the need to better understand how use of these technologies in the real world. The Wittich-laboratory participated in a multicenter prospective trial that investigated the effect of HMDs on 51 novice eSight Eyewear users for three months. Overall, visual ability, ADL and reading showed greatest benefit with device use [76]. Currently, little is known about why some individuals experience them as a success while others decide not to use them in the long-term. One of the goals of the research project was to identify which variables predict a change in device use among current eSight owners. It was hypothesized that variables that were previously found to be related to magnifying LVAs in the literature (Study 1) were replicated as predictors of abandonment of use in the specific context of this HMD.

Participants were recruited among eSight HMDs users from the eSight Corp (Toronto. Canada). Using a cross-sectional design, participants completed a 45-minute survey online, in

English. The eligibility criteria were minimum age of nine years, ownership of an eSight device for at least two months following the 1-month training period provided by the company, the ability to access the Internet and to read and write English. Informed consent was obtained from all participants when they clicked on a web page link. For minors, the consent was obtained through their parents.

In the context of our analyses, discontinuance in device use was defined as a participant reporting non-use of the device in the previous three months for any task [111] . The outcome was a binary variable, the levels are *used in past three months (utilization)* vs. *did not use in past three months (discontinuance)*. The survey was composed of 94 questions selected/developed according to their ability to evaluate factors related to the use and discontinuance of use of the device and the QoL in connection with using eSight Eyewear. Variables included in this survey have been shown to influence magnifying LVA use according to Study 1. These variables were classified into four families: *personal* (demographics, general health, ocular condition, LVA experience, material resources and psychological variables explored by the PIADS), *device-related* (objective, such as eSight version type, QUEST score; and subjective variables such as general discomfort, headache), *environmental* (social environment such as living arrangement, family/friends encouragement; and physical environment) and *interventional* (LV rehabilitation experience, training and follow-up service).

Study 3: Prospective approach (Articles 3, 4 and 5)

To overcome transportation issues identified in the literature, innovative internet-based communication technology presents itself as a potential solution for rehabilitation services. Despite the growing interest in telerehabilitation, very little research has been conducted with people with LV, and the absence of evidence-based practice recommendations may explain the

limited payment reimbursement mechanisms for remote services. However, evidence from a randomized controlled study of telerehabilitation for LV documenting changes in patient outcomes after telerehabilitation, could be used to support policy development and implementation programs that help provide payment to cover this type of intervention.

Using a randomized controlled trial design, the main goal was to conduct a feasibility study of administering several LV rehabilitation training sessions via telerehabilitation using an Internet-based video platform in participants with visual function loss, due to any ocular condition, using their eSight Eyewear at home. As secondary goals, it was determined if personalized intervention through telerehabilitation can help to reduce discontinuance for HMDs and improve QoL. In addition, other previously identified predictors of magnifying LVA use (i.e., experience with LV rehabilitation services, family/friends encouragement, physical environment) and eSight Eyewear use (i.e., other people's reaction while participants use their eSight device) were explored. It was hypothesized that personalized LV rehabilitation through telerehabilitation was a feasible (accessible and acceptable) modality to train individuals with LV to use their eSight device at home, reduce discontinuance and improve QoL.

This was a parallel two-arm pilot randomised controlled study which consisted of training individuals with LV in the use of eSight Eyewear when engaging in ADLs. The experimental intervention entailed a series of personalized LV telerehabilitation sessions with a LV rehabilitation specialist, focusing on the functional aspects of using eSight. The control intervention consisted of the current self-training standard provided by the device vendor eSight Corporation. Individuals with self-reported LV aged 18+, who were able to communicate in English or French, had a tablet, desktop or laptop computer with internet access, and recently bought (< one month) or were renting an eSight Eyewear device were included. Current device

users who had owned their eSight device for more than one month (and have therefore completed the eSight eSkills User Guide), as well as those self-reporting other severe sensory impairments that may interfere with communication, were excluded.

Contributions

Autorship. The next section summarizes the authors' contributions for each of the articles that were the subject of this thesis. For all the studies of the present research project, protocols were designed and developed by Marie-Céline Lorenzini, M.Sc. and Prof. Walter Wittich, PhD. Dr. Anni Hämäläinen's collaboration provided expertise on the use of a statistical method relevant to Study 2 of this research project.

Contributorship. The research project was possible thanks to the involvement of the following individuals: Patrice Dupont, librarian at the School of Optometry of the Université de Montréal, for his participation in the planning, development and implementation of research strategies for the Study 1; Pauline Bouchard, M.Sc. student at the School of Optometry of the Université de Montréal, for her collaboration for the screening of the articles for the Study 1; Rob Hilkes, Vice President of Clinical and Regulatory Affairs at eSight corp (Toronto. Canada); eSight clients who have assisted as research volunteers for Study 2 and Study 3 of the present research project; Prof. Aaron Johnson, PhD., for his advice on the choice of statistical analysis methodology in Study 3; Ms. Claire Fréchette, the LV therapist involved in Study 3; Jonathan Jarry, M.Sc. and Karine Elalouf, M.Sc., were research assistants of the *Visual Impairment and Rehabilitation Laboratory*

of the School of Optometry at the University of Montreal for the Study 2 and Study 3. The initials of the authors and other contributors' names are used in this next section.

Article 1. ***Factors related to the use of magnifying low vision aids: A scoping review***

MCL identified the research question, collected relevant studies, selected inclusion and exclusion criteria, and charted the data. PD was involved in the planning, development and implementation of research strategies for the Study 1; MCL and PB independently screened titles and abstracts, and then full-text articles against the eligibility criteria. MCL collated, summarized, and reported the results. MCL was responsible for interpreting the data as well as writing the manuscript. MCL and WW, reviewed, corrected and revised the manuscript.

Article 2. ***Factors related to the use of a head-mounted display for individuals with low vision***

MCL designed the survey online and was responsible for data collection. Data analyses, interpretation of the results and drafting of the manuscript were performed by MCL. English translation of questionnaires, letter of introduction of the study and consent form were edited by JJ. Participants were recruited among eSight HMDs users by RH. This manuscript benefited from the statistical expertise of AH for the use of logistic regression method. Revision and amendment of the present article were performed by MCL, AH and WW.

Article 3. ***Measuring changes in device use of a head-mounted low vision aid after personalized telerehabilitation: Protocol for a feasibility study***

The present protocol was drafted by MCL. English translation of questionnaires, letter of introduction of the study and consent form were edited by JJ. No acquisition and analysed of the data were managed at this point because this article is a protocol. The present article was critically reviewed and amended by MCL and WW.

Article 4. ***Impact of a personalized telerehabilitation program on the use of head- mounted low vision aid for individuals with visual impairment: A randomised prospective feasibility study***

The protocol of Article 3 has been partially reproduced for Article 4 to publish the results of the feasibility part of the study. MCL conducted the study, acquisition and analysis of the data. English translation of questionnaires, letter of introduction of the study and consent form were edited by JJ. Recruitment was initiated by RH, whereby he sent and letter introducing the study to inform clients of the opportunity of participate in the research project. CF enrolled participants, carried out their initial evaluations and provided telerehabilitation training for experimental group only. KE phoned to the participants of the experimental group to complete a satisfaction survey. MCL drafted the manuscript. Revision and amendment of the present article were performed by MCL and WW.

Article 5. ***Assessing changes in quality of life after personalized telerehabilitation in users of a head-mounted low vision aid***

The protocol of Article 3 has been partially reproduced for Article 5 to publish the results of the QoL part of the study. MCL conducted the study, acquisition and analysis of the data. English translation of questionnaires, letter of introduction of the study and consent form were edited by JJ. CF enrolled participants, carried out their initial evaluations and provided telerehabilitation training for experimental group. AJ provided advice on the choice of statistical analysis methodology. MCL drafted the manuscript. MCL and WW critically reviewed and amended the present article.

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Article 1: Factors related to the use of magnifying low vision aids: A scoping review

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Keywords

Visual impairment, Assistive technology, Magnification, Optical aid, Adherence, Abandonment

Accepted March 6th, 2019
Published in *Disability and Rehabilitation* May 23th, 2019

Marie-Céline Lorenzini & Walter Wittich (2019) Factors related to the use of magnifying low vision aids: a scoping review, Disability and Rehabilitation, DOI: 10.1080/09638288.2019.1593519

Abstract

Introduction: The decision process around the (non-)use of assistive technologies is multifactorial. Its determinants have previously been classified into *personal*, *device-related*, *environmental* and *interventional* categories. Whether these categories specifically apply to the use of magnifying low vision aids was explored here, using this classification. **Methods:** A scoping review (Embase, MedLine, Cochrane, ERIC ProQuest, CINAHL, NICE Evidence, Trip Database) was conducted to summarize the extent, range, and nature of research regarding the categories that are associated with low vision aid (non-)usage. A combination of key words and MeSH terms was used based upon the identified core concepts of the research question: *low vision*, *assistive technology* and *adherence*. Inter-rater reliability for the selection process was considered acceptable (kappa = .87). A combination of numerical and qualitative description of 21 studies was performed. **Results:** Studies report high variability rates of people possessing devices but not using them (range: 2.3%-50%, M=25%, SD=14%). We were able to replicate the conceptual structure of the four categories that had previsouly been identified with other devices. Age, diagnosis and visual acuity demonstrated contradictory influence on optical low vision aid usage. Change in vision, appropriate environment, consistent training, patient's motivation and awareness of low vision services, emerged as contributor factors of use. **Conclusion:** This review provides evidence that clinicians should not rely on traditionally available clinical factors to predict device use behaviour. Worsening vision and low motivation appear as predictors of device non-use and should be considered from the clinician's point of view. Education about potential facilitating factors and promotion of innovative care are strongly encouraged.

INTRODUCTION

The ability to be living independently in their own home and community has been reported as a major priority by individuals with a disability [1]. Independent living is strongly encouraged by health providers and policy makers in order to reduce social expenses [2]. In this context, assistive technologies might be considered as tools facilitating disability self-management to maintain independence and quality of life. Technology users want to be able to use the device to the best of their ability; however, in reality, acceptance of assistive technologies may be challenging. In recent decades, given rapid technological development and advancement, several studies have been performed in the field of assistive technology (non-)use and have found that the decision-making process of whether a person with a disability uses or abandons their aids is likely multi-factorial [3-5]. In the specific context of low vision, rehabilitation can be associated with improved visual ability and an increase in functional status. Just like other assistive technologies, low vision aids aim to increase autonomy and enhance quality of life. The prescription of magnification devices is one of the most common forms of intervention [6, 7]. Magnifiers are commonly handheld, head-mounted devices or spectacles with convex lenses to magnify objects and intend to facilitate the reading of small print at near or of details at far [8]. With the growing aging population, it is expected that the number of individuals with a visual impairment increases over the coming decades [9]. It is urgent to gain a better understanding of the mechanisms explaining the (non-)use of low vision aids, in order to improve their success rate, the benefits gained, and their cost-effectiveness. (Non-)use is a complex subject to study because many factors are likely to be involved. It is well known that, to gain the maximum benefit from low vision aids, device users require manual dexterity and motivation [10].

However, our knowledge about (non)-use rates and the factors specifically related to the (non-)use of magnifying low vision aids remains limited.

The reasons why clients with low vision may or may not choose to utilize their low vision aids can vary widely and the variability among reports of device abandonment is large. Without distinguishing among low vision aid types, 84.5% of devices prescribed were *still used* (defined by reported as helpful or used in the past year) by individuals with low vision in the U.S. Department of Veterans Affairs [11]. In contrast to this high usage rate and without distinction among low vision aid types, only 20% of their patients participating in a hospital-based low vision program used their low vision aids *frequently* (a term not defined by these authors) [12].

An overview of the determinants of assistive technology non-use in general has previously been classified into four categories: reasons related to the individual (e.g., depression or anxiety), to the device itself (e.g., device weight or size), to the user's environment (e.g., perception of stigma), and reasons related to the intervention with the device (e.g., absence of technical support) [13, 14]. Using the same paradigm, it is probable that some of these same categories common to adherence and the assistive technology field are also associated with the (non-)use of magnifying low vision aids. The investigation of the factors predicting non-use of low vision aids is important. Such insights can help clinicians to identify patients at higher risk of device abandonment, and can provide evidence for interventions designed to improve adherence. Moreover, to the best of our knowledge, no other review has so far focused on factors related to magnifying low vision aid use. Therefore, it was decided to conduct a scoping review on factors related to magnifying low vision aid (non-)use, building on an existing classification of assistive technology non-use in general.

MATERIALS AND METHODS

Here, it was conducted a scoping review, instead of a systematic review, in order to rapidly map and analyse the extent and nature of studies about magnifying low vision aids**.** This approach has previously been enhanced by healthcare researchers to provide increased relevance to the clinical environment [15], and is especially appropriate in specific practice areas of research for which only a limited amount of information has been published [16]. For our team, this was the first step in a series of studies exploring factors related to discontinuation of head-mounted displays, a new class of magnifying low vision aid where device (non-)use has not yet been explored**.** Following the systematic step-wise methodology laid out by Arksey and O'Malley [16], their guidelines were used to examine and summarize the volume, range, and nature of research activities and findings regarding categories of factors associated with magnifying low vision aid usage. This 5-step process was followed, which required us to a) identify the research question, b) identify relevant studies, c) select inclusion and exclusion criteria, d) chart the data and e) collate, summarize, and report the results.

Identify the research question

Previously, four categories of factors relevant to device use have been identified: they are *personal*, *AT-related*, *linked to the user's environment* and *intervention-related* [13]. The same categories have also been associated with adherence to medical interventions. Thus, this scoping review answers the following question: Are these previously identified categories of factors, that have been shown to be related to device use in general, also associated with the use of magnifying low vision aids?

Identify relevant studies

Searches were conducted using the following online databases: Embase, MedLine, Cochrane, ERIC ProQuest CINAHL, Trip Database and NICE Evidence, limited to English and French but without limitation on publication dates. The databases were searched up to October 2018 and each database was queried since its earliest available date. The starting point (year) of Embase search was 1974, 1946 for MedLine, 2005 for Cochrane, and for CINAHL, Eric ProQuest, NICE Evidence and Trip Database « all dates » option was selected. A combination of key words and MeSH terms was used (see Supplementary Tables S1 for MedLine; S2 for Embase; S3 for Cochrane; S4 for Eric ProQuest; S5 for CINAHL; and S6 for Grey literature research strategies), and based upon the identified core concepts of the research question: (1) Low vision; (2) Assistive technology; and (3) Adherence. The three concepts were searched individually and were then combined together: Low vision AND Assistive technology AND Adherence. The main investigator (MCL) and a research assistant independently screened titles and abstracts, and then full-text articles against the eligibility criteria (see below). Inter-rater reliability (kappa) was calculated for agreement between the two screeners when sorting articles, (first sample extracted from the titles and second sample extracted from abstracts and entire article) and was considered acceptable with a kappa value of 0.87.

Select inclusion and exclusion criteria

Through an iterative process with the literature about (non-)use of low vision technologies, inclusion and exclusion criteria were defined. Different inclusion criteria were applied between the first and second screening, whereby articles that were not about low vision aids were excluded during the first screening and articles that were not about magnifying low vision aids and that did not address (non)-use were excluded during the second screening. It was difficult to find the relevant literature about *magnifying* low vision aids in the initial research because

"magnification" is not a MeSH term; therefore, the search terms were chosen to be more global to include all literature on low vision aids. Once the search was complete, a refinement was implemented to exclude all articles on non-magnifying devices during the second screening.

For the purpose of this study, the full-text review included studies focusing on (1) low vision, (2) magnifying aids and (3) (non)-use, regardless of research methodology. Magnifying low vision aids refer to all systems enabling an enlargement of the image, with or without optical components or refractive system, whatever their distance of use and activities for which they are intended. The category of low vision aids studied here includes telescopic devices for distance tasks; handheld magnifiers and stand magnifiers (e.g., closed circuit television systems) for near tasks; and head-mounted-displays for both near and distance tasks. Other systems not involving optical lenses but enlarging the image, such as software integrated into a desktop or tablet computer or smartphone were also included. The terms "technology use" in this study was defined in various ways, including adoption, adherence, acceptance or compliance. In parallel, "technology non-use" here refers to abandonment, rejection, underutilization, non-acceptance or non-adherence. The population of interest consists of individuals with low vision without restriction of age or visual pathologies. Literature about magnifying low vision aids consisting of both peer-reviewed articles and grey literature where (non)-use was central to the assessment (main or secondary objective) were selected. In contrast, this scoping review excluded studies involving sensory substitution or mobility (e.g., cane or sound tools), as well as articles in which only satisfaction or performances with magnifying low vision aid components were the focus. A flow chart of the study exclusion process is shown in Figure 2. The terminology "patients" was used for individuals with low vision as it globally refers to health care and is consistent and suitable for a rehabilitation context.

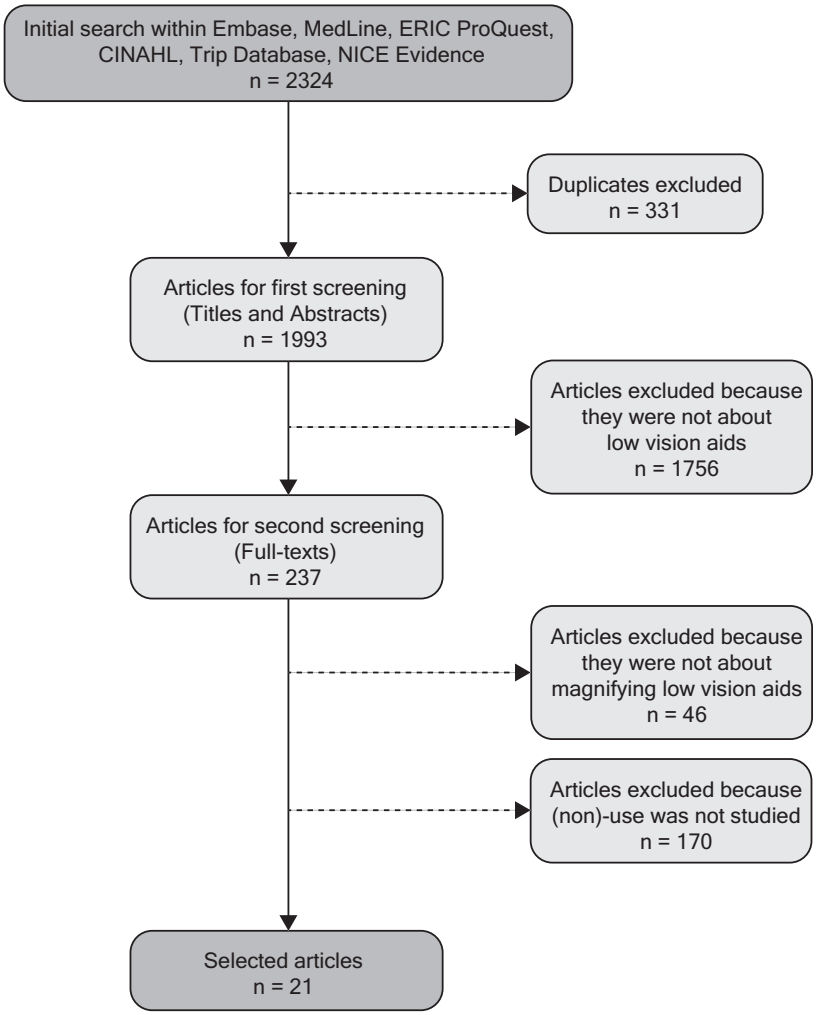

Figure 2. – Flow chart of study selection process

Charting the data

A charting form was developed by the first author to retrieve the following data from the selected studies: author(s), year of publication, methodology, design, population, sample size and characteristics of the participants, type of magnifying low vision aids, (non-)use measurement, usage rate, theoretical frameworks and categories of factors related to magnifying low vision aids use (see Supplementary Table S7).

Collating, summarizing, and reporting the results

By incorporating the guidelines published by Colquhoun et al. [15] as well as Sandelowski [17], the first author conducted a qualitative and numerical description, whereby the quantitative analysis focused on the characteristics of the studies (year of publication, design, sample/population). A qualitative description presents data to answer the scoping review question. The four previously presented categories of personal, device-related, environment and intervention were initially chosen [13, 14]. However, if a new category should emerge, based on information that would not fit these existing four categories, it would be reported as a new category. Then, each time an item was identified in articles selected, it was placed in one of the four pre-determined categories in the appropriate column of the charting form.

RESULTS

1. General findings

Study characteristics

The publication dates of the 21 selected studies ranged from 1974 and 2017. Observational studies (e.g., chart reviews or clinical service descriptions) represented 86% while 14% were intervention studies. Cross-sectional data collection was most frequent, representing 62%, compared to 38% for using a longitudinal design. Two randomized controlled trials were identified. Sample size varied between n = 11 and n = 343.

(Non-)usage rate

Studies on (non-)use of magnifying low vision aids exhibited high variability rates of participants owning/having devices available but not using them (range: 2.3% - 50%, M = 25%, SD = 14%). It is important to highlight that results from separate studies cannot be directly

compared, in part, because these studies did not focus on the same devices, they defined (non-)use in different ways, and measured it differently and at different moments in time. Thus, to attempt to present the results in a more cohesive way, low vision aids were categorized according to the working distance that characterizes their use. While studies focusing on low vision aids in general reported a nonuse rate ranging from 14.6% to 36% (M = 21.9, SD = 7.7) [11, 18, 19], those involving mainly near low vision aids exhibited a non-use rate between 2.3% and 46.72% (M = 20.5, SD = 10.6) [8, 10, 20-28], whereas the one study using distance low vision aids recorded a non-usage rate of 50% [24]. Some of the studies indicated that distance low vision aids were characterized by a very high rate of rejection as compared to near low vision aids. For instance, one study using closed-circuit television systems recorded a very good acceptance rate but telescopes were characterized by a very high rate of rejection (non-specified) [27].

Proportionally, the most prescribed low vision aids were for near tasks. For example, one of the studies reported that 89% of their patients were issued with low vision aids to assist near vision, whereas only 4% patients were issued with distance low vision aids, while 7% were issued with both [10]. Interestingly, one study explored the usage of near devices, which are the most abandoned; of the 33% of the near devices that were never used, 53% were hand-held, 28% were spectacle-mounted and 19% were stand magnifiers [10]. As mentioned above, the definition used by the authors to describe the (non)-use is important. For this scoping review, a range of definitions used to characterize (non)-use was established that are discussed in the next section.

Definition of (non-)use.

The clearest question that defined (non-)use of magnifying low vision aids was asking participants: “Have you used the device?” or specifying: “Have you used your devices consistently” [26,p.30]. In general, actual use was defined as a binary variable (yes/no question)

[20, 28, 29]. In one study, assistive technology use was measured as the reported total number of devices used, based on a given list of devices, wherein the authors aggregated all the information into a sum score [30]. Some authors applied a more refined and precise definition of (non-)use whereby device abandonment could be defined as no-use in the past three months [8] or in the past year [31], or as interrupted usage during the past year [31]. Non-use was defined as irregular use averaging less than twice per month [18] and as no use in the previous four weeks [21]. Quantitative details referred to: how long the device was used [22], the frequency of use [8, 10-12, 18-21, 23, 26-28, 32, 33], the duration of use [8, 11, 20, 21, 23, 26, 27] at one time [20], per day [23, 31] or the longest time of continuous use [21], the last time a device was used [11], or the average use [26]. Implementing a more functional approach, participants were asked to manipulate the device to prove that they continued using it [22]. Demirkilinc et al. [28,p.982] used the definition of Nilsson et al. [34] of "not treatment success" as a condition "when the patient does not find an aid beneficial and does not use it to solve one or more visual problems". More comprehensively, the use of low vision aids for reading was categorized at several levels of success whereby the determination of levels involved four factors: the degree of helpfulness in the reading task, the frequency of use, the duration of use, and the improvement in reading ability [11]. In the same way, Rosenbloom [25] defined usage as the extent to which a low vision patient continues to use a low vision aid and the extent of its use in his/her life. In summary, a large variety of terms referring to non-use can be found in the literature (also see Supplementary Table S7).

2. Categories of factors reported as related to (non-)use of magnifying low vision aids

Personal category

Demographic factors

Personal characteristics such as gender, age, and education, were studied by several authors in order to establish if they have the potential to influence and predict the (non-)use of magnifying low vision aids. Although a consensus was not always observed, the studies provided different insights. Regarding *gender*, it was found that females were more likely to use assistive technology after the provision and after one year following the provision [30]. However, in another study the authors indicated that gender was not significantly related to the perceived benefit of a magnifying low vision aid [20]. As far as *age* is concerned, several studies did not reveal any significant relation to low vision aid use [10, 11, 30, 31], nor was age an indicator of successful device use [20]. One study indicated that there was no evidence for low vision aids to be less frequently used by older patients [12]. In contrast, other studies highlighted that age was a risk factor for not using a magnifying low vision aid; it appeared that increasing age was a factor in decreasing compliance. For instance, Demirkilinc et al. [28] stated that 73% of their patients who were 65 years old or younger used their low vision aid. In contrast, only 47% of their patients older than 65 years used their devices. Similarly, Watson et al. [31] indicated that those under the age of 74 reported the most success with their device use. Other authors came to the same conclusion; however, they revealed that age could not be used as a reliable predictor of patient satisfaction or of eventual benefit [10]. Moreover, individuals with more *education* were more likely to use assistive technology initially, and education was significantly linked to change in the use of assistive technology over time, whereby those with more education showed a tendency to reduce the number of devices used over one year [30]. Other authors affirmed that lower education was not a contributing factor of device abandonment [29]. Finally, one study concluded that none of the demographic characteristics were significantly different between those who had abandoned a device and those who had not [8].

Physical factors

Physical factors were defined as characteristics such as: diagnosis, type of visual field deficit, duration of vision loss, visual acuity, global change in vision and functional and physiological issues.

The effect of *diagnosis* on the use of low vision aids had been studied by several authors, with divergent conclusions. Some did not detect a statistically significant difference in the usage rate across diagnostic groups [11, 28, 31]. However, for other authors etiology constituted a predictive factor related to device compliance. For instance, McIlwaine et al. [10] concluded that patients with non-macular disease tended to have lower compliance rates than patients with macular disease; however, they highlighted that etiology could not be used as a reliable predictor of patient satisfaction or of eventual benefit. It appeared that the *type of visual field* deficit was considered as a consistent predictive factor related to low vision aid compliance, whereby several authors observed that patients who had a documented loss of non-central visual field were significantly more likely to have abandoned their magnifying low vision aid [8, 26, 33]. One study reported that *duration of vision loss* on low vision aid compliance was positively related with low vision aid use at the delivery time and after one year, with an even stronger relation after a one-year period than initially [30]. *Visual acuity* was an important factor, and its link to device use has been studied extensively; however, divergent conclusions emerged from this scoping review. Some authors indicated that the patients' visual acuities were related to the compliance rate; for example, decreasing visual acuity might decrease compliance without visual acuity being used as a reliable predictor of patient satisfaction or of eventual benefit [10]. Interestingly, for these authors, visual acuity could not be used as a reliable predictor of patient

satisfaction or of eventual benefit. In contrast, for others, visual acuity was not statistically related to continued use [11, 28].

Global change in vision appeared as a factor related to perceived benefit of low vision aids use and motivation to use these aids [24] and was largely considered as a predicting factor of magnifying low vision aid usage. When vision was worse (decrease in visual acuity or general loss in vision), it appeared that usage rate was lower [8, 11, 25]. Two studies highlighted that when vision was much worse, aid use also decreased. However, the authors indicated that device use was improved when vision was improved or declined, and when it remained stable, device usage remained constant [20, 26].

Finally, among the other factors influencing success in magnifying low vision aid usage, *functional and physiological issues* such as degree of residual vision [25], fixation and focusing problems [24], and general age-related health changes or poor health were reported as relevant [25]. Interestingly, from a functional perspective, one study highlighted that when comparing subjects with different levels of disability (evaluated by a visual function questionnaire) at the beginning of device acquisition, those with a lower level of disability maintained a high level of use, suggesting that the level of disability did not appear to be predictive of (non)-use [18].

Psycho-social factors

Psycho-social factors make reference to various aspects in which magnifying low vision aids might impact on the individual's internal state, they refer to: perceived effectiveness, adaptability, self-esteem, confidence, and motivation.

For a device to be used, it must be perceived as *effective* to the one who uses it and provide some level of benefit. In this section, *benefit* makes reference to what extent the device meets the needs of its user, and concerns both occupational factors, referring to activities of daily living, and functional factors, making reference to more general near or distance tasks. Benefits of low vision aids might be seen as a substantial solution to a variety of needs, including reading, writing, and money management [35]. Moreover, the number of tasks that a patient was able to accomplish with a device was associated with perceived success [19, 20]. Feeling more competent and productive was a major factor influencing device usage [32]. Moreover, some studies point out that certain devices could encourage their use for new additional tasks beyond those initially anticipated, which could be considered as a signifier of success [35]. Indeed, it was estimated that 42% of the devices were used for additional tasks, with an average of two new tasks per device [11]. Similarly, Copolillo et al. [35] were interested in characteristics leading to successful low vision aid use decision-making, and highlighted the importance of experiencing positive appraisals of devices and discovering unexpected advantages. Intuitively, when the user failed to effectively realize a task with a device, the chances of abandonment increased [8]. It is important to highlight that, even if participants had abandoned their devices because they did not completely meet their needs, they recognized how much the device served them [26].

Adaptability is defined here as the ability to adjust to one's visual disability, to develop new strategies, to involve coping mechanisms to face the challenges of visual disability. In this scoping review, adaptability appeared to substantially affect magnifying low vision aids use. For example, Copolillo et al. [35,p.310] made reference to “adjustment to low vision disability”, involving different components, such as experiencing emotional reactions to having to abandon desired activities, making psychological and logistic adjustments, and maintaining independence.

Similarly, other authors investigated factors influencing success or usage failure and concluded that psychological and emotional adjustment to life with a visual impairment were considered success indicators [25, 26]. Interestingly, one study revealed that assistive technology users with visual impairments showed a statistically higher level of adaptability versus those with another sensory or with motor impairments [32]. In the majority of the cases reported, developing new strategies and skills influenced usage success; however, this was not always the case. For example, Bachofer [26] indicated that some users developed other strategies for the period when visual access was problematic, they felt that their coping skills were strong enough that the low vision aids use was not deemed necessary.

S*elf-esteem and self-confidence* were considered by some authors as key to success in the process of magnifying low vision aid use [32]. Moreover, confidence in assistive technology and placing high personal value on optical devices had been reported as a successful user's characteristic [26].

Motivation emerged as one of the main psychological factors, having received the most attention in the reviewed articles, and was influenced by intrinsic need as well as the presence/absence of depression. In this scoping review, studies that focused on motivation, agreed in their reports about its substantial influence on the use of optical low vision aids. Some authors indicated psychological reasons for the non-acceptance or discontinuation of an optical low vision aid, such as poor motivation and depression [24, 25]. Elsewhere, motivation was associated with success [32]. Moreover, for a user to use a device, it was necessary not only that s/he had identified its utility but also the need to use it. These two components were considered as fundamental [24, 26, 28].

Other personal factors

Use of several low vision aids. Other material resources closely related to device non-use or discontinuation relate to the use of another or other device(s) to complete the task [8, 11, 31]. The number of low vision aids owned was not related to successful or continued device use [20]. *Combination of personal factors*. A specific combination of personal factors previously cited could represent a predictor of the participants' confidence about device use. According to Bachofer [26], device users were statistically more confident about magnifying low vision aid use if they were male, had better central vision, and had used optical devices for a longer period of time. However, no direct comparison between these factors and the rate of use was made. Although a classification was used to make distinctions among the main categories related to the use of low vision aids, certain complex factors are influenced by overlap among categories as well as their interactions. This overlap is demonstrated in more detail in Figure 3. For example, satisfaction towards device use may be interpreted both as within the personal and the device categories. Satisfaction is reported here globally, without any distinction of specific components (i.e., performance, ease of use, service provided, counseling). Few of the selected studies revealed information about the users' global satisfaction with their devices. Using the Quebec User Evaluation of Satisfaction with Assistive Technology questionnaire to assess user's satisfaction [36], Burton et al. [32], stated that participants generally reported medium to high satisfaction with their assistive technology. Also, the number of tasks that a user was able to accomplish and the frequency of use had been associated with perceived success but not duration of use [20]. Interestingly, despite using a device, users may not necessary be satisfied by using it. Indeed, among patients who used their low vision aid, only 30% were satisfied [28]. Along the same lines, another study exhibited a significant reduction in patient satisfaction after 18 months,

compared to the initial three months. Yet, disability was reduced from the low vision aid acquisition, the use of devices remained high, and there was no substantial change in device use for the same time period [18].

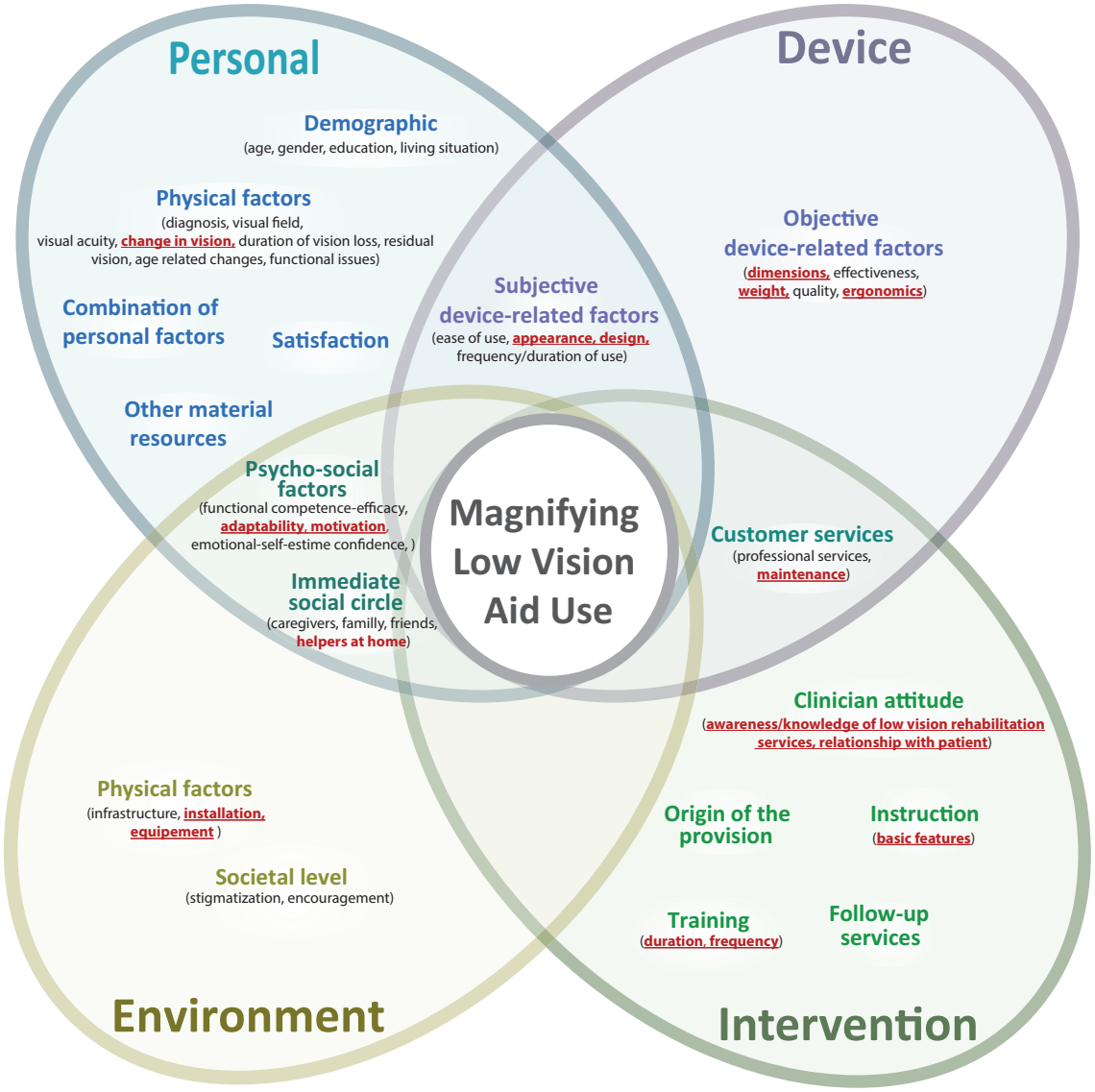

Figure 3. – Classification of categories influencing the use of magnifying low vision aids.

Figure 3 displays the factors involved in the use of low vision aids use according to the selected articles of this scoping review. The most frequently mentioned contributing factors are underlined.

Device category

Factors in this category refer to objective and subjective components of the device. Objective aspects make reference to intrinsic parameters of the device such as: dimensions, weights, ergonomics, quality, effectiveness, and maintenance. Subjective aspects define extrinsic parameters involving the habits or the judgment of the user such as: frequency and duration of use, design/appearance, or ease of use.

Objective device-related factors

Types, dimensions, weight, design/ergonomics, quality of the device, technical performance and price may be considered as facilitators or barriers. Two studies indicated that low vision aid type was relevant because distance low vision aids were characterized by a very high rate of rejection as compared to near low vision aids [24, 33]. Dimension and weight were considered as challenges to successful device usage. Indeed, limits of low vision aids use were reported for devices characterized as too big, heavy, or as taking too much space [10, 35]. Another reason for discontinuing use were the ergonomics [11]. Rinnert et al. [27] indicated that, of approximately one fifth of non-used low vision aids, one of the responsible reasons was impractical handling of the device. Another reason related to the ergonomics was cited by Chan et al. [24] and concerned five of 30 participants who decided not to use a microscopic system because of the uncomfortable short working distance between the reading material and the eye. The quality of the device was also a predictor of the (non-)use, whereby 17% of participants abandoned their device because of a defective lens that interfered with use [8]. Technical performance was mentioned in some studies and corresponded to the functionality that a device may have, depending on the nature of its technical components. One of the main reasons reported by users who had abandoned their device was that the magnifying power was too low [11]. The

cost of the device and its maintenance were important factors mentioned as potentially impacting the usage but they were not extensively studied [29]. Maintenance is not only related to the device but also to the intervention and may be analyzed as a more complex combination of factors belonging to two categories (i.e., device and intervention categories).

Subjective device-related factors

The way in which the device is used is intimately related to the user's lifestyle. It appeared that the frequency of low vision aid use was a good indicator of its perceived benefit [28]. However, for other authors the duration and frequency of use did not represent a success predictor [20]. Reasons for discontinuing usage also related to dislike of the design and appearance [11]. Magnifying low vision aids characterized as awkward [26, 35] or with a cumbersome appearance [33] were often abandoned. The ease to use a device is an intuitive indicator. Demirkilinc et al. [28] stated that 29% of the patients who obtained a low vision aid, but never used it had done so because the devices were not practical, a finding replicated by Bachofer [26]. Additionally, magnifying low vision aids continued to be abandoned due to time-consuming manipulation [33]. In the context of children with low vision, device features that were not adapted to their age, represented a barrier [19]. The place where users keep their device was considered as an indicator of successful use (i.e., reachable versus inaccessible) [20]. Maintenance, as well as professional or follow-up services were classified in a combination of the *device* and the *intervention* categories. The fact that a device had been lost or broken and had not been replaced was one of the reasons for not using magnifying low vision aids [26].

Social acceptance and fear of stigmatization can be related to the psycho-social impact of the device on the user and is another example of overlap. They might be considered part of device (subjective factors), personal (psychological), and environment (society) categories. Little

information was found within the reviewed studies. In one study, magnifying aid users were characterized by having a high social acceptance of their devices [26]. Surprisingly, Copolillo et al. [35] reported that the literature did not document fear of stigmatization as a major concern for older adults; however, this fear constituted one of the reasons for not using devices by younger adults [26].

Environmental category

Environmental factors refer to the immediate personal social circle (e.g., caregivers, family and friends), the larger-scale *social* environment (e.g., at the societal level), as well as the *physical environment* (e.g., urban or home architecture, outside and interior infrastructures). The social circle is probably the most frequently solicited support environment by the visually impaired person, and includes individuals who are most familiar with the person's needs. Resource exchange refers to a well-established, informal network of families, friends and people with low vision [35]. It has been demonstrated that having a supporting individual in the home was significantly related to use of the low vision aids [11, 31], where the probability was 1.9 times higher of continued device use [11]. The majority of study participants across publications referred to the family as a support system; however, some also acknowledged the potential negative effect on autonomy by relying on family instead of independent action initiated by the person with a visual impairment. For example, some individuals were pressured into getting a device by their family members without really wanting it [8].

The extended social environment can also potentially impact on how a person will use a technological aid. Its effect can be a facilitator as reported by Burton et al. [32]. When asking the question, "What have been the biggest keys to your success with assistive technologies?" one user commented, "It's about taking recommendations from other very important

folks" [32,p.104]. In parallel, the impact of society can induce the opposite effect; for example, Bachofer [26] reported a form of stigmatization induced by student's mockery, causing abandonment of the low vision aids. Interestingly, a recent randomized controlled trial exhibited no negative peer comments for children experimenting with iPads as a mainstream device at school [19].

Physical barriers to device training represent another cause of potential non-use. Infrastructure, such as limited access to transportation, appeared to limit the ability to receive training with a device [29]. Lack of supplementary materials to facilitate device use, such as a reading desk, was also a limiting factor, highlighting the importance of equipment and appropriate installation for the optimal device use home [8]. In some cases, although lighting needs were assessed in the clinic, they could also be problematic if the user was unable to maintain and control the optimal illumination level at home [31]. These non-optimal lighting conditions should all the more to be taken into consideration, as a fifth of low vision aid non-use was caused by unsatisfactory illumination [27]. In addition, with the use of mainstream devices, a connected environment becomes indispensable. For example, in the context of the use of an iPad by visually impaired children in school, a lack of access to the Internet had been reported as a major barrier [19].

Intervention category

For a device to be disseminated to the user, practitioners / professionals must be aware of the existence of the device, and be able to identify the needs of their patients in order to direct them towards the most beneficial magnifying low vision aid. It seems obvious that appropriate devices assured continuous use [35]. Yet, Copolillo et al. [35] observed that a certain number of professionals lacked awareness of optical low vision aids as alternative solution and did not

discuss low vision devices with their patients nor oriented them towards low vision rehabilitation services. It appeared that maintaining positive interactions between the patient/client and low vision health care professionals were essential in the process of acquiring and incorporating low vision devices. Negative health care experiences, unmet device needs, poor knowledge of devices, and delays in obtaining an appointment were considered as barriers to magnifying devices use [35].

When an individual starts to use an assistive technology, s/he should undergo the correct provision process, training in its use and installation in the specific environment or context. Proper instructions about the use and maintenance of the device by the clinician or any provider appeared as essential to enhance the use of a device [23]. Indeed, one fifth of non-used low vision aids were abandoned, in part, because the prescribing practitioner failed to provide instructions [27]. Innovative therapeutic education strategies are increasingly used in visual rehabilitation. For example, the impact of a video program, explaining ocular disease and treatment solutions and optical devices, on knowledge and willingness to use the devices have been explored and the authors concluded that the video program had a clinically small but statistically significant impact on use [29].

After initial and basic instructions, training emerged as an important component for magnifying low vision aid users. Indeed, 50% of users felt training was somewhat to extremely important and was very critical of how care is provided and how monitoring is ensured. [32]. According to McIlwaine et al. [10], 50% of patients were not satisfied with the service they received, of which 25% requested more training in the use of their device, and about 50% wanted follow-up appointments. However, in another study 75% of participants preferred to have access

to a setting where they could try out on their own different devices and ask question, rather than a specific group or individual training session [32].

The duration and frequency of training seemed to be predictors of a high level of compliance. Some authors suggested that a higher degree of training could be related to successful low vision aids use [31]. For example, a very high compliance rate was observed in a population of low vision veterans, where most of them received more than 20 hrs of training and more than 20 hrs of practice in the use of their devices at the clinic. Among these veterans, 95% stated receiving enough training and practice [11]. In another study, the authors highlighted that health services providing intensive training in optical device use achieved a higher level of compliance. These same authors concluded that a mean to improve service may be operated by employing additional providers specifically trained to teach low vision patients how to optimize the use of their devices [10]. Finally, frequency of use was a better indicator of perceived benefit from low vision rehabilitation [20]. Clinical training is the most commonly reported intervention type, but for ecological reasons, some authors highlighted the importance of transferring learning from the clinic to the home when attempting to incorporate optical low vision aids into the daily routine [35]. Finally, neither the number of visits to the clinic nor the place where the device was provided constituted factors of success [20]. However, others observed that, although some users may be disappointed by their device, the use of magnifying low vision aids was more frequent by those who had attended a low vision clinic [12], whereas benefits from attending the clinic were reported by 89.5% of patients and 81% of patients were regularly using low vision devices [20].

DISCUSSION

The purpose of the present scoping review was to map the literature on factors related to magnifying low vision aids (non-)use, building on an existing classification of assistive

technology non-use in general [13, 14]. As expected, the previously established four categories (*personal*, *device-related*, *environmental* and *interventional*) were well suited for the classification of the factors that emerged from our review, whereby the most frequently reported category consisted of factors related to the personal characteristics of the device users.

Expected and present findings

Personal category

Demographic factors have been identified in this review as conflictingly influencing low vision aid (non-)usage. The effects of *age, gender,* and *education* were reported in the selected studies in an inconsistent way. In parallel to some demographic factors identified here as contradictorily influencing low vision aid (non-)usage, the influence of age was also reported in the literature in an inconsistent way. Advanced age of the users represented one of the predictors for non-use. For example, Zammitt et al. [37] had identified that referral at an early age represented a factor likely to positively affect device use. It appeared that elderly patients were more likely to have general associated health problems and limited dexterity skills, which impacted on low vision aid use. However, in other studies, age had not been associated with (non-)use of devices [38]. Leat et al. [39] did not find a relationship between age and perceived benefit of low vision aids use as a measure of success.

Regarding physical factors, the effects of *diagnosis, visual acuity,* and *visual fields deficit* on the use of low vision aids had been studied by several authors and divergent conclusions emerged. One study looked at the effect of *duration of vision loss* on device compliance and reported it to be positively related with low vision aid use. *Change in vision* appeared as an important factor related to device use, whereby, when vision was worse low vision aid use was

decreased. As reviewed here, it seems that a consensus was not always observed regarding conclusions related to etiology. Indeed, while some authors considered ocular diagnosis as a predictor of use [40], others reported that etiology did not affect the continued use of devices in patients with diabetic retinopathy, glaucoma, optic atrophy, myopia, and retinitis pigmentosa, as well as in patients with macular degeneration [34].

Considering psycho-social factors, very little information was obtained regarding the social acceptance of low vision aids, and findings about stigmatization did not entirely converge. However, *psychological factors* were explored in different ways through *functional competence-efficacy*, *adaptability, self-esteem, confidence*, and *motivation*, having been reported as predictors of use. *Motivation and adaptability* are certainly the main psychological factors, having received the most attention in the reviewed articles and appearing as substantially affecting magnifying devices use. In line with these findings, literature exploring assistive devices use in other disabilities highlights that the *functional competence or efficacy* with the device is an important issue. If in general an assistive technology fails to improve function, it will probably be abandoned [41]. Regarding the psycho-*social* factors, many reasons for abandonment of assistive technologies are reported, but among the important reasons identified by the users, appearance remains a major concern [42]. Negative terms evoked by users, such as the fear to feel "dehumanized" or to appear "freaky" qualified their discomfort. Several studies related to low vision aid use in general and not necessarily related to magnifying systems, highlighted the importance of the *motivational and need* factors. Series of focus groups, conducted by the National Eye Institute (NEI) in the U.S. in 2001 [43], identified that patient motivation was one of the barriers to follow through on referral. Healthier psychological status and higher motivation at the time of rehabilitation were associated with better outcomes [44]. Along these lines,

Overbury et al. [45] found that success with low vision aids was positively associated with present need for activities requiring vision. When the assistive technology was well integrated into the users' own life, device users felt grateful, and when they considered the device as a physical extension of themselves, the acceptance was described as internal [46]. Surprisingly, 23% of the general low vision aids prescribed were found useful at home [40]. Acceptance is compromised when a person accepts the assistive technology only when there is a need and when it is a means of carrying out activities of daily living [47]. Psychological factors, such as adaptability, were also highlighted by several authors; coping strategies influenced acceptability of an assistive device, they referred either to personal adaptation, or active modification of the environment [48].

Device category

Design and appearance emerged as predictors of use, and devices whose appearance was judged negatively by their owners were mainly not used. Several studies converged in the conclusion that ease of use is another major factor. Devices perceived as awkward are likely to be abandoned [49]. In parallel to theses *subjective* aspects identified in the present review, the difficulty in operating the device and its maintenance were reported as major barriers for assistive technology use in general [50]. Regarding the *objective* aspects, dimension, weight and ergonomics emerged here as challenges to successful low vision aid usage. In line with this conclusion, assistive technologies that feel heavy or defective were not being used [49]. In this scoping review, low vision aid type mattered since distance devices were characterized by a very high rate of rejection as compared to near devices. However, this findings needs to be considered with a grain of salt, given that only one study reported a nonuse rate for distance low vision aids. Proportionally, low vision aids for near tasks were the most prescribed because near vision

activities, such as reading, are the main reason for consultation in low vision rehabilitation. Patients used more microscope than telescope systems because they had a greater need for near vision tasks in their daily lives, and also because telescope systems may present problems of focusing and fixation at a certain level of magnification [24].

Environmental category

Regarding environmental factors and, more specifically, the users' *social circle*, the majority of the selected studies referred to the family as a support system. Having a helper at home was significantly related to use of the low vision aids. Parallels in the literature have been reported whereby parental involvement has been shown to be a statistically significant predictor of device use. For example, high school students having a visual impairment with parents involved in several parent meetings or participating in training sessions were more likely to use assistive devices in comparison to those whose parents were not involved [51]. Similarly, Zammitt et al. [37] found that a lack of involvement of the child's teacher and parent negatively affected device use. However, the influence of family did not seem to easily replicate as Overbury et al. [45] found that success with low vision aids in general was not positively associated with the degree of family support. While this scoping review provides little insight about social acceptance, previous reports indicate that stereotypes maintained in society and the media in general might negatively influence the use of assistive devices [52]. Various studies indicated that fear of stigma and marginalization is implicated in the process of deciding when and under what conditions to use low vision aids [53, 54]. Change in personal competencies suggested by the use of an assistive technology may have the potential to trigger negative social judgments and affect its acceptability [55]. Many of the studies selected here agree that the *physical environment* can represent barriers to device use. This scoping review shows the

importance of equipment and appropriate installation for the optimal use of devices at home, and that a lack of adapted materials/environment represents an important barrier. Limiting physical access to training represents an important cause of potential non-use as well. Similarly, transportation to and from device training was identified as a barrier [43]. Given that environmental barriers can indirectly limit the acceptance of an assistive technology, other authors insisted on the importance to assess physical environmental barriers in the home and in the outdoor environment [56].

Intervention category

Among intervention characteristics, professionals lacked awareness of low vision rehabilitation services and types of available low vision aids are commonly reported as barriers. Negative interactions between the patient and healthcare professional represent another barrier to use in the context of the *provisioning and attribution processes*. Similarly, knowledge of and ability to communicate about a patient's visual impairment might have an impact on positive response to using low vision aids [57]. It seems obvious that for a patient to access low vision services or appropriate devices, it is necessary to first be aware of their existence. However, not only are many adults unaware that they are eligible to receive low vision services, but they have limited knowledge about the varieties and types of available low vision aids and whether they may be of benefit. For example, individuals with low vision have very limited awareness of the benefits of additional lighting [58], while limited knowledge of both services and devices substantially contributed to the delay or absence of device acquisition [59]. Another barrier to referral was the length of time to obtain an appointment [43]. Yet, delayed introduction to devices negatively affected device use [37].

Proper basic instructions and *training* about the use and maintenance of a device by the clinician or any provider appeared as essential to enhance the use of magnifying low vision aids. Interestingly, duration and frequency of training seem to be predictors of a high level of compliance and most of the selected studies agree that intensive programs increase device use. Similarly*, training* has previously been identified as an important aspect in the process of low vision aid use in the literature at large (i.e., not necessarily related to magnifying systems). For example, in different studies involving patients with visual loss due to complications of diabetes [60] or macular degeneration [34], training was considered as essential, and insufficient training negatively affected device use [37]. An increase in quality and quantity of training in device use had been identified as a potential correlate of successful low vision aid use [35]. Interestingly, in comparison with traditional low vision services, Shuttleworth et al. [61] argued the importance of an integrated approach to low vision rehabilitation with an emphasis on training. In view of the importance of training, the characteristics of the population are relevant. Indeed, older adults might experience difficulty transferring what they have learned in a clinic to their living environment [62]. Finally, to maintain relevant training specifically addressing the individual's needs, regular follow-up was necessary, as failure to provide timely reassessment negatively affected device use [37]. While the present study did not find congruent conclusions related to the *place where the individuals practice with their device,* literature provides insights. In the context of young adults, school placement represented a statistically significant predictor of device use. For example, high school students with low vision attending residential schools were 1.8 times more likely to use assistive technologies than those not attending [51].

Expected but absent findings

Interestingly, some anticipated factors such as quality of life, did not emerge in this scoping review. Although different psycho-social factors have been studied separately, they have not been related to each other so as to reflect quality of life more generally. Yet, in the same way as if an assistive device fails to improve function, or if quality of life is not improved or even declines, the device will probably be abandoned. For example, Day et al. [63,p. 34] stated that "an assistive device should promote good quality of life for the user to the extent to which it makes the user feel competent, confident and inclined (or motivated) to exploit life's possibilities". Taking into account quality of life, the Psychosocial Impact of Assistive Devices Scale (PIADS) [41] was developed specifically to assess this dimension of assistive technology use. It reflects the quality of life with three distinct subscales: competence, adaptability and self-esteem, and is a reliable and valid tool that appears to have significant power to predict abandonment and retention.

In the present study, the focus is on optical and non-optical magnifying systems. Most of the studies concerned near optical low vision aids, such as handheld and stand magnifiers. In contrast, very little information has been gathered about magnifying software. Yet, software has become more and more available with the digital development, and its use is widespread among individuals with visual impairment that are using computers. A preliminary search within online databases revealed articles about tablets and smartphones as low vision aids [64]; however, these articles were excluded from this scoping review because they were not associated with non-use but only focused on performance measure comparisons. Unexpectedly, taking the user opinion into account during the low vision aid selection process did not emerge as a factor. Yet, the

literature defending the need to include user input in the process of assistive device provision is abundant [41, 63, 65].

Finally, the present scoping review focused on sophisticated devices requiring a certain budget. One expected major potential negative factor that did not appear in the selected studies was the expense related to the devices; yet, a series of focus groups [43] had identified the cost of visual aids as one of the major barriers to referral. More generally, cost has been identified as the primary barrier to acquiring all assistive technology, including low vision aids [66, 67]. In line with these findings, devices outside of low vision also faced this issue. It was speculate that the regional differences in third-party payer systems and insurance eligibilities across countries are partially responsible for why the topic of funding and device expenses is only discussed within the context of cost-benefit analyses but not within studies on device abandonment.

Theories on the prediction of compliance behaviour

Parallels have been found between the mechanisms influencing non-use of assistive technology and those influencing non-adherence with other medical interventions [68]. Adherence to healthcare treatments or intervention is complex involving multiple factors that interact and produce individual behaviors. Model-linked medication adherence interventions, such as the Theory of Planned Behavior, the Health Belief Model and the Medication-Taking Behavior Model [69-71] propose four influencing categories of factors related to the: person (e.g., self-efficacy, cognitive impairment, culture and ethnicity, stress, depression, comorbid conditions); health system (e.g., access to medication, care delivery approach); treatment (e.g., cost, regimen complexity, treatment duration) and environment (interpersonal influences, or information from friends, relatives). Although these categories are named differently, there is

large overlap in their content when compared to those identified here for assistive technologies and low vision aids [13, 14].

Currently, more and more medical research is based on psychological theories in order to study and predict the adherence to and compliance with a specific treatment. The extent of theory use and intervention effectiveness in terms of adherence and clinical outcomes varied across studies. Interestingly, Livi et al. [72] used a health behaviour theory to predict non-compliance with daily disposable contact lenses replacement. Using the Theory of Planned Behaviour model [73], they showed that user's perceived behavioural control and its subjective norms are two significant predictors of compliance behaviour. Regarding technology acceptance, The Technology Acceptance Model [74] and the Unified Theory of Acceptance and Use of Technology [75] are the models often employed to explain (non-)usage based on specific predictors. These two models are relevant but do not take into account biophysical, psychological, and contextual factors [76]. In this context, the biopsychosocial model of the International Classification of Functioning, Disability and Health [77] had been identified as a more comprehensive predictive model to determine the best match between person and technology [78]. Despite the increasing use of theories, more research testing theory-based interventions is necessary to add to the body of evidence in this field [79]. Indeed, only 18% of medical adherence interventions identified reported using a theory or conceptual framework for developing interventions [80]. In comparison, only 15% of the studies included in the present scoping review used a conceptual framework. Among them, the theories included were mainly borrowed from the field of health psychology, but were not directly related to prediction of compliance behaviour or potential to adopt a particular technology. Like in many medical interventions, it would be relevant and advisable to use theories, such as Health Psychology

Theories or those related to assistive technology models to explain the mechanisms underlying the use of low vision aids.

Implications for rehabilitation

The results suggest that clinicians should establish positive partnerships with patients for them to better be able to understand the necessity and expected effectiveness of the low vision rehabilitation services and devices as prescribed. It appears that acceptability of assistive technology is highly related to its characteristics and emphasizes the need for developing/enhancing collaborations between clinicians, researchers, engineers and industry in order to pool their expertise and efforts towards emergence of effective and appropriate assistive technologies accepted by the target population. These findings also suggest that clinicians should involve patient's relatives more in the rehabilitation process. Health policy and healthcare providers should further support the deployment of evaluation and training in the patient's home, providing individualized services, overcoming physical distance as a barrier, and promoting innovative intervention, such as telerehabilitation.

Limitations and Next directions

Several challenges in this scoping review were associated with the heterogeneity in terms of populations, low vision aids, adherence definition, adherence measurement, application of relevant theory in terms of independent variable selection, study duration, and presentation of outcomes. Regarding the populations, the reviewed studies mainly focused on older adults with a diagnosis of macular degeneration. Thus, it seems difficult to generalize to the entire low vision population. In terms of type of magnifying low vision aids, studies related to tablets and smartphones were mostly excluded because all except one did not included measures of non-use

or related factors. More information on the reasons for abandoning these technologies and comparisons with conventional low vision systems would provide a more complete view, especially as these current technologies are increasingly used as magnifying visual aids by the visually impaired population [64, 81]. Given their multi-functionality, it will be interesting to observe how non-use will eventually be defined for these devices, as they may be used for some activities in an adapted format (e.g., enhanced contrast) and for other functionalities without adaptations (e.g., music). Moreover, it was difficult to isolate magnifying devices during the review because some studies included magnifying low vision aids exclusively while others did not. In these cases, the specific information extracted on magnifying low vision aids was compromised. Several challenges were associated with the design of the studies. In the majority, self-report was the main measure of low vision aid use. However, indirect measures can involve some degree of assumption that a participant has used the device, leading to a potential overestimation of utilisation, thereby reflecting response bias. Further, few of the studies were longitudinal with follow-up assessments of usage rate, and very little information was available about changes in magnifying low vision aid (non-)use over time. Despite the limitations, we were able to identify and summarize a large number of predictors. This scoping review repesents the first step, in the context of exploring factors related to discontinuation of head-mounted displays, a new class of magnifying low vision aid, used both at near and distance, for which we do not yet have insights about which factors may be related to their non-use. Both a cross-sectional study and a prospective trial are ongoing to determine whether similar variables are involved.

Conclusion

When studying the factors that affect the non-use of low vision aids, through an existing classification in four categories, it was possible to replicate the same classification of personal, device-related, environment and intervention categories to the specific context of magnifying low vision aids. Although a categorical classification was used, there was a dynamic interconnection among the four categories influencing the use of such devices. Certain complex factors are influenced by overlap and interactions among categories. We hope that our work will assist clinicians in their efforts to identify patients that are unlikely to utilize their low vision aids, and overcome their barriers to device acceptance. We aim to provide evidence for optimal rehabilitation service provision to the low vision population designed to reduce device non-use and to improve the patients' quality of life. The fact that magnifying low vision aids and medical interventions, in general, share the same categories influencing patients' behaviour suggests that strategies applied to enhance adherence of a treatment might be useful to reduce non-use of low vision aids. More complete descriptions of interventions and the linkages between specific intervention components within a theory framework are the next logical steps.

Acknowledgement: The work was supported by Mitacs Accelerate Fellowship IT08595 Grant.

Declaration of Interest: No potential conflict of interest was reported by the authors.

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Article 2: Factors related to the use of a head-mounted display for individuals with low vision

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Keywords

Visual impairment, Assistive technology, Head-mounted display, Magnification, Adherence, Abandonment

Accepted December 10th, 2019
In press with *Disability and Rehabilitation*

Marie-Céline Lorenzini, Anni Hämäläinen and Walter Wittich (2019) Factors related to the use of a head-mounted display for individuals with low vision, Disability and Rehabilitation,
DOI: 10.1080/09638288.2019.1704892

Abstract

Introduction: The decision-making process around the (non-)use of assistive technologies is multifactorial. The goal of the present study was to identify which factors predict or correlate with the use of a head-mounted magnification device for low vision (eSight Eyewear), by applying this multifactorial paradigm in order to tailor low vision rehabilitation interventions to reduce device abandonment. **Methods:** Using a cross-sectional design, participants were recruited from 567 eSight Eyewear owners to complete a 45-min survey online including questions from standardized questionnaires classified into four families: *personal, device-related, environmental* and *interventional.* Using current device use/non-use as a binary outcome, logistic regression analyses were performed to identify the variables that predicted the highest percentage of variance in eSight use. **Results:** The 109 (19.2%) respondents with complete data had a mean age of 47.7 years (SD=25.4, range: 9-96), 51% self-reported a central visual impairment. The final regression model alternatives accounted for 84.7%, 68.7%, 83.7% and 64.7% (Nagelkerke's pseudo R^2) of the variance in eSight use. The most consistently predictive variables of sustained device use across models were: higher scores on the **P**sychological **I**mpact of **A**ssistive **D**evices **S**cale (PIADS) and the **Q**uebec **U**ser **E**valuation of **S**atisfaction with assistive **T**echnology (QUEST) scale, and participants' lack of experiencing headaches while using the device. **Conclusion:** None of the traditional clinical variables (demographics, ocular or general health), or low vision rehabilitation experience was predictive of sustained use of a head-mounted low vision display. However, the administration of standardized device-impact questionnaires may be able to identify device users that could benefit from individualized attention during low vision rehabilitation provision to reduce the probability of device abandonment.

INTRODUCTION

Assistive technologies (ATs) are provided to increase the level of independence and function when engaging in activities of daily living (ADL), thereby promoting quality of life (QoL) [1]. Several studies recognize the strong association between needs and AT use and also the direct link between types and frequency of AT use and the type and severity of disability [2-4]. However, despite the functional and evidence-based benefits of AT use, the literature shows high rates of, and various reasons for, AT abandonment. The present study examines this phenomenon specifically in the context of a head-mounted magnification device for low vision (LV) because the majority of investigations so far have been conducted in disabilities other than visual impairment, or with LV devices that are not head-mounted. A person with low vision is defined as someone having difficulty to accomplish visuals tasks, even with optimal standard refraction, and having the potential to enhance his/her ability to perform these tasks using compensatory visual strategies, such as low vision aids and environmental modifications [5, 6].

In general, considering groups with various disabilities and device types, most authors report data that converge around an AT abandonment rate of 30% within the first year [7-9]. In the context of physical medicine and rehabilitation, Sugawara et al. [10] reported an abandonment rate of 19.4% for mobility ATs, such as wheelchairs or canes. In the context of LV rehabilitation, involving a wide range of low vision aids (LVAs, e.g., electronic canes, braille systems, electronic enhancement systems), the abandonment rates vary widely from 2.3% to 50% (Mean=25%, SD=14%) [11]. Health Psychology Theories, such as the Theory of Planned Behavior, the Health Belief Model and the Medication-Taking Behavior Model [12-14] were used to explain the determinants that can influence the likelihood of adherence to medical intervention to eventually anticipate and improve it [15, 16]. These models were then used to

make parallels between the mechanisms and variables influencing non-use of assistive technology or LVAs and those influencing non-adherence with other medical interventions [11,17]. Most researchers agree that AT abandonment is best viewed as multifactorial, being the outcome of a complex interaction of four main families of variables: *personal* (e.g., age, sex, diagnosis, expectations, motivation, health or disability evolution, etc.); *device* (e.g., weight, design, appearance, features and performance, etc.); *environment* (e.g., social support, physical barriers, etc.); and *intervention* (e.g., instruction and training, follow-up service, etc.) [18, 19]. The same families of variables were replicated in the context of magnifying LVAs. Fifteen percent of the included studies used a conceptual framework for developing their research. Among them, the theories included were mainly borrowed from the field of health psychology, but were not directly related to prediction of compliance behaviour or potential to adopt a particular technology [11]. The Technology Acceptance Model [20] and the Unified Theory of Acceptance and Use of Technology [21] are the models most often employed to explain (non-)usage based on specific predictor variables. These two models are relevant but do not take into account variables such as biophysical, psychological, and contextual factors [22]. In contrast, the bio-psycho-social model of the International Classification of Functioning, Disability and Health (ICF) [23] has been identified as a more comprehensive predictive model to determine the best match between person and technology [24] and would be consistent with the four families of variables previously identified.

It is, however, possible that the effect of variables differs among the various types of technologies available. One of the first head mounted displays (HMDs) was the Low Vision Enhancement System, a device that demonstrated its effectiveness in adults [25, 26] and in children with LV by improving visual acuity, contrast sensitivity and control of ambient

light [27]. Later, after considerable technological evolution, allowing them to become smaller and lighter, different HMDs (e.g., Jordy, Flipperport, Maxport and NuVision) had been compared with traditional optical LVAs (e.g., magnifiers, closed circuit television, telescopic systems) [28]. In this context, the importance of training for the use of HMDs were demonstrated for distant and intermediate vision compared to traditional LVAs. With the massive evolution of new technologies, mobile and wearable devices combining immersive or semi-immersive systems, such as virtual reality, have grown considerably and become more and more available for LV rehabilitation [29]. A recent trend has been towards portable HMDs, such as eSight Eyewear, a semi-immersive system, providing handsfree magnification and contrast enhancements at all distances, using digital image processing and real time video technology enabling users to scan through a wide-field image by responding to their head motion [30].

Currently, when purchasing eSight Eyewear, the users are provided with the eSkills User Guide [31], a self-training program developed by eSight Corporation. It provides instructions and exercises (e.g., modules on reading at distance and near, writing, and general viewing strategies) for device users, intended to increase their competence and familiarity with the device, and has been shown to be effective by improving visual abilities such as reading [32]. Systematic clinical evaluations of such devices remain rare. Recently, a multicenter prospective trial (NCT02616900) investigated the effect of HMDs on 51 novice eSight Eyewear users for three months. Overall, visual ability, ADL and reading showed greatest improvement with device use [32]. Currently little is known about why some individuals experience them as a success while others decide not to use them in the long-term. The main goal of the present study was to identify which variables predict a change in device use among current eSight owners. It was hypothesized that the four variable categories (*personal, device-related, environmental* and

interventional) that have been previously identified in the literature, in line with the bio-psycho-social model of the International Classification of Functioning, Disability and Health [23], to be related to magnifying LVAs would be replicated as predictors of abandonment of use in the specific context of this HMD.

METHODS

Definitions and Terminology

In the context of magnifying LVAs, definitions reported in the literature have not been harmonized; non-use was mainly defined as a binary variable (yes/no question) [33-35], was defined along measurable quantitative scales (start date, duration, frequency of use) [35-39], or qualitative observations ("*asked to manipulate the device to prove that they continued using it*" as defined by these authors) [37]. Some authors applied a more refined and precise definition of (non-)use whereby device abandonment could be defined as no use in the previous four weeks [38], or in the past three months [40] or discontinuation during the past year [41]. Therefore, in the present study, it was decided to use the past three months as the defining limit for usage. Moreover, as suggested by Lauer et al. [42], it was decided to replace the negative term "abandonment" with the more neutral term "discontinuance".

Participants and Recruitment

Ethical approval was provided by the Health Institutional Review Board of the Université de Montréal (#17-102-CERES-D), and the project adhered to the tenets of the Declaration of Helsinki for research with human participants [43]. Participants were recruited among eSight HMDs users from the eSight Corp (Toronto. Canada). They were users of second (eSight 2) or third generation (eSight 3) Eyewear which differ slightly in weight, ergonomics and quality of

the image. The current users were directly contacted by the eSight company via email to introduce the possibility of participation in this study, indicating the website link to access the survey. The company mentioned that the study was conducted independently, the company would not have access to any identifying information of the participants, and would not participate in the collection and analysis of the data. Additional recruitment was conducted though an announcement on YouTube via a low-vision-specific channel (The Blind Life: https://www.youtube.com/watch?v=VWzVucl7Xh8&t=101s) that focuses on visually impaired assistive device users. The eligibility criteria were minimum age of nine years, ownership of an eSight device for at least two months following the 1-month training period provided by the company, the ability to access the Internet and to read and write English. Informed consent was obtained from all participants, when they clicked on a web page link. For minors, the consent was obtained through their parents.

Design

Using a cross-sectional study design, participants completed a 45-minute survey online, in English, with servers located in Canada (https://www.hostedincanadasurveys.ca/), conforming with the national Tri-Council policy. Before its launch, the survey was pilot-tested by four individuals, one with normal sight to confirm content consistency and general accessibility, followed by three visually impaired individuals to confirm accessibility with technologies, one with JAWS screen reading software and two using ZoomText magnification software.

Demographics

Participants' data on sex, age, country, living arrangement, main cause of vision loss, visual field deficit as well as employment/study, educational, perceived general health and vision

status were collected. Participants were asked whether over the previous three months they felt their overall health and vision had stayed the same, improved, or deteriorated. They were also asked about having another sensory, physical, memory or cognitive impairment and, if applicable, asked to indicate the type and onset of the impairment.

Outcome measures

In the context of the analyses, discontinuance in device use was defined as a participant reporting non-use of the device in the previous three months for any task [44]. The outcome is a binary variable, the levels are *used in past three months (utilization)* vs. *did not use in past three months (discontinuance)*. The survey was composed of 94 questions adopted from two quantitative standardized questionnaires (PIADS [45, 46] & QUEST [47]) and one questionnaire specifically developed for this study, containing open and closed-ended questions (detailed below). These questionnaires were selected/developed according to their ability to evaluate factors related to the use and discontinuance of use of the device and QoL in connection with using eSight Eyewear. Variables included in this survey have been shown to influence magnifying LVA use according to a scoping review [11]. These variables were classified into four families: *personal* (demographics, general health, ocular condition, LVA experience, material resources and psychological variables explored by the PIADS), *device-related* (objective, such as eSight version type, QUEST score; and subjective variables such as general discomfort, headache), *environmental* (social environment such as living arrangement, family/friends encouragement; and physical environment) and *interventional* (LV rehabilitation experience, training and follow-up service).

Vision-Related Quality of Life measures

To measure the QoL impact of AT in a standardized and objective way requires specific designed tools such as the Psychosocial Impact of Assistive Devices Scale (PIADS) [46]. The PIADS is a 26-item questionnaire that measures the impact of using ATs on QoL in populations of adults who have various forms of disability and medical conditions [48], and was originally developed to measure the effect of glasses and contact lenses on QoL in college students [49]. The PIADS was created from empirical explorations with qualitative research, rooted in the literature on personality research. Relying on the fact that the construct of self-esteem is based on feelings of competence in the activities of daily living [50] and that the construct of competence is associated with independence [51], the PIADS includes items that are associated with constructs such as perceived self-efficacy and personal control. The PIADS is a reliable and valid tool that appears to have very significant power to predict AD abandonment and retention [52]. There are three subscales: competence (e.g., productivity), adaptability (e.g., eagerness to try new things) and self-esteem (e.g., sense of power) that are included within the construct of QoL, and constitute at least a portion of this complex construct. For each item, the respondents must provide a score ranging from –3 (negative impact) to +3 (positive impact); the final score is the overall mean. The Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0) is a 12-items outcome measure that assesses user satisfaction with two components, Device and Services, with a wide range of ATs in a structured and standardized way [47]. The QUEST was inspired by the *Satisfaction with assistive technology model* [53], whereby the relations between the variables involved in the experience of satisfaction with assistive technology are represented within a linear general framework and satisfaction is conceived as a reaction to assistive technology provision. However, satisfaction is also conceived as a person's critical

evaluation of several aspects of a device, influenced by his/her expectations, perceptions, attitudes and personal values. Thus, considering satisfaction as a multidimensional concept with Device and Services as two underlying dimensions respectively related to assistive technology, the authors designed the QUEST 2.0 as a bidimensional satisfaction structure. It is a reliable and valid instrument for measuring outcomes in the field of AT [54]. The twelve items are rated on a 5-point satisfaction scale grade (with one for "not satisfied at all" and five for "very satisfied"). Device (e.g., how easy it is to use your device), Services (e.g., the follow-up services, such as continuing support services, received for your device), and total QUEST score are calculated by averaging valid responses to assigned items (range 1 to 5).

Factors related to use

A questionnaire included in the survey (see Supplemental material S8), designed by the authors, was specifically developed to study the use of eSight Eyewear. It is a questionnaire with open and closed-ended questions whose main items refer to timing and frequency of use, nature of the task for which the device is used or abandoned, and reasons for discontinuation. It is composed of 40 items divided into five parts: Part 1 defines the use of eSight Eyewear (twelve items); Part 2 concerns eSight user's characteristics (eight items); Part 3 refers to eSight use changes (six items); Part 4 concerns social and physical environment (six items); and Part 5 asks about training/intervention (six items).

Statistical Analysis

Descriptive analyses were performed on demographic variables. Continuous variables are presented as mean and standard deviation (SD), whereas categorical variables are presented as absolute (n) and relative frequencies (%). Differences in categorical data between the groups (e.g,

participants who used versus those who discontinued device use) were compared with the Chi-square test. Differences in continuous variables between groups were evaluated with the Mann-Whitney U test for skewed distributed data, and t-tests were used for normally distributed data.

Analyses were based on an ecological approach in which variables were analyzed together. This approach assumed that discontinuance had a multifactorial origin, where the variables were interconnected. Logistic regression analyses were performed in order to highlight the variables that are predictive of eSight Eyewear use. The coding for dichotomous dependant variables for regression analyses was as follows: 0 (discontinuance) and 1 (utilization). From the 94 questions of the survey, grouped into four "families": personal, device, environment and intervention, 31 independent variables were initially tested (see Supplementary Table S9)**.** There were 15 **personal variables** (age, sex, level of study, ocular diagnosis, the onset of eye disease, change in vision over time, health condition, other impairment, experience with video magnifiers, experience with another HMD type, current use of several LVAs, total PIADS score, ability to control usage of eSight Eyewear, the question whether eSight Eyewear is right for the user, people's perception on whether the device owner should use the device); five **device-related variables** (eSight version type, QUEST score, general discomfort, presence of headache, and presence of eyestrain); seven **environmental variables** (living arrangement, who decided to buy eSight Eyewear, whether family helped with ADL, family/friends encouragement, people's reaction while eSight is used, people's perception on whether the device owner should use the device, physical environment interferences); and four **interventional variables** (LV rehabilitation experience, eSight training program completion, eSight training program is helpful, follow-up service satisfaction).

Logistic regressions were performed to assess the effects of the above predictor variables

on the use vs. non-use of the device. The strategy used for logistic regression analyses (Figure 4) was based on variable membership in the four "families" and performed in two steps: by first analyzing the effects of the most closely related variables (belonging to the same family), then moving on to associations of the least related variables (belonging to different families). The goal of Step 1 was to identify which variables within each family remained statistically significant when combined. These combinations were first made within sub-categories of variables (e.g., the device family was composed of two sub-categories: 1) objective variables such as *eSight version type* and *QUEST score;* and 2) subjective variables such as presence of *general discomfort*, *eyestrain* and *headache*), and then the variables that emerged as significant were combined overall within each family (Figure 4). Only variables that remained significant after this second combination were retained for Step 2 analyses. This approach was taken because the overall sample size of n = 109 was too small to allow for one overall model to be created with all variables entered at the same time. Therefore, this selection process was necessary to arrive at one final model that contained the smallest number of variables explaining the largest amount of variability. The goal of Step 2 was to combine pairs of families of variables (e.g., personal & device) using logistic regression in order to identify integrative models accounting for the highest percentage of variance in eSight use (higher Nagelkerke's pseudo R^2) (Figure 4). For models selected, the regression coefficient, odds ratio (OR), confidence interval for OR and pseudo R^2 were reported.

For each analysis, age and sex were controlled to serve as reference variables and because the continuous age variable can improve the model estimation. The independent variables were entered in the model using a "forced entry" strategy. Statistical analyses involving Chi-squared, Mann-Whitney and t-tests were conducted with JASP version 0.8.4 (JASP, Department of

Psychological Methods University of Amsterdam, Amsterdam, The Netherlands). Logistic regression tests were performed with SPSS version 25 (IBM SPSS Statistics, Armonk, New York, USA). A P-value < .05 was considered statistically significant and P values between 0.05 and 0.07 were considered statistical trends.

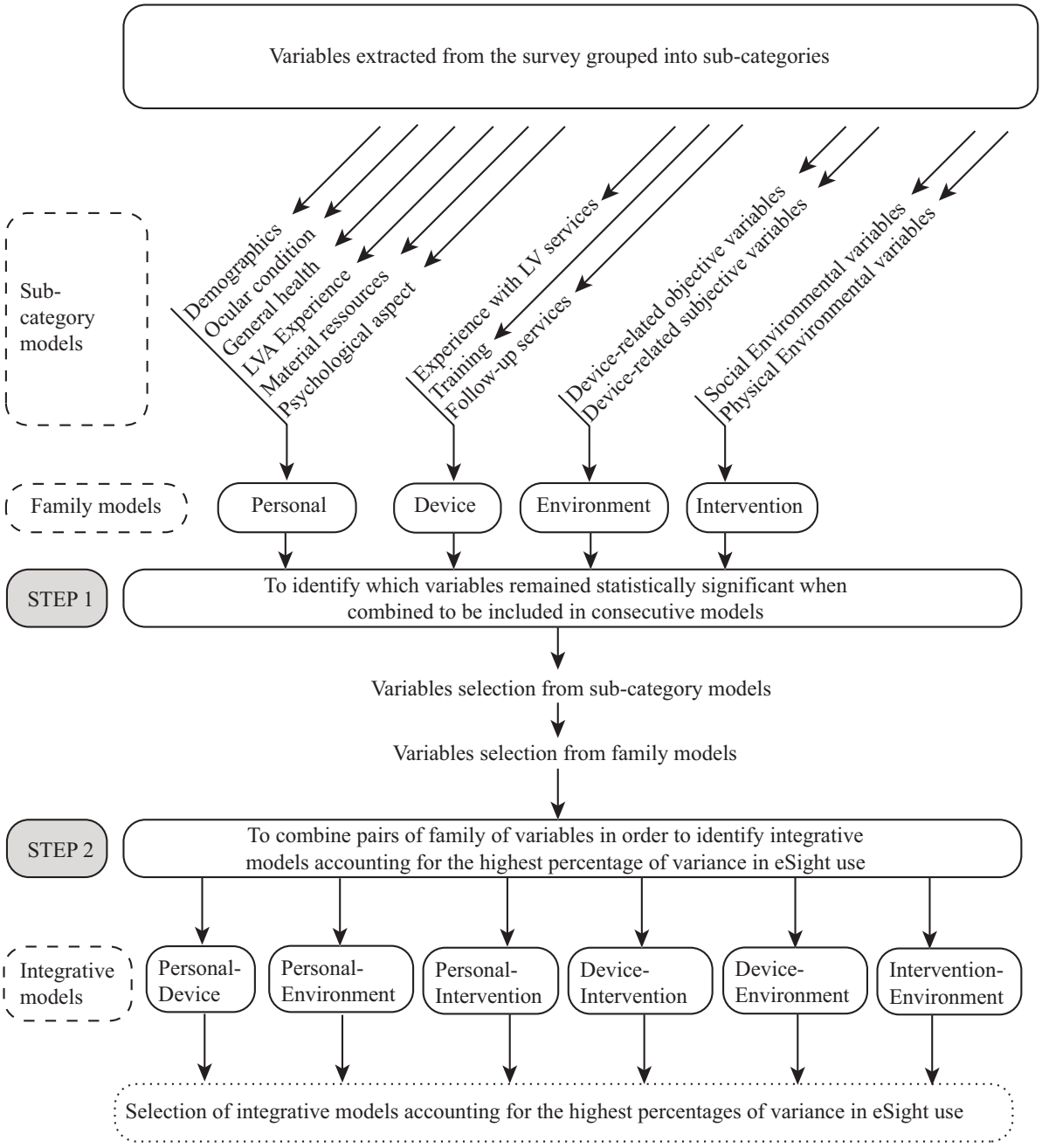

Figure 4. – Variables selection process

RESULTS

Participant Characteristics

Over a recruitment period of five months, 567 individuals were invited by email to take part in the study. One-hundred seventy-four participants (30.7%) responded to the survey including 65 (11.5%) who answered partially and were excluded from further analyses because of missing data on the variables of interest. Of the 109 (19.2%) with complete data, 61 (54.0%) were females, with an overall mean age of 47.7 years (SD=25.4, range: 9-96) and 79 (73%) of whom resided in the USA. For self-reported main cause of vision loss, 51% (n = 56) indicated a central, 6% (n = 6) a peripheral, or 45% (n = 47) a general visual impairment (see Table 1). Of the 109 participants, 36% reported that less than six months had passed between the acquisition of the device and the current survey, between 6-12 months for 22%, 12-18 months for 17%, 18-24 months for 11%, and >24 months for 15% of the participants. Among reasons reported by all participants who no longer used the device, 29% were related to heavy weight, 21% reported discomfort, 13% were associated with poor image quality when using magnification, 13% concerned embarrassment, 8% referred to difficulty of use, 4% to device breakage, 8% reported inadequacy for their needs, and 4% experienced further vision deterioration, interfering with device use. Sixty-four percent of participants (n=70) were eSight 3 owners with the remaining being eSight 2 owners (n=39). Table 2 shows the distribution of participants for demographic variables according to whether they used or discontinued eSight use. Demographic variables did not differ between those who still used eSight Eyewear and those who did not, except for age (P = 0.026), with older participants being more likely to use eSight; and for the average consecutive time of use, indicating that participants using eSight over a shorter time period were more likely to have discontinued using the device (χ^2 (2) = 41.07, P < 0.001). A statistical trend for level of

study was noted as well, whereby those who used eSight were more likely to have higher levels of education than those who did not (χ^2 (2) = 5.23, P = 0.071). Overall, 17.4% (n=19) of the participants had discontinued their eSight use. Some P-values in Table 2 are reported as "No Value" (NV) as some levels of variables had no/very few responses.

Table 1. – Participant characteristics

Gender (n)	
Male	48
Female	61
Country (n)	
USA	79
Canada	30
Main cause of vision loss (n)	
Central visual impairment	56
Retinopathy of prematurity	5
Macular degeneration	4
Age-related macular degeneration	18
Ocular albinism	5
Stargardt's disease	18
Achromatopsia	1
Retinal detachment	5
Peripheral visual impairment	6
Glaucoma	1
Retinitis pigmentosa	3
Choroideremia	2
General visual impairment	47
Diabetic retinopathy	5
Optic nerve atrophy	16
Cone rod dystrophia	7
Coloboma	4
Aniridia	2
Other	8
Unknown	5

(n): number of participants

Table 2. – Demographic variables and their relationship with utilization and discontinuance of use

Variable	Utilization (n=90)	Discontinuance (n=19)	p value	Raw discontinuance %	Total participants (n=109)
Age in years (n=109) Mean (SD)	50 (25)	36 (25)	0.026*	NV	48 (25)
Sex %			0.852		
Male (n=48)	37	7		17	46
Female (n=61)	46	10		7	54
Country %			NV		
USA (n=79)	61	12		16	72
Canada (n=27)	19	5		22	25
Other (n=3)	3	0		0	3
Living situation %			0.190		
Retired (n=35)	29	3		9,000	32
Unemployed (n=17)	12	4		24	16
Student (n=24)	16	4		29	22
Employed (n=33)	26	5		15	30
Living arrangement %			NV		
Alone (n=12)	10	1		8	9
Not alone (n=97)	72	17		19	91
Level of study %			0.071		
Elementary (n=16)	10	6		38	15
Secondary (n=38)	33	5		13	35
Post secondary (n=55)	47	8		15	50
Ocular diagnosis %			NV		
Central (n=56)	45	6		13	51
Peripheral (n=6)	5	1		17	6
General (n=47)	33	10		23	45
Eye disease onset %			0.503		
Birth (n=43)	32	7		19	39
< 6 months ago (n=2)	2	0		0	2
1-2 years ago (n=2)	1	1		50	2
2-5 years ago (n=13)	11	1		8	12
> 5 years ago (n=49)	37	8		18	45
Visual field deficit %			NV		
Peripheral (n=13)	11	1		8	12
Central (n=41)	30	8		20	38
Both (n=45)	33	8		20	41
None (n=10)	8	1		10	9
Other sensory impairment %			0.945		
No (n=98)	74	16		17	90
Yes (n=11)	8	2		18	10
Cognitive impairment %			NV		
No (n=104)	86	18		17	95
Yes (n=5)	4	1		20	5
Motor impairment %			NV		
No (n=93)	69	16		19	85
Yes (n=16)	14	1		6	15
Health condition %			0.272		
Poor (n=1)	1	0		0	1
Fair (n=9)	5	3		33	8
Good (n=42)	28	10		26	39
Very good (n=38)	32	3		8	35
Excellent (n=19)	16	2		11	17
eSight version type %			0.001		
eSight 2 (n=39)	24	12		33	36
esight 3 (n=70)	59	5		9	64
**eSigh consecutive time of use %			< 0.001		
< half an hour (n=15)	4	11		78	14
Between 30 mn - 1 hr (n=33)	27	6		18	30
> 1 hr (n=61)	59	2		3	56

p value calculated with Chi-squared; NV means "No Value" because Chi-squared were no possible as some levels of variables had no/very few cases ; LV: low vision; *p value calculated with Mann-Whitney tests; **Please note that this variable was also include in the definition of the discontinuance group; Row discontinuance % calculated with: N discontinued/ (N discontinued + N continued) x100

Logistic Regression

Step 1– Identifying the variables to be included in consecutive/integrative models

The goal of Step 1 analyses was to utilize logistics regression to identify which variables within each family (e.g., personal, device) remained statistically significantly associated with device use when combined. These combinations were first made within sub-categories of variables (e.g., demographics, psychological variables), and then the variables that emerged as significant were combined overall within each family. Only variables that remained significant after this second combination were retained for Step 2 analyses (see Table 3).

From the 15 variables that composed the ***personal*** family, *health condition*, the *total PIADS score*, the question whether *eSight is right for the user*, and *people's perception on whether the device owner should use the device* were retained for consecutive analyses. From the five variables that compose the ***device*** family, only the QUEST *score,* presence of *general discomfort* and *headache* were selected. From the seven variables constituting the ***environment*** family, only *Family/friends encouragement*, *people's reaction* and *physical environment interferences* were retained. Finally, from four variables that made up the ***intervention*** family, only *the training program considered as helpful* and *satisfaction with the device follow-up service* were retained for consecutive analyses (see Table 3).

Table 3. – Consecutive logistic regression steps

Family	Variables	Sub-categories	step 1: Identify the variables to be included in consecutive models.		Step 2: Combination of several families to obtain integrative models	
			Variables selection from sub-category Models	Variables selection from family models	Variables within integrative models	
Personal	Age	Demographics	Age			
	Sex		Sex			
	Level of study		Level of study			
	Ocular diagnosis	Ocular condition	Ocular diagnosis			
	Eye disease onset		Eye disease onset			
	Change in vision over time		Change in vision over time			
	Health condition	General health	Health condition			
	Other impairment		Other impairment			
	Experience with video magnifiers	LVA Experience	Experience with magnifiers			
	Experience with another HMD type		Experience with another HMD type			
	Currently use of several LVAs	Material resources	Currently use of several LVAs			
	Total PIADS score	Psychological variables	Total PIADS score * (0.016)	Total PIADS score** (0.009)	Total PIADS score * (0.011)	Total PIADS score * (0.01)
	Ability to control usage of eSight		Ability to control usage of eSight			
	eSight is right for the user		eSight is right for the user * (0.034)	eSight is right for the user * (0.027)	eSight is right for the user (*) (0.060)	eSight is right for the user
	People's perception on whether the device owner should use the device		People's perception on whether the device owner should use the device * (0.045)	People's perception on whether the device owner should use the device * (0.017)	People's perception on whether the device owner should use the device * (0.029)	People's perception on whether the device owner should use the device
Intervention	LV rehabilitation experience	Experience with LV services	LV rehabilitation experience			
	Training program completion	Training	Training program completion			
	Training program is helpful		Training program is helpful (*) (0.061)	Training program is helpful		
	Follow-up service satisfaction	Follow-up service	Follow-up service satisfaction *** <0.001	Follow-up service satisfaction *** (<0.001)	Follow-up service satisfaction (*) (0.053)	Follow-up service satisfaction
Device	eSight version type	Device-related objective variables	eSight version type			
	QUEST score		QUEST score *** <0.001	QUEST score *** (<0.001)	QUEST score ** (0.001)	QUEST score ** (0.001)
	General discomfort	Device-related subjective variables	General discomfort ** (0.009)			
	Headache		Headache * (0.011)	Headache * (0.046)	Headache (*) (0.050)	Headache * (0.024)
	Eyestrain		Eyestrain			
Environment	Living arrangement	Social Environmental variables	Living arrangement			
	Who decided to buy eSight		Who decided to buy eSight			
	Family helps with ADL		Family helps with ADL			
	Family/friends encouragement		Family/friends encouragements * (0.044)	Family/friends encouragement (*) (0.056)	Family/friends encouragement	Family/friends encouragement
	People's reaction		People's reaction ** (0.004)	People's reaction * (0.013)	People's reaction * (0.018)	People's reaction (*) (0.063)
	People's perception on whether the device owner should use the device		People's perception on whether the device owner should use the device			
	Physical environment interferences	Physical Environmental variables	Physical environment interferences (*) (0.072)	Physical environment interferences		

Personal model is shaded dark blue; Intervention model is shaded light blue; Device model is shaded grey; Environment model is shaded green; Personal-intervention model is shaded purple; Device-environment model is shaded orange; Personal-environment model is shaded beige; Device-intervention model is shaded red.

Blank cells mean that the variable was not included in the model; (*) means that P [0.050-0.072]; * for P [0.010-0.049]; ** for P [0.001-0.009]; *** for P < 0.001.

Table 3 presents the analyses process based on an ecological approach in which variables were analyzed together and selected from successive models (i.e., sub-category models, family models and integrative models). Step 1 was to identify which variables within each family remained statistically significant when combined. These combinations were first made within sub-categories of variables and then the variables that emerged as significant were combined overall within each family. The goal of Step 2 was to combine pairs of families of variables (e.g., personal & device) using logistic regression in order to identify integrative models accounting for the highest percentage of variance in eSight use. Four integrative models were obtained: personal-intervention, device-environment, personal-envrironment and device-intervention model.

Step 2– Combination of several families.

The goal of Step 2 analyses was to combine two pairs of different families (e.g., device and personal with environment and intervention) using logistic regression in order to identify integrative models accounting for the highest percentage of variance in eSight use (higher Nagelkerke's pseudo R^2). All possible combinations of family pairs were tested. By associating two families in order to highlight integrative models recording the higher Nagelkerke's pseudo R^2, six models were tested, four of which were retained: the personal/intervention, the device/environment, the personal/environment and the device/intervention models (see Table 4).

Table 4. – Integrative models selection based on their Nagelkerke's pseudo R^2

Integrative models	Nagelkerke's pseudo R2
Personal/Device	NV
Environment/Intervention	0.483
Personal/Environment	0.837
Device/Intervention	0.647
Personal/Intervention	0.847
Device/Environment	0.687

NV: no value because model did not work mathematically

A combination of **personal and intervention variables** explained 84.7% (Nagelkerke's pseudo R^2) of the variance in eSight use, correctly classifying 94.4 % of cases (78.9 % correct for discontinuation and 97.7% correct for utilization) and the model was statistically significant (χ^2 (11) = 77.304 P < 0.001). Participants reporting that *people around them thought that they should use eSight* had slightly higher odds of maintaining their use of eSight (P = 0.029) but this result should be interpreted with caution as it may be an artefact of the data distribution and small sample size. The fact that more positive assessments were not associating with larger odds also suggests this is a sample size artefact rather than a strong real effect (Table 5). Participants who were satisfied "little to some of the time" with *follow-up service* had 251 times the odds to use

eSight than those who were “not at all” or “slightly” satisfied (P = 0.053). Participants who thought that *eSight is right for them* tended to have 5.62 times the odds to maintain its use (P = 0.060). Finally, a higher *total PIADS score* was associated with increased odds of using eSight (P = 0.011) (Table 5).

Table 5. – Summary statistics for the 2nd step logistic regression analyses for the Personal-Intervention model

Variables Included		B(SE)	95% CI for OR Lower	OR	Upper	p value
Personal-Intervention Model						
Block 1						
Age		0.026 (0.11)	1.004	1.026	1.050	0.023*
Sex	Female			Reference		
	Male	0.281 (0.532)	0.467	1.325	3.760	0.597
Constant		0.303 (0.586)		1.353		0.605
Omnibus Tests of Model Coefficients: p=0.056						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 94.311						
Block 2						
Age		0.216 (0.097)	1.027	1.241	1.500	0.025*
Sex	Female			Reference		
	Male	5.330 (3.122)	0.454	206.374	93807.959	0.088
Follow-up service satisfaction						0.146
	None of the time			Reference		
	Little to Some of the time	5.527 (2.857)	0.931	251.407	67899.373	0.053(*)
	A good bit to All of the time	1.170 (1.732)	0.108	3.222	95.945	0.499
Total PIADS score		0.225 (0.088)	1.053	1.252	1.489	0.011*
eSight is right for the user						0.060 (*)
	Not at all to Slightly			Reference		
	Moderately	8.850 (3.845)	3.722	6975.625	13074974.900	0.021*
	Quite a bit to extremely	5.683 (2.597)	1.811	293.893	47703.182	0.029*
People’s perception on whether the device owner should use the device						0.255
	Not at all			Reference		
	Slightly	15.335 (6.989)	5.142	4568968.300	4,06E+12	0.028*
	Moderately	6.361 (4.252)	0.139	578.758	2406809.63	0.135
	Quit a bit	10.544 (5.486)	0.812	37953.776	1,77E+09	0.055(*)
	Extremely	12.264 (5.680)	3.501	211919.666	1,28E+10	0.029*
Constant		-39.101 (16.148)		< 0.001		0.015*
Variables entered: Sex, Age, Follow-up service satisfaction, Total PIADS score, eSight is right for the user and People’s perception on whether						
Omnibus Tests of Model Coefficients: **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.847; -2 Log likelihood = 22.782						

None of the predictor variables were significantly correlated; OR: Odds ratio**;** (*) means that P [0.050-0.072]; * for P [0.010-0.049]

Moreover, a combination of **device and environment variables** in the same model explained 68.7% (Nagelkerke’s pseudo R^2) of the variance in eSight use, correctly classifying 95.4% of cases (73.7% correct for discontinuation and 100% correct for utilization) and was

statistically significant (χ^2 (6) = 58.38, P < 0.001). Participants who *felt a reaction from people when they wore eSight* had 7.86 times higher odds to continue the use of eSight Eyewear relative to those who did not report feeling such reactions (P = 0.018). Interestingly, when asked what the type of reaction was, 80% expressed that it was interest and curiosity, with the remaining comments being negative feedback. Participants who reported *presence of headache* had 5.32 times the odds to discontinue eSight use (P = 0.050). Finally, higher *Quest scores* were associated with increased odds of using eSight (P = 0.001). In contrast, *Family and friends encouragement* was not a significant predictor of eSight use (P = 0.417) (Table 6).

Table 6. – Summary statistics for the 2nd step logistic regression analyses with the Device-Environment model

Variables Included		95% CI for OR				
		B(SE)	Lower	OR	Upper	p value
Device-Environment Model						
Block 1						
Age		0.026 (0.11)	1.003	1.026	1.049	0.024*
Sex	Female			Reference		
	Male	0.336 (0.531)	0.494	1.400	3.964	0.527
Constant		0.303 (0.586)		1.353		0.605
Omnibus Tests of Model Coefficients: p=0.057						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.042 (0.018)	1.008	1.043	1.080	0.017*
Sex	Female			Reference		
	Male	1.552 (0.992)	0.676	4.720	32.362	0.118
QUEST score		0.261 (0.077)	1.115	1.298	1.511	0.001**
Headache	No			Reference		
	Yes	-1.669 (0.853)	0.035	0.188	1.002	0.050(*)
Family/friend encouragement	No			Reference		
	Yes	0.933 (1.150)	2.267	3.682	24.243	0.417
People's reaction	No			Reference		
	Yes	2.061 (0.872)	1.423	7.855	43.351	0.018*
Constant		-8.978 (2.863)		< 0.001		0.002**
Variables entered: Sex, Age, QUEST score, Headache, Family/friend encouragement and Feel people's reaction						
Omnibus Tests of Model Coefficients: **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.687; -2 Log likelihood = 42.475						

None of the predictor variables were significantly correlated; OR: Odds ratio; (*) means that P [0.050-0.072]; * for P [0.010-0.049] ; ** for P [0.001-0.009]

A model combining **personal and environment variables** explained 83.7% (Nagelkerke's pseudo R^2) of the variance in eSight use, correctly classifying 96.3% of cases

(85.2% correct for discontinuation and 98.9% correct for utilization) and was statistically significant (χ^2 (11) = 76.073, P < 0.001). Participants recording lower *PIADS scores* had higher odds to discontinue use (P=0.010). Participants who *felt a reaction from people when they wore eSight* tended to be associated with increased use (P=0.063). In contrast, the question whether *eSight is right for the user*, *people's perception on whether the device owner should use the device* and *family/friend encouragement* were not significant predictors of eSight use (Table 7).

Table 7. – Summary statistics for the 2nd step logistic regression analyses with the Personal-Environment model

Variables Included		95% CI for OR				
		B(SE)	Lower	OR	Upper	p value
Personal-Environment Model						
Block 1						
Age		0.026 (0.11)	1.004	1.026	1.050	0.023*
Sex	Female			Reference		
	Male	0.281 (0.532)	0.467	1.325	3.760	0.597
Constant		0.296 (0.586)		1.345		0.613
Omnibus Tests of Model Coefficients: p=0.056 Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 94.311						
Block 2						
Age		0.155 (0.070)	1.019	1.168	1.339	0.026*
Sex	Female			Reference		
	Male	3.599 (2.270)	0.428	36.562	3126.961	0.113
Total PIADS score		0.135 (0.052)	1.033	1.144	1.268	0.010*
eSight is right for the user						0.243
	Not at all to Slightly			Reference		
	Moderately	3.859 (2.357)	0.468	47.408	4805.711	0.102
	Quite a bit to extremely	3.428 (2.273)	0.358	30.813	2653.613	0.132
People's perception on whether the device owner should use the device						0.403
	Not at all			Reference		
	Slightly	8.841 (4.950)	0.423	6913.639	1,13E+08	0.074
	Moderately	4.229 (4.025)	0.026	68.635	1,83E+05	0.293
	Quit a bit	5.877 (4.394)	0.065	356.900	1,96E+06	0.181
	Extremely	7.868 (4.534)	0.361	2612.254	1,89E+07	0.083
Family/friend encouragement	No			Reference		
	Yes	0.177 (2.232)	0.015	1.193	94.833	0.937
People's reaction	No			Reference		
	Yes	2.807 (1.512)	0.856	16.553	320.245	0.063(*)
Constant		-28.135 (11.085)		< 0.001		0.011*
Variables entered: Sex, Age, Health condition, Total PIADS score, eSight is right for the user, People's perception on whether the device owner should use the device, Family/friend encouragement and People's reaction Omnibus Tests of Model Coefficients: **p < 0.001** Model Summary: Nagelkerke R Square = 0.837; -2 Log likelihood = 24.012						

None of the predictor variables were significantly correlated; OR: Odds ratio; (*) means that P [0.050-0.072]; * for P [0.010-0.049].

Finally, a combination model of **device and intervention variables** explained 64.7% (Nagelkerke's pseudo R^2) of the variance in eSight use, correctly classifying 89.9% of cases (57.9% correct for discontinuation and 96.7% correct for utilization) and was statistically significant (χ^2 (6) = 53.961, P < 0.001). Participants reporting *presence of headache* had six times the odds to discontinue use than those who did not. Participants with lower *PIADS scores* had higher odds to discontinue use (P=0.001). In contrast, *follow-up service satisfaction* was not a significant predictor of continued eSight use (Table 8). Supplementary tables S10 provide details about Step 1 and Step 2 logistic regression analyses.

Table 8. – Summary statistics for the 2nd step logistic regression analyses with the Device-Intervention model

Variables Included		95% CI for OR				
		B(SE)	Lower	OR	Upper	p value
Device-Intervention Model						
Block 1						
Age		0.026 (0.011)	1.003	1.026	1.049	0.024*
Sex	Female			Reference		
	Male	0.336 (0.531)	0.494	1.400	3.964	0.527
Constant		0.303 (0.586)		1.353		0.605
Omnibus Tests of Model Coefficients: p=0.057 Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.026 (0.016)	0.994	1.026	1.059	0.111
Sex	Female			Reference		
	Male	1.148 (0/953)	0.487	3.151	20.391	0.228
Headache	No			Reference		
	Yes	-1.794 (0.795)	0.035	0.166	0.790	0.024*
QUEST score		0.307 (0.097)	1.125	1.359	1.642	0.001**
Follow-up service satisfaction						0.517
	None of the time			Reference		
	Little to Some of the time	0.989 (1.341)	0.194	2.687	37.213	0.461
	A good bit to All of the time	-0.829 (1.242)	0.038	0.436	4.980	0.504
Constant		-6.992 (2.373)		0.001		0.003**
Variables entered: Sex, Age, Headache, QUEST score and Follow-up service satisfaction Omnibus Tests of Model Coefficients : **p < 0.001** Model Summary: Nagelkerke R Square = 0.647; -2 Log likelihood = 46.898						

None of the predictor variables were significantly correlated; OR: Odds ratio; (*) means that P [0.050-0.072]; * for P [0.010-0.049]; ** for P [0.001-0.009]

DISCUSSION

The purpose of the present study was to determine predictors of the continued use of a head-mounted low vision device through a survey of visually impaired individuals using eSight Eyewear. The overall discontinuance proportion of eSight Eyewear was around 17%, and given the sampling condition (survey mode), it could not be directly compared to the rate of 30% usually reported within one year in the general context of ATs [7, 55, 56]. Those device owners who reported higher PIADS scores (e.g., perceiving a higher positive impact of the device on their QoL), those indicating higher QUEST scores (e.g., reporting higher satisfaction with the device), and those expressing the absence of headaches, were consistently more likely to continue using eSight Eyewear as an assistive device for their visual impairment. In none of the analysis models was *eSight version type* a statistically significant predictor. In addition, those having perceived people's positive reaction while they used eSight, those with a higher follow-up service satisfaction, and those exhibiting a positive attitude toward the device, were more likely to continue using eSight Eyewear.

Effects that align with previous results

As expected, the PIADS score emerged as a statistically significant predictor of eSight use in both the personal-intervention and personal-environment models, the two most robust models. In these two cited models specifically, the *personal* family reappears in both, indicating the importance of individualized attention focusing on the user**.** Unlike other QoL measurement scales, such as the MOS 36 Short Form [57] or The Nottingham Health Profile [58] that were designed to measure health-related QoL, the PIADS was specifically designed to measure the impact of ATs on QoL [45]. QoL has been reported as being dynamic, changing over time throughout a person's life [59], and being a complex and multidimensional construct [45]. In this

context, the QUEST considers another QoL aspect, taking into account the point of view of the user's satisfaction towards the device. As anticipated, QUEST scores were found to be an important predictor of use in both the device-environment and device-intervention models. The fact that both PIADS and QUEST scores emerged as predictor variables supports the idea that, for an AT to be used, it should promote good QoL for the users.

In line with previous work, *level of study* did not emerge as a predictor of device use. Although a consensus was not always observed among previous authors, in this study lower education was not a contributing factor to device abandonment [33]. The personal-intervention model revealed the importance of *follow-up service satisfaction* regarding the decision to use eSight Eyewear. Having an ineffective *follow-up service,* for example in the case where a device was lost or broken and was not replaced, had been identified as one of the reasons for not using magnifying LVAs [36].

When examining family models based on their respective groups of variables, two questionnaire items emerged as statistically significant: 1) *eSight is right for the user* and *2)* according to their perspective, *people around them thought that they should use their eSight*. In the Theory of Planned Behaviour, the prediction of behavioural intentions is determined by three main components: *attitude*, *perceived behavioural control* and *subjective norms* [60]. Parallels can be made between this theory and the present study, whereby *attitude* directly refers to whether participants consider *eSight as being right for them*, and *subjective norms* directly refered to whether participants thought that *people around them expected them to use their eSight device.* The Theory of Planned Behaviour is one of the Health Behavioural Theories, aiming to explain the determinants that can influence the likelihood of health-related behaviour to eventually anticipate and improve it. Theory of Planned Behaviour has been applied to clinical or

screening behaviour more generally [61] and also to compliance with contact lens wear. The statistical significance of these two variables suggests that future comprehensive studies should include such a behavioral theory to confirm if these results could be replicated in the context of LVA use and and device adoption in general.

As anticipated, the presence of any discomfort induced by wearing an HMD is a potential barrier to use. Here, the presence of *headache* secondary to eSight use was a predictor of discontinuance in the device-intervention model, and demonstrated a statistical trend in the device-environment model. Moreover, causes of eSight Eyewear non-use reported were mainly associated with ergonomics, whereby 21% concerned discomfort and 29% referred to heavy weight as their reason. Discomfort related to device ergonomics has been documented as a factor in discontinuance in the litterature [41, 62]. For example Chan et al. reported that one sixth of participants decided not to use a microscope system because of the uncomfortable short working distance [63].

Contradicting or new effects

Several demographic variables such as *living situation, eye disease onset,* report of *other impairment* and *health condition* did not emerge as usage predictors. Previous work examined the effect of duration of vision loss on LVA compliance and reported it to be positively related with LVA use at the delivery time and after one year [64]. Studying AT use related to physical impairments among community-based frail elders, Tomita et al. concluded that demographic variables such as physical disability level, medication intake, race and living arrangements were predictors of use [4]. Although age-related changes or poor health were reported as variables influencing success or failure in the magnifying LVA usage [65], in the context of eSight, none of the studied models replicated such influence. Interestingly, some anticipated factors such as

having *experience with video magnifiers* and/or *other HMDs* and the *current use of several LVAs* did not predict eSight use. Predominantly, having other material resources has been closely related to device non-use or discontinuation, more precisely through the use of another or several device(s) to complete the task [40, 41]. Unexpectedly, user opinion during the LVA selection process did not emerge as a significant predictor of use. Indeed*, the person who made the choice to buy the eSight* was not found to be a statistically significant predictor. Yet, the literature defending the need to include user input in the process of AT provision is abundant [47, 66]. Using the Matching Person and Technology Model [67], Scherer pointed out the need to involve consumer's opinions and preferences in the decision-making around AT selection [7]. In the present data, this involvement may not have emerged as a usage barrier because the choice of purchase itself may be the indicating variable that the user is involved, unlike in traditional LV rehabilitation, where clinician recommendations also play a part.

When the intervention-related variables was analyzed, except for the level of satisfaction with the company follow-up service, none of the variables were predictors of use. The findings support recent work in which the lack of prior LV rehabilitation experience was not predictive of device discontinuance [68]. However, several previous studies had shown the importance of intervention, whereby training had been identified as essential in the process [69, 70] and insufficient training negatively affected device use [71]. In contrast, an increase in quality and quantity of training in device use was a potential correlate of successful LVA use [72]. In the context of eSight, the eSkills program focused on the technical aspects of using the device is designed and provided by the company itself. It could be speculated that such instructions may not reflect the training provided though traditional rehabilitation services. LV therapists are certified knowledge experts who can train, advise, and follow up on LVAs. Considering training

is a potential factor involved in adherence behaviour suggests a need to design and assess the impact of training provided in the context of a professional LV rehabilitation team.

Whether users felt a *reaction from people around them towards their eSight use* was a predictor of use in the device-environment model and also a tendency in the personal-environment model and was actually expected because it had already been explored in the Theory of Planned Behaviour and called "*perceived behavioural control"* [60]. However, it was unexpected that participants *feeling people's reaction* tended to be associated with increased use, reporting positive feedback, whereas this impact of society has previously been reported as mainly negative in the context of stigmatization [36]. According to the qualitative comments provided by device users as part of the survey, in most cases, the wearing of the eSight device in public generated interest and positive curiosity from people, not about a possible visual impairment but rather because observers thought that the user is engaging in a video or virtual reality game.

Virtual reality systems, on which HMD technologies are based, are defined as an interactive, immersive and realistic simulated world [73]. The main inconvenience of virtual reality is cybersickness which is inherent to the technology per se, and experiences of cybersickness vary greatly between individuals [74]. Cybersickness can be characterized as a range of symptoms including nausea, disorientation, vertigo, headaches, and eyestrain induced by virtual reality [75]. It has been reported that in some virtual environments, cybersickness could be an important usability issue potentially impacting the adoption of technology [76]. So far nothing is known about the potential experiences of cybersickness felt by individuals with a visual impairment using HMDs and about the possible connection with device discontinuation. If we examine the analysis of discomfort components, we notice that the presence of *headache*

emerged as a predictor of use discontinuance, but not the presence of *general discomfort* and *eyestrain.* This could be explained by the fact that HMDs, such as eSight, do not use an immersive virtual environment made of a synthetic image, but a semi-immersive enviroment with a real image. More generally, experiences of cybersickness vary greatly between individuals and the tasks being performed [74]. These results suggest that it would be useful to further explore the type, the conditions of occurrence, duration, and importance of these symptoms in the visually impaired population using HMDs as LVAs.

Limitations

One potential limitation of this study, directly relating to its design, is the absence of objective visual function measures such as visual acuity, visual field, or contrast sensitivity, which could have provided complementary insight. Given the on-line nature of data collection, access to medical chart information was not feasible. The questionnaire format may be considered as an unreliable source of information because of possible false memories and the potential influence of social desirability. The use of eSight during ADLs was studied but not integrated here as this is planned for a future publication. It could be suspected that those who were satisfied with eSight would be more likely to respond to the survey than those who had a negative experience. This potential bias could lead to an underestimate both of the number of participants who discontinued use and factors involved in its discontinuance. Variables such as *eSight consecutive time of use* and *frequency of use* exhibited a risk of complete separation because these items were included in the definition of the outcome variable of discontinuance. Although being a variable of interest, *period of device use* could not be integrated either because of the strong correlation with *eSight version type* inducing a risk of multicollinearity (those who used eSight 2 were statistically significantly more likely to use it more than one year ago).

Another potential limitation concerns the generalization of these results to the global LV population because most of the participants resided in the USA. The limited sample size did not enable us to analyze data from different visual diagnoses separately. Moreover, limited sample size led us to test six integrative models including only combinations of two families of variables instead of testing a single model involving all four families together. While these were necessary actions to ensure an appropriate treatment of these data, we were nevertheless able to analyse a large number of variables across four families of variables, thus covering a large portion of the variables included in the predictive framework of LVA discontinuation. Moreover, it was used a binary definition of abandonment selecting the terms *utilization* and *discontinuation* limited to the past three months. However, subsequent studies should address more degrees of discontinuance in their definition. For example, Scherer [77] proposed a more refined definitions of non-use, whereby she differentiated between ATs which were no longer used and set aside because they probably would not have been useful anymore, and ATs which were not used due to frustration or annoyance. Finally HMDs was studied using eSight Eyewear as an example; however, additional studies should replicate the results with other types of HMD to confirm that the same variables are involved in predicting use. Using a similar approach (multivariate regression), Tomita et al. [4] identified six predictors accounting for 24% of the variance in AT use with a model of device use that addressed physical impairments among community-based frail elders. In the present study, the four models of use selected accounted for 64.7% (device-intervention model) to 84.7% (personal-intervention model) of the variance in eSight use. This difference is certainly due to the selection process which reduced the number of variables included in our models.

Implications for rehabilitation

Variables in the personal category reappear in both the Personal/Environment and the Personal/Intervention statistical analysis models, suggesting the importance of individualized attention focusing on the user during low vision rehabilitation provision and training. Clinicians should consider the use of device-related quality-of-life measures, such as the PIADS and the QUEST scores, that include psychological aspects. They emerged as robust predictors from the integrative models and may be able to identify device users that could benefit from individualized attention during low vision rehabilitation provision, in order to reduce the probability of device abandonment. Health policy and healthcare providers should further support the deployment of evaluation and training in the client's home, providing individualized services, overcoming physical distance as a barrier, and promoting innovative intervention, such as telerehabilitation. The present data indicate that acceptability of assistive technology is highly related to its physical characteristics as well as the absence of headaches during use. User follow-up service satisfaction was another important predictor, providing evidence that manufacturers and rehabilitation service agencies delivering HMDs need to maintain a high level of follow-up service and training. These findings emphasizes the need for developing/enhancing collaborations among clinicians, researchers, engineers and industry in order to pool their expertise and efforts towards the emergence of effective and appropriate assistive technologies accepted by the target population.

Conclusion

The present study indicates that neither patient demographic characteristics, low vision rehabilitation experience, nor eSight version type were predictive of eSight discontinuance. However, device-related quality of life measures, such as PIADS and QUEST scores, and the absence of headaches were robust predictors emerging from the integrative models. User follow-

up service satisfaction was an import predictor of use. A better understanding of predictors of HMDs use and effectiveness, from evidence-based findings, is relevant because it allows clinicians to provide the best information to their patients. Next directions are to assess repeatability of the survey and to develop an assessment grid including the predictors that the clinician and health provider (e.g., optometrist, ophthalmologist, low vision therapist, occupational therapist) could integrate into their practice to select patients / clients who may potentially benefit the most from this type of technology. Considering AT use as a type of health behaviour, these findings may contribute to a better screening of users that could benefit from individualized attention during device training and low vision rehabilitation provision in order to decrease the likelihood of discontinuance of use and maintain independence and quality of life.

Acknowledgement: The work was supported by Mitacs Accelerate Fellowship IT08595 Grant.

Declaration of Interest: No potential conflict of interest was reported by the authors.

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Article 3: Measuring changes in device use of a head-mounted low vision aid after personalized telerehabilitation: Protocol for a feasibility study

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Keywords

Low vision, Assistive technology, Head-mounted display, Telerehabilitation, Compliance

Accepted September 5th, 2019
Published in *BMJ Open* September 22th, 2019

Access at : http://bmjopen.bmj.com/cgi/content/full/bmjopen-2019-030149

Abstract

Introduction. A recent trend in low vision has been towards the use of portable head mounted displays to enhance residual vision. The decision process around the (non-)use of such devices have been identified as multifactorial. Among important barriers identified in the context of magnifying low vision aids were transportation issues and insufficient training. In recent years, telerehabilitation has become of growing interest in health care because it allows individuals to remain at home while receiving rehabilitation services. A recent pilot study indicated encouraging outcomes; however, very few applications of telerehabilitation for low vision have been tested systematically. **Methods and analysis.** To help guide evidence-based practice recommendations for this modality, a feasibility study will be carried out to assess the recruitment, retention, accessibility and acceptability of an eventual fully randomised trial of telerehabilitation for people with low vision using head mounted displays. Sixty participants aged 18+ will be recruite among prospective eSight Eyewear owners, randomised 1:1 into two parallel groups. The active intervention will be the telerehabilitation operated by a low-vision therapist; the control arm will be the current self-training standard provided by the device vendor. The primary feasibility outcome measures will be: time to recruit participants, loss to follow-up, accessibility and acceptability of the telerehabilitation (satisfaction of the users and low-vision therapist). Exploratory outcomes will be the impact of telerehabilitation on eSight Eyewear use behavior (discontinuance rate) and validated measures of assistive-technology-related quality of life.

INTRODUCTION

It is estimated that 314 million people are visually impaired worldwide [1], making this approximation a global concern that is likely to become more significant as average lifespans increase in many countries. Visual impairment includes blindness and low vision (LV), and it is globally prevalent across the lifespan [2]. LV is defined as mild or moderate visual impairment that is not correctable with glasses, contact lenses, or surgical intervention, and interferes with normal everyday functioning [3]. Low-vision rehabilitation is the primary intervention for people with residual vision and has been shown to be effective, specifically in the context of magnification [4]. The goal is to improve independence in activities of daily living and quality of life of people with reduced visual function by enhancing their remaining sight [4]. One of the main methods of achieving such improvement is through the provision of and training in the use of LV aids (LVAs). Optical and electronic magnification devices, such as loupes, close-circuit television and telescopic systems are among the most common forms of intervention in a LV rehabilitation program [5].

With the massive evolution of new technologies, such as mobile and wearable devices, immersive systems (e.g. virtual reality) have become more and more available for LV rehabilitation [6]. A recent trend has been towards portable head mounted displays (HMDs), providing hands-free magnification and contrast enhancements at all distances, using optoelectronics and real time video technology [7]. One of the first HMDs was the Low Vision Enhancement System that demonstrated its usefulness in adults [8, 9] and in children with LV by improving visual acuity, contrast sensitivity and control of ambient light [10]. After considerable technological evolution, HMDs currently available such as the redesigned Jordy (Enhanced Vision Systems, Huntington Beach, California, USA), NuEyes Pro Smartglasses (NuEyes USA,

Newport Beach, California, USA), CyberTimez Cyber Eyez (Cyber Timez, Winchester, Virginia, USA), Evergaze seeBOOST (Evergaze, LLC, Richardson, Texas, USA), and IrisVision (Visionize, L.L.C., Berkeley, California, USA), became smaller and lighter. Their performances have been compared with traditional optical LVAs (i.e., magnifiers, closed circuit television, telescopic systems) [11]. The importance of training in the use of HMDs was demonstrated for distant and intermediate vision compared to traditional LVAs [12]. One of the more recently developed HMDs, eSight Eyewear (eSight Corp., Toronto, Ontario, Canada), was designed to improve on previous devices by not only providing variable magnification, auto focus, contrast enhancement, hands-free use, and portability, but also offering digital image processing that allows the user to scan through a wide-field image. In 2018, a multicenter prospective trial investigated the effect of eSight Eyewear on 51 novice users for three months, demonstrating that activities of daily living and reading showed greatest benefit from device use [13].

Continuation and interruptions in the use of electronic assistive devices

Despite the functional and evidence-based benefits of LVA use [4, 14], a scoping review documented high variability rates of device non-use for magnifying LVAs after their prescription, ranging from 2.3%-50% (M=25%, SD=14%) [15]. In the context of eSight Eyewear, a cross-sectional study revealed that of 109 users, 17.4% (n=19) had discontinued their use [16]. The authors reported that reasons for non-use had been identified as multifactorial, involving the device, the user, the environment and the intervention. Among important barriers in the process of acquiring and incorporating magnifying LVAs were limited access to transportation to receive training with a device, insufficient training duration and frequency, and negative health care experiences including providers' poor knowledge of devices, absence of positive interactions between the patient/client and LV health care professionals as well as delays in obtaining an

appointment [15]. Regarding HMDs, a cross-sectional study concluded that device-related quality of life, absence of headaches and follow-up service satisfaction were important predictors of eSight Eyewear use [16]. Transportation issues limited the ability of individuals to access follow-up interventions for their LVA training and skill reinforcement [17, 18]. This is particularly a challenge in the USA, given that two-thirds of the LV population do not or are not permitted to drive [19]. Moreover, the paucity of LV rehabilitation providers exacerbates issues related to limited care access in rural areas of geographically dispersed countries, such as Australia, the USA and Canada [20, 21]. To overcome such barriers, innovative internet-based communication technology presents itself as a potential solution for rehabilitation services.

Telerehabilitation: An alternative modality for LV rehabilitation services.

In recent years, telerehabilitation has become of growing interest in health care because it allows individuals to remain at home while receiving rehabilitation services via information and communication technologies [22]. Several advantages of telerehabilitation have been documented when compared to traditional in-office interventions, including overcoming transportation difficulties, optimizing follow-up session scheduling and evaluation of the patients' environment. A systematic review on telerehabilitation across disabilities (but not including LV) revealed that 71% of the interventions were successful [23], thereby supporting evidence-based practice recommendations towards implementation of remote on-line health care intervention.

In LV rehabilitation, visual aids using video systems (e.g., smart phone, tablet) are used more and more by people with visual impairments and suggest that they could be used to provide telerehabilitation services [24]. A Cochrane systematic review documented very few applications of telerehabilitation to LV and no published outcomes [25]. Recently, a pilot study indicated encouraging outcomes confirming the feasibility and acceptability of training to optimize the use

of handheld magnifiers in ten patients with LV via telerehabilitation from their home [26]. To help guide evidence-based practice recommendations for this modality, the main goal of the present protocol is to conduct a feasibility study using telerehabilitation operated by a LV therapist, compared to the current self-training standard provided by the device vendor, eSight Corporation. It is expected to obtain evidence about feasibility (time to recruit participants, loss to follow-up, accessibility and acceptability) of administering several LV rehabilitation training sessions via telerehabilitation using an Internet-based video platform to participants with LV using their eSight Eyewear at home. As secondary goals, it is planned to determine if personalized intervention through telerehabilitation can help to reduce discontinuance (or induce change in use) for HMDs and improve quality of life. In addition, other previously identified predictors of eSight Eyewear use, such as follow-up service satisfaction, will be explored. It is hypothesized that personalized LV rehabilitation through telerehabilitation will be a feasible (accessible and acceptable) modality to train individuals with LV to use their eSight device in their environment, will reduce discontinuance and will improve quality of life.

METHODS AND ANALYSIS

Study design

This feasibility study considered the CONSORT guideline components [27], and is a parallel two-arm randomised study consisting of training individuals with LV in the use of eSight Eyewear when engaging in activities of daily living. The experimental intervention will entail a series of personalized LV telerehabilitation sessions with a LV rehabilitation specialist. The control intervention will consist of the conventional eSight self-training using their eSkills User Guide [28] as well as optional access to standard support available through eSight Corporation staff. These staff members may either be normally sighted, or may be device users whose experience is based

on their own visual impairment. The study will be based at the School of Optometry of the *Université de Montréal,* Montreal, Quebec, Canada, and follows the requirements of the Declaration of Helsinki for conducting research with human participants [29].

Telerehabilitation Equipment

In the case of personalized training by telerehabilitation, participants will benefit from distance training sessions delivered to their home via the Internet with a LV therapist at the School of Optometry of the *Université de Montréal*. Each participant will be able to interact in real time, using a secure and password protected connection, with the LV therapist using the REACTS telehealth platform, accessible from their computer or digital tablet at specific appointments (https://www.iitreacts.com).

Inclusion & Exclusion criteria

Individuals with self-reported LV aged 18+, who are able to communicate in English or French, have a tablet, desktop or laptop computer with internet access, are highly motivated to participate in the study, and recently (< one month) bought or are currently renting an eSight Eyewear device will be included. Current device users who have owned their eSight device for more than one month (and have therefore completed the eSight eSkills User Guide), as well as those self-reporting other severe sensory impairments that may interfere with communication, will be excluded. The LV therapist will confirm whether participants are able to follow a 20 min phone conversation (i.e., sufficient hearing and cognition to complete oral informed consent and protocol procedures by phone, based on her clinical experience), and will exclude them if comprehension and/or communication are challenged. Figure 5 summarizes the design of the study; each of the study aspects is described in detail below.

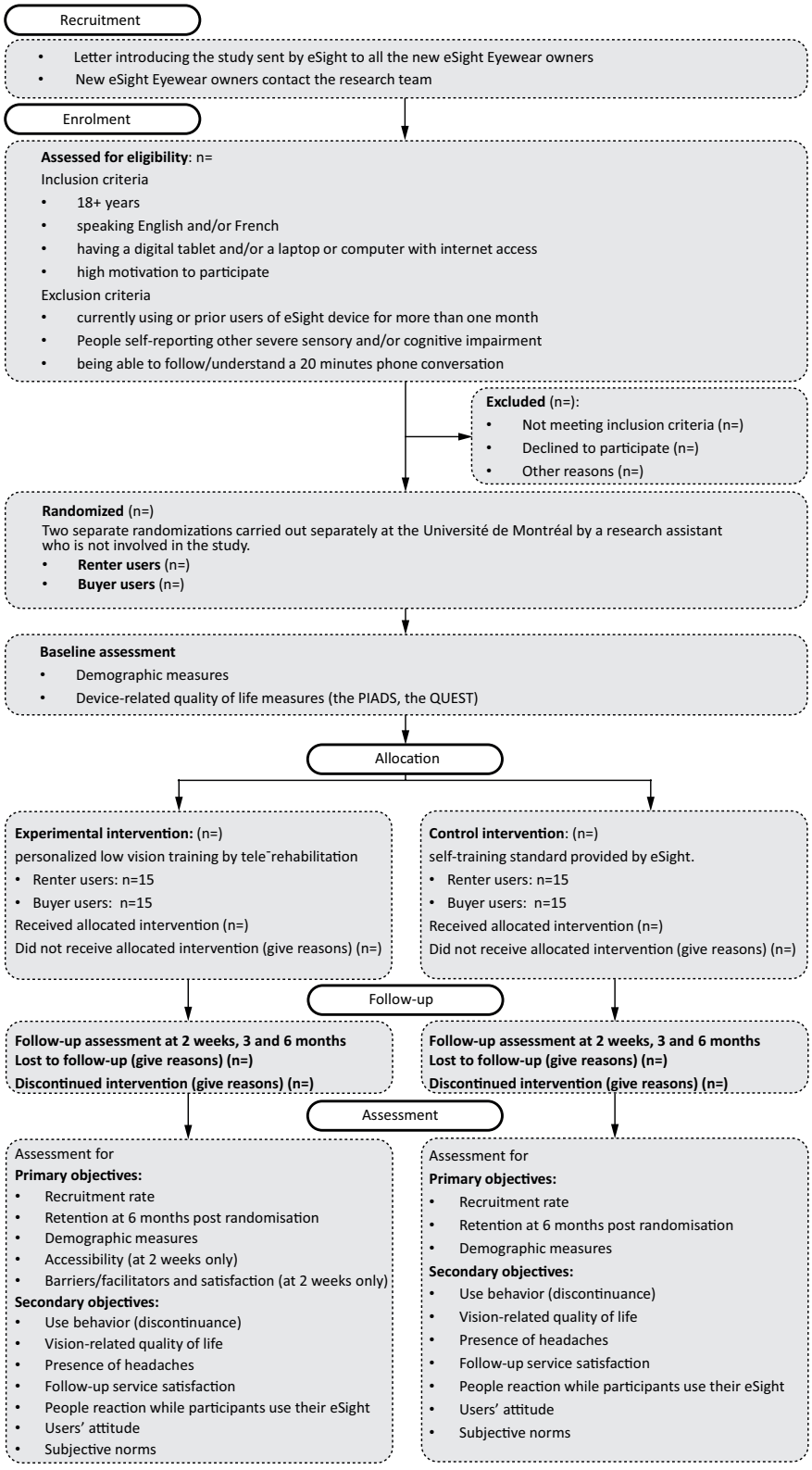

Figure 5. – Chart showing planned participants flow

Interventions

Self-training standard provided by eSight. This intervention focuses on the technical aspect of using the eSight device, namely: "how does eSight Eyewear work?". All participants in the control group will receive the eSkills learning and training guide [28] as usually provided when purchasing the device. This guide is a self-training program that spans one hour per day for one month (30 hours) to be performed self-guided at home, and divided into four weeks of exercises (see Table 9). At the end of the training, the participants will continue to use the eSight Eyewear in their environment until the end of the study five months later (and beyond).

Table 9. – The eSkills User Guide, a self-training program divided across four weeks

Week	Skills
Week 1	Learning the technical aspects of eSight Eyewear as well as the settings for distance vision and reading
Week 2	Exercises focused on distance vision and reading
Week 3	Refinement of the previous tasks associating additional complexity and introduces exercises for handwriting and hand-eye coordination
Week 4	Improvement of the tasks involving hand-eye coordination and will introduce viewing techniques on other media (digital tablets, TV etc.)

Personalized training through telerehabilitation. This intervention focuses on the functional aspect of using eSight, namely: "How to achieve your activities of daily living with eSight Eyewear?". The personalized training by telerehabilitation will be provided by the same and only LV therapist involved in the study and will consist of six one-hour on-line training sessions within the first two weeks (six hours), 12 additional hours of homework in parallel during the same two weeks, and an additional 12 hours of homework in the following two weeks. The LV therapist and participants will share common work materials composed of exercises that they can easily refer to. The materials are composed of the eSkills learning and training guide [28] and digitized exercises extracted from the VisExc – eccentric fixation program [30] (partially

adapted from the McGill Low Vision Manual [31]), sent by email for eccentric fixation training). The six sessions will be scheduled at the beginning of the study according to the participants' and the LV therapist's availabilities (see Table 10). Individualized training in the use of the eSight Eyewear will be provided to each participant and tailored to the needs of each person, as would be the case in face-to-face clinical practice.

Table 10. – Personalized training program through telerehabilitation

Session	Goal	Exercises	Specifics	General aspects
Session 1	To become familiar with the various settings of the device	Change the battery in their magnification device or operate a specific setting (contrast, enlargement, colour reversal, specific distance settings, lighting).	Session 1 is similar to the self-training standard provided by eSight. However, instead of explaining **all** the functions, the low vision therapist will select and focus on **relevant** functions according to the participant's needs and level of technical expertise. For example, color inversion will be presented to subjects with glaucoma and they will receive a detailed explanation as to why and under what circumstances this function may be useful to them	Generally, the training strategy first requires that participants locate and focus on the desired material (e.g., text, medication label). Then, through verbal instructions, they will adjust settings and the position of the head. Given the description of what they can see through eSight Eyewear, they will receive feedback on the working distance, viewing angle and level of zoom to obtain the best magnification and field of view. To optimize verbal instruction, the low vision therapist will utilize an eSight device at the same time and will be able to adjust settings synchronously with participants. Then, the participants are required to keep a stable and optimal position and will be asked later to reproduce it with less and less assistance from the low vision therapist.
Session 2	To train eye movement control and, if needed, eccentric fixation	Training of eye movement control, such as fixation and saccades, with various exercises, such as the following of a moving target with different sizes and contrasts, or exercises to reach the maximum position of gaze (extracted from the McGill Low Vision Manual and the eSkills guide) Training for eccentric fixation using specific exercises extracted from the VisExc – INLB eccentric fixation program.	Use of exercices extracted from **standard/well established** clinical Low vision guides (the McGill Low Vision Manual and the VisExc – INLB eccentric fixation program) Expertise of an experienced low vision therapist to train eccentric fixation, if needed	
Session 3	To focus on visual discrimination and reading skills	Exercises of growing complexity: beginning by reading letters, words, sentences, newspaper or bills; then, continuing with reading instructions on various products and medication labels**.** Combination of exercices extracted from the McGill Low Vision Manual, the INLB eccentric program, the eSkills guide and specific relevant reading materials directly identified by the participants.	The low vision therapist will be able to estimate via the video what the participant's level of reading ability with their eSight device is (i.e., working distance, viewing angle, lighting), and will rely on the audio component, listening to the participant read aloud, for their reading fluency (i.e., speed, accuracy, and print size). Participants will also read relevant materials on their own and will be asked immediately afterward to hold them up to the camera to confirm whether they had read the text correctly.	
Session 4	To train writing skills and hand-eye coordination	Training on various writing tasks, such as signing participants' name, check writing, drawing reproduction, writing tasks according to each person's needs (i.e., crosswords, drawing or painting). For hand-eye coordination, exercises with card games, exercises by picking up and selecting coins, drawing reproduction, as well as pouring water. Combination of exercices extracted from the McGill Low Vision Manual, the INLB eccentric program, the eSkills guide and specific relevant reading materials identified by the participants.	Mostly focused on participants' specific needs	
Session 5	To focus on viewing TV, computer and smartphone screens directly through the eSight Eyewear display	Once participants will have received explanation on how to make the connections between devices by the eSight Corporation staff, they will be trained to adapt the background display, tune in various TV channels, search and dial a phone number, according to their specific needs	Entirely focused on participants' specific needs	
Session 6	To train to specific and personalized tasks, according to the needs of each participant	Personalized tasks will be the focus of the training session, and will mostly concern manual activities such as sewing or knitting, crafts, or reading sheet music	Entirely focused on participants' specific needs	

At each session, a 5-min break will be offered to participants when needed. Between each of these six sessions, participants are asked to continue to train themselves at home using the eSkills learning and training guide for approximately six hours per week (12 hours of homework). At the end of the two weeks (telerehabilitation intervention), the participants will continue their training for two weeks (12 hours of homework remaining) and continue using their eSight device at home, until the end of the study five months later (and beyond).

Outcomes

The primary outcome of this study is related to the feasibility of telerehabilitation in the context of eSight Eyewear users and encompasses several measures: (1) enrolment target (signed consent) within ten months, (2) retention of participants until six months after randomisation, (3) accessibility of telerehabilitation training, (4) acceptability of telerehabilitation training.

Primary outcomes.

Considering the feasibility aspect of the study, the enrolment target is 60 participants (30 renters and 30 buyers of eSight Eyewear) over ten months. A trial will be considered as feasible if 80% of this figure (n=54) is enrolled during this period and/or if 100% are enrolled over 12 months. We will record the number of eligible individuals declining to participate and why, and capture whether any participants dropped out of the study and why. Retention will be monitored by follow-up evaluations and through questionnaires (see Supplementary materials S11 and S12). Accessibility of the training via telerehabilitation will be determined by asking participants and the LV therapist independently about any problems related to Internet connectivity, access to the videoconference platform, use of the hardware, and audio/visual quality. At each training session, the LV therapist will report any problems in a diary, for each participant and herself, respectively.

Regarding acceptability, all participants and the LV therapist will complete a satisfaction survey with a research assistant, containing quantitative and qualitative items, to indicate their preferences regarding the telerehabilitation intervention or the self-training program, as well as to report barriers and facilitators. Participants will be asked to rate the experience of telerehabilitation or self-training for comfort, efficiency, effectiveness, and likelihood for future use, rated on a 4-point Likert scale ("Strongly agree" to"Strongly disagree"). The LV therapist will be asked to provide her overall perception and judgment of the telerehabilitation compared to her previous experience with face-to-face intervention (in-office sessions and/or home visits). In addition, participants will be asked for their written permission (consent form to be provided by mail) to contact their eye care professional to obtain an eye report, including visual information (i.e., visual acuities, diagnosis) (Supplementary information S13 and S14).

Exploratory/secondary outcomes.

In addition to the primary outcomes, measures about the impact of telerehabilitation on use behavior (eSight Eyewear discontinuance rate) and on participants' quality of life (measured will be collected with two standardized device-related quality of life questionnaires (described below). It will be explored important predictors of eSight Eyewear use pre-identified in a cross-sectional study [16], such as the presence of headaches, follow-up service satisfaction, and other people's reaction while participants use their eSight device.

Discontinued device use will be monitored by follow-up evaluations and through questionnaires. In the context of the analyses, *early discontinuance in device use* is defined as a participant who stops using the device during the first two weeks of the study (either a renter who decides not to buy the device at the end of the rental period, or a buyer who decides not to use it anymore), because this is the time period during which eSight Corporation offers a loan to

customers. From a clinical research point of view, *discontinuance in device use* will be defined as a participant reporting non-use of the device in the previous three months on any given task, as it has previously been applied in the context of LV devices in an outpatient population [32] and as reported in a questionnaire specifically developed for this study, containing open and closed questions (detailed in Supplementary materials S11 and S12).

The impact of assistive technology on quality of life will be measured in a standardized and objective way with the Psychosocial Impact of Assistive Devices Scale (PIADS) [33-35] and the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) [36, 37], both of which are validated in English and French. The PIADS is a 26-item questionnaire originally developed to measure the effect of assistive devices on quality of life and was pilot-tested with eyeglasses and contact lenses [35]. The PIADS has previously been used with LV magnification devices, specifically with CCTVs [38, 39]. It is a reliable and valid tool and can predict assistive technology abandonment [33, 35]. There are three subscales: competence, adaptability and self-esteem. The QUEST [37] is a 12-item outcome measure that assesses user satisfaction with two components, Device and Services, with a wide range of assistive technology in a structured and standardized way. Psychometric properties have been tested with respect to test-retest stability, alternate-form equivalence, internal consistency, and factorial composition validity, and appear to be adequate [37]. Device dimension embraces eight items related to salient characteristics of the assistive technology whereas the Services dimension encompasses four inter-correlated items.

To explore factors related to the use and discontinuance of use of the device in connection with using eSight, a questionnaire was specifically developed. It employs open and closed questions whose items refer to timing and frequency of use, nature of the task for which the

device is used or discontinued. It is composed of 40 items, examining the use of eSight, user's characteristics, utilization changes, social and physical environments and training/intervention.

Participation timeline

Each participant will be engaged in the study anywhere between two weeks (renters who choose not to purchase) and six months (buyers, and initial renter deciding to buy eSight Eyewear after the trial period) starting at randomisation, with assessments at baseline, two weeks, three and six months. After their recruitment, participants will be contacted by phone about an hour before the scheduled telerehabilitation session time, to guide them through the setup process and help with any questions or issues related to accessing the videoconference portal. An initial questionnaire (~30 min), administered by the LV therapist, will be used to collect data on demographics, health conditions and quality of life. Then, a second questionnaire (~45 min), will be used for the three follow-up assessments. This questionnaire is composed of 94 questions adopted from the PIADS and the QUEST, and questions specifically developed for this study, and will be self-administered online, accessible through a URL link. The schedule of assessments is summarised in Table 11. This survey has been pilot-tested with four individuals, one with normal sight to confirm content consistency and general accessibility, followed by three individuals with visual impairment to confirm accessibility with technologies, two using ZoomText magnification software and one with JAWS screen reading software.

Table 11. – Schedule of enrolment, interventions and assessments

	Enrolment	Allocation	Post-allocation		
Timepoint	0	0	2 weeks	3 months	6 months
Enrolment					
Eligibility screen	x				
Informed consent	x				
Demographic and clinical details	x				
Allocation		x			
Interventions					
telerehabilitation		x			
self-training standard (eSkills User Guide)		x			
Assessment					
Baseline					
initial questionnaire (demographics; health condition; PIADS and QUEST)		x			
Post-allocation					
follow-up questionnaire (PIADS and QUEST; factors related to the use of the device)			x	x	x
usage/discontinuance eSight device					
accessibility of telerehabilitation*			x		
satisfaction with telerehabilitation*			x		
barriers and facilitators of telerehabilitation*			x		
lost to follow-up			x	x	x
adverse outcomes			x	x	x

*Experimental group only; PIADS: Psychosocial Impact of Assistive Devices Scale

Sample size

A previous clinical trial using eSight Eyewear reported recruiting 74 individuals across six sites, of which 51 completed the study (drop-out rate of 31%) [13]; however, a key difference was that the investigators provided eSight Eyewear as a loan for the period of the 3-month study, and participants were not self-selected device owners/renter, as is the case in the present study. Therefore, without direct comparison standard, sixty participants will be recruited in total, with 30 individuals in each group. This sample size is comparable to other feasibility studies in low vision rehabilitation[40] and is intended to maximize the available data given the opportunity created through the collaboration with the device manufacturer. Given the proposed recruitment period, this sample size will allow us to evaluate any possible limitations with enrolment and retention more robustly, and will provide rich data on accessibility and acceptability of a telerehabilitation training. A previous multicenter prospective demonstrating the short and

medium term effects of eSight Eyewear, reported various effect sizes that cover the secondary outcome measures proposed in the present protocol, ranging from ω^2 = .04 to .83. Choosing a conservative average effect size of ω^2 = .23 to calculate the sample of the present study (based on mixed design ANOVA), power analysis using G*Power [41, 42] indicated that, with a desired power of .95 and alpha level of .05, the necessary sample size is n = 60, with n = 30 in each arm, a sample size commonly used in feasibility studies.

Recruitment

The projected study timeline is from September 2018 to December 2019. Directly after buying or renting an eSight device, clients will be informed by an employee of eSight Corporation of the opportunity to participate in the present research project. A letter introducing the study will be sent by email at the time of device delivery, and a paper version will be added in the parcel, providing the contact information of the research team to the users, so they can express their interest in participation. Once a person has expressed an interest, the LV therapist will provide verbal (by phone) and written (outline of the study and consent form will be sent by email to the potential participant) study information, explaining the objectives and the schedule of the study, will check eligibility and obtain informed written consent. Potential participants will be asked to sign, scan/photograph and return their consent form by email.

Assignment of interventions

Participants will be randomised to receive either personalized LV training by telerehabilitation, or the self-training standard provided by eSight. Allocation will be at a 1:1 ratio, whereby two randomizations will be carried out separately at the *Université de Montréal* by a research assistant who is not involved in the study: one for the participants who bought the

eSight Eyewear, the other for those who rented them. Given the small samples sizes, and in order not to take the risk of having unbalanced control and experimental groups, the first participant of each group will be allocated by coin toss, and then allocation of all following participants will alternate. The LV therapist is only notified of group allocation at the first testing session.

Bias control

Both participants and the LV therapist administering the protocol will be aware to which condition (control or experimental) the participants are allocated. Therefore, in order to minimize experimenter bias, it will be used online follow-up questionnaires via an URL link (https://www.hostedincanadasurveys.ca).

Data collection, management and analysis

Data collection and data management. Participants will be assigned a study number after consent prior to randomisation. Quantitative data will be tabulated using a Microsoft Office Excel spreadsheet. Interview data will be audio-recorded and transcribed verbatim into a Microsoft Office Word document. All data will be analysed by the study principal investigator (MCL), who will not meet the participants or be involved in data collection and will be masked to group membership until data collection is complete in order to reduce detection bias. Data will be stored centrally and kept in locked, secure access filing cabinets or on password-protected computers on *Université de Montréal* premises; this includes electronic data and case report forms and interview materials. These data will be stored for a period of seven years until the end of the project, after which they will be destroyed.

Statistical analyses.

Data will be analyzed using JASP Version 0.9 software [43]. The analysis plan consists of three steps. In Step 1, descriptive statistics will be used to present the sample and responses on all outcome measures. In Step 2, It will be examined the primary outcome measures to evaluate feasibility, including recruitment, retention, accessibility and acceptability, while in step 3, possible effects within the secondary outcomes, including device abandonment and quality of life, will be explored.

Step 1. Descriptive measures, including participants' demographic and clinical characteristics, will be summarized as means and standard deviations, medians and interquartile ranges, and by counts and percentages as appropriate.

Step 2. Enrolment will be analyzed using the period of recruitment defined (from September 2018 to June 2019), reporting the number of participants assessed for eligibility and the number of participants that will be excluded (number of participants declining to participate and number of participants not meeting the inclusion criteria). It will be reported the number of participants that will be enrolled within the 10-month recruitment period and whether the minimum required 80 % (54 participants) were reached.

Retention in both the experimental and the control groups will be analyzed at two weeks, as well as three and six months using the number of participants remaining in the study. If participants wish to withdraw after they have been allocated to an intervention group, they will have the opportunity to explain their reasoning, should they be interested in sharing these reasons, and will record them in the case report.

Accessibility of telerehabilitation training (numbers and types of issues with: Internet connectivity, access to the videoconference platform, use of the hardware, and audio/visual quality) will be presented as frequency counts as well as analyzed using qualitative description [44].

Acceptability will be measured using quantitative (satisfaction surveys) and qualitative measures (interview with the LV therapist). Quantitative measures (ordinal data) will be presented using descriptive statistics. Qualitative analysis will reveal barriers and facilitators related to telerehabilitation intervention. An interview with the LV therapist will be transcribed verbatim and coded by the first author and a research assistant, using a case study approach, starting with open coding [45]. Significant sentences in each transcript that have relevance to the research question to help us better understand barriers and facilitators to the telerehabilitation intervention with eSight users, as experienced by the LV therapist, will be highlighted [46]. Then, all codes will be grouped together according to common themes. Coding disagreements will be resolved in face-to-face discussion, and any remaining disagreement will be decided by a third party (WW). Finally, the codes will be grouped into themes to establish an overall descriptive picture of the interview content that allows the reader to better understand the barriers and facilitators related to this telerehabilitation intervention [47].

Step 3. Secondary outcomes. 1) eSight Eyewear early discontinuance rate at two weeks and discontinuance rate at six months will be analyzed using descriptive statistics. 2) Quality of life as measured by the PIADS and QUEST will be examined according to a factorial design approach (see Figure 5), comparing outcomes for device renters with those of device owners; in addition, participants who are in the control group will be compared to those in the intervention group, both across follow-up time points (pre-intervention, after two weeks, as well after three and six months of device use). Given the repeated-measures component of the study, and in order

to accommodate potentially missing data, the analyses will be conducted using a mixed-effects model, and post-hoc tests using Tukey's honestly significant difference correction. 3) Factors pre-identified as being predictive of eSight, depending on the nature of the 40 items questionnaire, Spearman correlation coefficients and Chi squares will be calculated to examine the relationships between ordinal (e.g., quality of life score) and categorical (e.g., discontinuation frequency) variables, respectively. Data collected up to the point of withdraw will be included in the data analysis.

Study status

Recruitment and data collection are currently ongoing. Recruitment is expected to be completed in June 2019, given minor delays in the timeline. Data collection is expected to be complete in December 2019, followed by data analyses and manuscript preparation in early 2020.

Patient and Public Involvement

The research questions and outcome measures of the present study were tailored to reflect the barriers and facilitators to eSight Eyewear use as identified by device users in a cross-sectional study[16]. It is planned, once the telerehabilitation intervention is completed, to ask participants to assess the burden of the telerehabilitation intervention and the time required to participate, in order to design future interventions to accommodate accordingly.

Limitations and possible solutions

A limitation in the study is self-selection bias, as participants who spontaneously decide to rent or purchase eSight Eyewear, express interest in research participation, own the computer equipment necessary for telerehabilitation and data collection, and are willing to try an Internet-based video conference platform will be enrolled. To overcome this potential bias, it is planned to

loan eSight Eyewear and tablets to participants in the next phase of this project.

Another limitation is that it will not always be possible to differentiate all possible reasons for discontinuance versus drop-out or other types of attrition. This will probably be the case specifically for participants lost to follow-up without explanation. However, through regular monitoring throughout the study, we hope to be able to record most reasons for leaving the study. Another potential limitation is the absence of an in-office evaluation with objective visual function measures, such as visual acuity, visual field, or contrast sensitivity, which could provide complementary insight. Given the on-line survey nature of data collection, complete access to medical chart information will not be feasible. However, we will be able to obtain some objective information about visual function by asking participants to give the research team access to their most recent eye report.

Dissemination plan & Knowledge Translation

The results of this study will be presented at local, national and international conferences that cater to low vision rehabilitation professionals and researchers, and will be published in a peer-reviewed research journal. It is also planned to publish an article in a journal that is more focused on clinical outcomes in vision rehabilitation or on assistive technology.

Acknowledgements

We thank Josée Duquette for her permission to use the VisExc – INLB eccentric fixation program.

Ethics and Dissemination

The study was approved by the Ethics Review Board of the *Centre de Recherche*

Interdisciplinaire en Réadaptation de Montréal métropolitain (CRIR# 1286-1217). Dissemination is planned via local, national and international healthcare conferences and peer-reviewed journal publications.

Competing interests

None declared.

Funding

This study was funded by Mitacs Accelerate Fellowship IT08595 Grant.

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Article 4: Impact of a personalized telerehabilitation program on the use of a head-mounted low vision aid for individuals with visual impairment: A randomised prospective feasibility study

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Keywords

Low vision, Assistive technology, Head-mounted display, Telerehabilitation, Compliance, feasibility

Submitted, under review
Optometry and Vision Science

Abstract

Significance. A recent trend in low vision rehabilitation has been the use of portable head-mounted displays to enhance residual vision. The decision process around the (non-)use of such devices is multifactorial. Among important barriers to the use of magnifying low vision aids are transportation issues and insufficient training. In recent years, telerehabilitation has become of growing interest in health care. While a recent pilot study indicated encouraging outcomes, very few applications of telerehabilitation for low vision have been tested systematically. **Purpose.** To help guide evidence-based practice recommendations for this rehabilitation modality, a feasibility study of an eventual fully randomised trial of telerehabilitation was carried out for people with low vision using head-mounted displays. **Methods.** Participants aged 18+ among prospective eSight Eyewear owners were recruited, randomised 1:1 into two parallel groups, whereby the experimental intervention was telerehabilitation provided by a low-vision therapist. The primary feasibility outcome measures were whether the recruitment goal was attainable within one year, and how participants judged accessibility and acceptability of the telerehabilitation. An exploratory outcome was the impact of telerehabilitation on eSight Eyewear use behaviour. **Results:** Among 333 novice eSights users, 57 participants were enrolled, approaching 100 % of the enrolment target. Once enrolled, 35% of participants withdrew from the study while the remainder completed the entire 6-month follow-up. High accessibility and acceptability were reported among those who completed the protocol. Telerehabilitation was well perceived by both the low vision therapist and participants. All of the participants agreed that they were satisfied with receiving telerehabilitation training, whereby 65% strongly agreed. The low vision therapist had no difficulty with assessing the participants' reading speed and accuracy while participants used their head-mounted display, and reported that most participants improved their activities of

daily living with this device. No differences were observed between the 16 % of participants who decided not to use the eSight Eyewear anymore and those sustaining their device use. **Conclusion:** The data demonstrated the feasibility of a randomized controlled study of telerehabilitation for people with low vision using a head-mounted display. Positive feedback from the participants and the low vision therapist suggest the potential value of this modality for low vision services.

INTRODUCTION

Worldwide, around 314 million people have a visual impairment [1]. This is a public health concern that is likely to expand as the standard of medical care improves and the population of older adults increases. Visual impairment is globally prevalent across the lifespan and includes blindness and low vision [2]. Low vision is defined as mild or moderate visual impairment that is not correctable with glasses, contact lenses, or surgical interventions, and interferes with normal everyday functioning [3]. Low vision rehabilitation is the primary intervention for individuals with reduced visual function and has been shown to be effective to improve independence in activities of daily living and quality of life by enhancing their remaining sight [4]. Among the most common forms of intervention in a low vision rehabilitation program is the provision of and training in the use of visual aids, such as optical and electronic magnification devices, including hand-held magnifiers, close-circuit televisions and telescopic systems [5].

A recent development in low vision rehabilitation has been towards the use of wearable head-mounted displays that are immersive systems (e.g. virtual reality) providing hands-free magnification and contrast enhancements at all distances, using optoelectronics and real time

video technology [6]. In adults [7, 8] and children with low vision, one of the first head-mounted displays, the Low Vision Enhancement System, demonstrated positive vision outcomes, improving visual acuity, contrast sensitivity and control of ambient light [9]. Benefitting from major technological evolution, head-mounted displays such as the redesigned Jordy, (Enhanced Vision Systems, Inc., Huntington Beach, CA, US) and IrisVision (Visionize, L.L.C., Berkeley, CA, US), became smaller and lighter. Their performance has been compared with traditional optical visual aids (i.e., magnifiers, closed circuit television, telescopic systems) and demonstrated positive outcomes [10]. The importance of training in the use of head-mounted displays was demonstrated for distant and intermediate vision compared to traditional visual aids [11]. Continuing this trend, a recent head-mounted display, eSight Eyewear (eSight Corp., Toronto, ON, Canada), was designed to improve on previous devices by not only providing modular magnification, auto focus, contrast enhancement, hands-free use, and portability, but also offering the user ability to scan a wide-field image through digital image processing. In 2018, a multicenter prospective trial demonstrated improvement in visual ability including activities of daily living and reading in 51 novice eSight Eyewear users followed over three months [12].

Despite the functional and evidence-based benefits of magnifying low vision aid use [4, 13], rates of device non-use are highly variable [14]. A cross-sectional study revealed that of 109 eSight Eyewear users, 17.4% (n=19) did not use their device in the past three months [15] (see Article 2). The reasons of non-use had been identified as multifactorial, involving the device, the user, the environment and the intervention. Limited access to transportation to receive training with a device [14, 16, 17] and insufficient training duration and frequency were identified as important barriers to magnifying low vision aid use [14]. This is particularly a challenge given the paucity of

specialty low vision clinics, thereby considerably affecting the access to care in rural areas of geographically dispersed countries, such as the USA and Canada [18, 19].

In recent years, telerehabilitation has become a viable alternative for delivering rehabilitation services, allowing individuals to remain at home while interacting with a rehabilitation professional via internet-based communication technology [20]. A systematic review on telerehabilitation across disabilities revealed that most of the interventions were successful [21], thereby contributing to evidence-based practice recommendations towards its implementation. In the context of low vision, a Cochrane systematic review documented very few applications and no published outcomes [22]. Since then, a pilot study confirmed the feasibility and acceptability of training to optimize the use of handheld magnifiers in ten individuals with low vision via telerehabilitation from their home environment [23]. Mobile devices, using video systems (e.g., smart phone, tablet) have become widely accepted and adopted by the visually impaired population and suggest that they could be used to provide telerehabilitation services [24].

Given the absence of previous randomized controlled studies and to help guide evidence-based practice recommendations for this modality, this pilot study was conducted. The primary objective was to determine whether administering several low vision rehabilitation training sessions via telerehabilitation, using an Internet-based video platform, to participants with low vision using their eSight Eyewear in their environment, would be feasible. Specifically, it was asked whether one year would be sufficient to recruit the required number of participants, what proportion of participants would be lost to follow-up, and whether participants would judge the intervention as accessible and acceptable. The secondary objective was to determine if personalized intervention through telerehabilitation would be able to reduce discontinuance of head-mounted display use.

METHODS

Study design

This feasibility study considered the CONSORT guideline components [25]. This is a parallel two-arm randomised pilot study, consisting of training individuals with low vision in the use of eSight Eyewear when engaging in activities of daily living. The participants were enrolled through the School of Optometry of the *Université de Montréal,* Montreal, Quebec, Canada. The protocol has previously been published in more detail [26], and was approved by the institutional review board of the *Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain* (CRIR# 1286-1217). It complied with the ethical standards defined by the Declaration of Helsinki and its requirements for conducting research with human participants [27].

Sample size and participant eligibility criteria

Clients were informed by an employee of eSight Corporation of the opportunity to participate in the present study immediately after buying or renting an eSight device. Novice users with self-reported low vision, aged 18+, who were able to communicate in English or French, had a tablet, desktop or laptop computer with Internet access, and recently bought (< one month) or were renting eSight Eyewear were enrolled in the study. Exclusion criteria were as follows: device users owning their eSight device for more than one month (and had therefore completed the eSight eSkills User Guide [28]), and self-reporting other severe sensory impairments that may interfere with communication. The low vision therapist involved in the study confirmed whether participants were able to follow a 20-min phone conversation (i.e., sufficient hearing and cognition to complete oral informed consent and protocol procedures by phone, based on her 27 years of clinical experience). Figure 6 summarizes the design of the study; each of the study aspects is described in detail below.

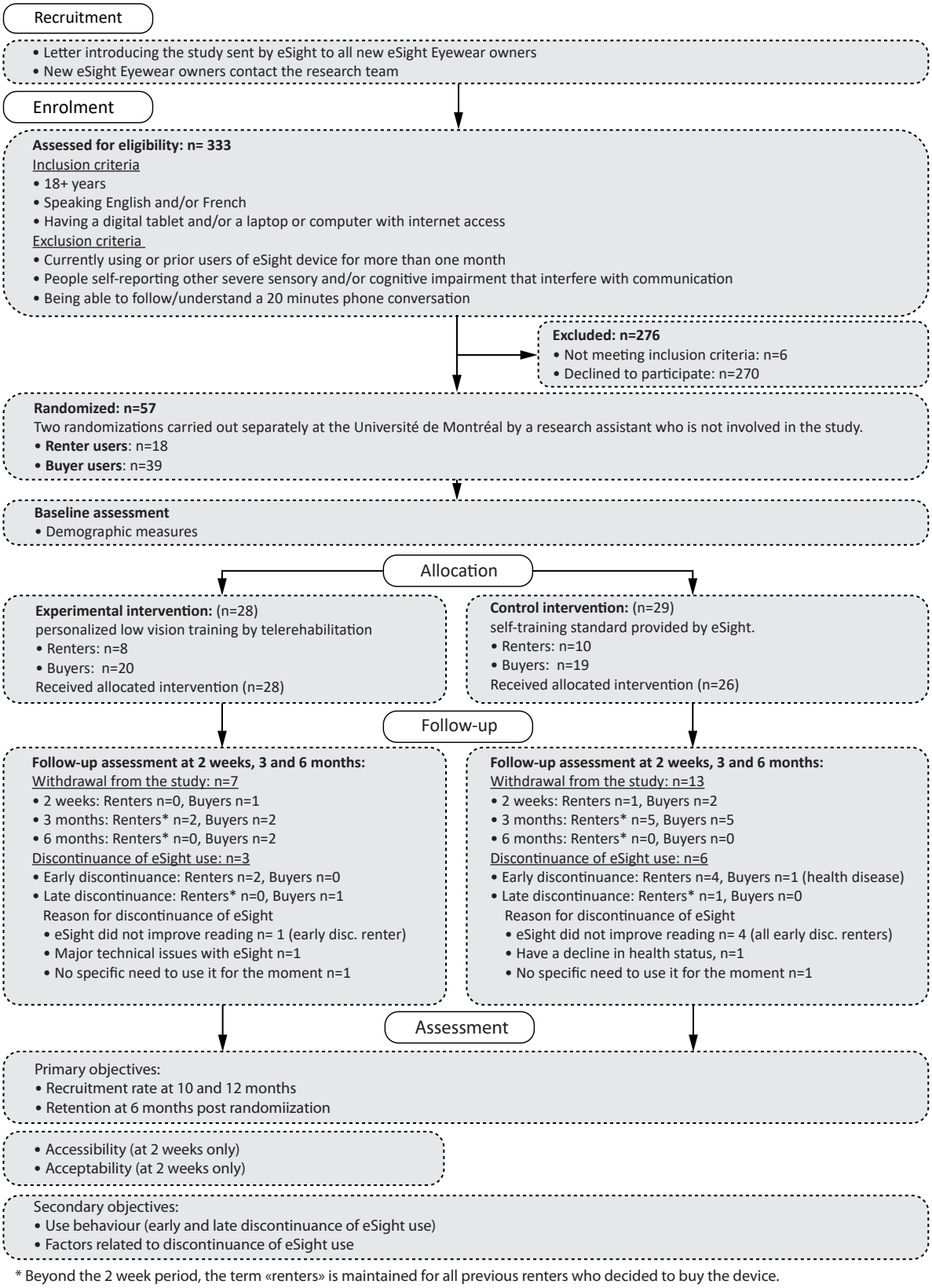

Figure 6. – Chart showing participant flow

Interventions

Participants were randomised to receive either personalized low vision training through telerehabilitation, or the self-training standard provided by eSight. Allocation was at a 1:1 ratio, whereby a research assistant who was not involved in the study carried out two separate randomizations: one for the participants who bought eSight Eyewear, the other for those who rented the device, given the consumers type difference and the potential influence of the company over those who have not yet made the purchase of the device.

Control intervention. The control intervention focused on the technical aspect of using the eSight device, namely: "How does eSight Eyewear work?". Participants in the control group received the self-training standard provided by eSight, including the eSkills learning and training guide [28] as provided upon purchase. This guide is a self-training program that spans one hour per day for one month (30 hours) to be performed at home, and divided into four weeks of exercises detailed in the published protocol [26]. At the end of the training, the participants continued to use the device in their environment until the end of the study five months later (and beyond).

Experimental intervention. The experimental group received personalized training through telerehabilitation that focused on the functional aspects of using eSight, namely: "How to achieve your activities of daily living with eSight Eyewear?". Participants benefitted from remote training sessions delivered to their home environment using a secure and password-protected connection via the Reacts telehealth platform, accessible through their computer or digital tablet at specific appointments (https://www.iitreacts.com). They interacted in real time with the low vision therapist involved in the study at the School of Optometry of the *Université de Montréal*. The personalized training by telerehabilitation consisted of six one-hour on-line training sessions within the first two weeks (six hours), 12 additional hours of homework in parallel during the

same 2 weeks, and an additional 12 hours of homework in the following two weeks (total 30 hours). The low vision therapist and participants shared common work materials composed of exercises that they could easily refer to: the eSkills learning and training guide [28] and digitized exercises extracted from the VisExc –eccentric fixation program [29] (partially adapted from the McGill Low Vision Manual [30]) detailed in the published protocol [26]. Individualized training was tailored to the needs of each participant. Between each of these six sessions, participants were asked to continue to train themselves at home using the eSkills learning and training guide for approximately six hours per week (12 hours of homework). At the end of the two telerehabilitation intervention weeks, the participants continued to train themselves for two weeks (12 hours of homework remaining) and continued using their eSight device in their environment, until the end of the study five months later (and beyond). After their enrolment, about an hour before the scheduled telerehabilitation session time, the low vision therapist contacted the participants by phone to guide them through the setup process and help with any questions or issues related to accessing the videoconference portal.

Outcomes

Primary outcomes.

The primary outcome of this study was the feasibility of telerehabilitation in the context of eSight Eyewear users: (1) enrolment target (signed consent) within ten as well as 12 months, (2) retention of participants until six months after randomisation, (3) accessibility of telerehabilitation training, and (4) acceptability of telerehabilitation training.

Given that the enrolment target was 60 participants (30 renters and 30 buyers of eSight Eyewear) over 12 months, the criterion for success was 48 participants (80%) over ten months

and/or 60 (100%) over 12 months. The number of eligible individuals declining to participate and why was recorded, and it was captured whether any participants withdrew from the study and why. Retention was monitored by follow-up evaluations and through questionnaires composed of individual questions specifically developed for the study. Accessibility of the training by telerehabilitation was determined by asking the low vision therapist about any problems related to Internet connectivity, access to the videoconference platform, use of the hardware, and audio/visual quality. At each training session, the low vision therapist reported any problems in a diary, for each participant and herself, respectively. Regarding acceptability, participants of the experimental group completed a satisfaction survey with a research assistant, whereby they were asked to rate the experience of telerehabilitation for comfort, efficiency, effectiveness, likelihood for future use, and overall satisfaction rated on a 4-point Likert scale ("Strongly agree" to"Strongly disagree"). The low vision therapist was asked to use a rating scale (“No difficulty” to “Impossible”) to indicate the difficulty with using the videoconference portal to estimate the participants' working distance, lighting environment while using their eSight device and quantify their reading fluency (i.e., speed, accuracy) using shared reading material, as well as her impressions of the effect of the intervention on participants (estimate of goals reached for each participants ranged from “completely” to “not at all”) (Supplementary information S13 and S14).

Secondary outcomes.

The effect of telerehabilitation on eSight device use behaviour (discontinuance rate) was assessed at two different times. In the context of the analyses, *early discontinuance in device use* was defined as when a participant who stopped using the device during the first two weeks of the study (either a renter who decided not to buy the device at the end of the rental period, or a buyer who decided not to use it anymore). L*ate discontinuance in device use* was defined as a

participant reporting non-use of the device in the previous three months on any given task, a period commonly used in previous research [31, 32]. The tasks were reported in 94 open and closed questions adopted from and including the items of the Psychosocial Impact of Assistive Devices Scale [33-35] and the Quebec User Evaluation of Satisfaction with Assistive Technology [36,37] (see additional analyses of these measures in Article 5), and questions specifically developed for this study about device user's characteristics and device use changes, available in the published protocol (detailed in Supplementary materials S11 and S12). [26] The questionnaires were administered at baseline by the low vision therapist and self-administered online through a URL link at two weeks, three and six months after randomization. Finally, factors pre-identified as being predictive of magnifying low vision aid use [14] (e.g., experience with low vision rehabilitation services, family/friend encouragement, physical environment) and eSight use [15] (see Article 2; e.g., other people's reaction while participants use their eSight device) were explored though the questionnaires.

Sample size

The enrolment target was 60 participants in total, with 30 individuals in each group. This sample size is comparable to other feasibility studies in low vision rehabilitation [38, 39] and was intended to maximize the available data given the opportunity created through the collaboration with the device manufacturer. Given the proposed recruitment period, this sample size allowed for the evaluation of any possible limitations with enrolment and retention more robustly, and provided rich data on accessibility and acceptability of telerehabilitation training.

Statistical analyses

Statistical analyses were conducted using JASP Version 0.9 software [40]. The analysis plan consisted of 3 steps. In Step 1, descriptive statistics were used to present the sample and responses on all outcome measures. In Step 2, enrolment was analyzed using the 1-year period of recruitment reporting the number of participants assessed for eligibility and the number of participants that were excluded (number of participants declining to participate and number of participants not meeting the inclusion criteria). Here, we report the number of participants that were enrolled within the 12-month recruitment period and whether the minimum required 80 % (48 participants) were reached. Retention in both the experimental and the control groups were analyzed at two weeks, as well as three and six months using the number of participants remaining in the study. If participants wished to withdraw after they had been allocated to an intervention group, they were given the opportunity to explain their reasoning, should they be interested in sharing these reasons, and recorded them in the case report. Variables assessing *accessibility* of telerehabilitation training (numbers and types of issues with: Internet connectivity, access to the videoconference platform, use of the hardware, and audio/visual quality) were presented as frequency counts. *Acceptability* was measured using ordinal data from a satisfaction survey, and descriptive statistics. In Step 3, early device discontinuance rate at two weeks and late discontinuance rate (from three months onwards) were analyzed using descriptive statistics. Factors pre-identified as being predictive of magnifying low vision aid use (i.e., experience with low vision rehabilitation services, use of several low vision aids, family/friend encouragement) and eSight use (i.e., people's reaction) were examined through the questions developed for the study to confirm their relationship with use behaviour. Depending on the nature of the questionnaire items, Spearman correlation coefficients or Chi-squares were calculated. Data collected up to the point of withdrawal were included in the data analysis.

RESULTS

Recruitment

Recruitment took place from June 2018 to June 2019. The participant flow is shown in Figure 6. A total of 333 eSight users were assessed for eligibility and approached by eSight Corporation. Of these, 270 declined to participate, and six did not meet inclusion criteria (one did not speak English and or French, two were under 18 years old, two had poor general health, one had cognitive issues interfering with communication).

Baseline Characteristics

The mean age of the participants was 54.5 years (SD, 16.7; range 21-82 years, see Table 12 for group-specific details). Participant characteristics at randomization are summarized in Table 13 and show comparable demographic and descriptive variables in both groups, albeit with retired participants' preponderance in the control-renters sub-group, and a male majority in the control group. Participants completing the trial had a range of ocular pathologies, although optic nerve dystrophies and central degenerations were the most common cause of vision impairment across groups (see Table 14). The 20 individuals that withdrew from the study (lost during the follow-up period) did not differ statistically on any of the demographic measures from those who completed the follow-up period (see Table 15). The nine individuals that reported not using their eSight Eyewear anymore (both early and late discontinuance) did not differ statistically on any of the demographic measures (statistically comparable, given the frequency distribution of the data) from those with complete data, with the exception of their distribution across their country of residence: more Canadians reported to not use their device anymore after the initial assessment (n = 4/7), whereas the user pool contained more Americans (n = 41/7) ($\chi 2$ 1 [n = 57] = 7.66, P < .01) (see Table 16).

Table 12. – Participant characteristics

	Control buyers (n=19)	Control Renters (n=10)	Experimental Buyers (n=20)	Experimental Renters (n=8)
Age, mean (SD) (y)	55.53 (11.72)	61.40 (12.91)	50.30 (20.95)	54.13 (18.94)
Male/female, n (%)	12(63)/7(37)	7(70)/3(30)	10(50)/10(50)	4(50)/4(50)
Country, n (%)				
USA	17 (89)	6 (60)	17 (85)	5 (63)
Canada	2 (11)	4 (40)	3 (15)	3 (37)
Living situation, n (%)				
Student/employed	8 (42)*	1 (10)	4 (20)	3 (37)
Unemployed	7 (37)	2 (20)	7 (35)	1 (13)
Retired	4 (21)	7 (70)	9 (45)	4 (50)
Living arrangement,n (%)				
Alone	4 (21)	3 (30)	3 (15)	2 (25)
Not alone	15 (79)	7 (70)	17 (85)	6 (75)
Level of study, n (%)				
Secondary	7 (37)	3 (30)	11 (55)	1 (13)
Post-secondary	12 (63)	7 (70)	9 (45)	7 (87)
Visual field deficit, n (%)				
Peripheral	5 (26)	2 (20)	8 (40)	2 (25)
Central	7 (37)	4 (40)	4 (20)	4 (50)
Both	4 (21)	3 (30)	3 (15)	1 (12)
None	3 (16)	1 (10)	5 (25)	1 (13)
Ocular disease, n (%)				
Central	8 (42)	5 (50)	7 (35)	3 (37)
Peripheral	2 (11)	3 (30)	1 (5)	2 (25)
General	9 (47)	2 (20)	12 (60)	3 (38)
Eye disease onset, n (%)				
Birth	6 (32)	3 (30)	7 (35)	2 (25)
>10 yrs	6 (31)	4 (40)	6 (30)	5 (62)
<6 months to 10 yrs	7 (37)	3 (30)	7 (35)	1 (13)
Other sensory impairment, n (%)				
No	15 (79)	8 (80)	17 (85)	6 (75)
Yes	4 (21)	2 (20)	3 (15)	2 (25)
Cognitive impairment, n (%)				
No	19 (100)	10 (100)	20 (100)	8 (100)
Physical impairment, n (%)				
No	16 (84)	8 (80)	16 (80)	7 (87)
Yes	3 (16)	2 (20)	4 (20)	1 (13)
Health condition, n (%)				
Poor to good	11 (58)	6 (60)	12 (60)	4 (50)
Very good	5 (26)	2 (20)	7 (35)	2 (25)
Excellent	3 (16)	2 (20)	1 (5)	2 (25)

*Chi-squarred with $p < .05$

The table displays descriptive comparisons between buyers and renters belonging to the control group, and between buyers and renters belonging to the experimental group. Statistical comparisons were calculated when the frequency distribution of the data allowed it. Participant characteristics at randomization show comparable demographic and descriptive variables across groups, albeit with a retired participants preponderance in the control-renters sub-group.

Table 13. – Participant characteristics and their relationship with group type

	Control group (n=29)	Experimental group (n=28)	p value	Buyer (n=39)	Renter (n=18)	p value
Age, mean (SD) (y)	57.55 (12.25)	51.39 (20.12)	.34*	52.85 (17.07)	58.17 (15.80)	.30*
Male/female, n (%)	19 (66)/10(34)	14(50)/14(50)	.24	22(56)/17(44)	11(61)/7(39)	.56
Country, n (%)			.67			.15
USA	23 (79)	22 (79)		34 (87)	11 (61)	
Canada	6 (21)	6 (21)		5 (13)	7 (39)	
User type, n (%)			.63			
Renter	10 (34)	8 (29)				
Buyer	19 (66)	20 (71)				
Living situation, n (%)			.80			NV
Student/employed	9 (31)	7 (25)		12 (31)	4 (22)	
Unemployed	9 (31)	8 (29)		14 (36)	3 (17)	
Retired	11 (38)	13 (46)		13 (33)	11 (61)	
Living arrangement,n (%)			.56			.40
Alone	7 (24)	5 (18)		7 (18)	5 (28)	
Not alone	22 (76)	23 (82)		32 (82)	13 (72)	
Level of study, n (%)			.52			.08
Secondary	10 (34)	12 (43)		18 (46)	4 (22)	
Post-secondary	19 (66)	16 (57)		21 (54)	14 (78)	
Visual field deficit, n (%)			.53			.53
Peripheral	7 (24)	10 (36)		13 (33)	4 (22)	
Central	11 (38)	8 (29)		11 (28)	8 (45)	
Both	7 (24)	4 (14)		7 (18)	4 (22)	
None	4 (14)	6 (21)		8 (21)	2 (11)	
Ocular disease, n (%)			.48			.06
Central	13 (45)	10 (36)		15 (38)	8 (44)	
Peripheral	4 (14)	3 (11)		3 (7)	5 (28)	
General	11 (38)	15 (53)		21 (54)	5 (28)	
Eye disease onset, n (%)			.88			.35
Birth	9 (31)	9 (32)		13 (33)	5 (28)	
>10 yrs	10 (34)	11 (39)		12 (31)	9 (50)	
<6 months to 10 yrs	10 (35)	8 (29)		14 (36)	4 (22)	
Other sensory impairment, n (%)			.79			.70
No	23 (79)	23 (82)		32 (82)	14 (78)	
Yes	6 (21)	5 (18)		7 (18)	4 (22)	
Cognitive impairment, n (%)			NV			NV
No	29 (100)	28 (100)		39 (100)	18 (100)	
Physical impairment, n (%)			.95			NV
No	24 (83)	23 (82)		32 (82)	15 (83)	
Yes	5 (17)	5 (18)		7 (18)	3 (17)	
Health condition, n (%)			.68			NV
Poor to good	17 (58)	16 (57)		23 (59)	10 (56)	
Very good	7 (24)	9 (32)		12 (31)	4 (22)	
Excellent	5 (17)	3 (11)		4 (10)	4 (22)	

p value calculated with Chi-squared; * p value calculated with Mann-Whitney tests, NV indicates “no value” when statistical comparisons were not possible given the frequency distribution of the data.

This table displays descriptive comparisons between control and experimental groups, and between buyer and renter groups. Participant characteristics at randomization show comparable demographic and descriptive variables across groups, albeit with a male majority in the control group.

Table 14. – Causes of vision impairment

Cause of sight impairment, n (%)	Control group (n=29)	Experimental group (n=28)
Optic nerve disease	8	10
Age-related macular degeneration	6	6
Retinopathy of prematurity	3	2
Retinis pigmentosa	3	1
Diabetic retinopathy	0	2
Stargardt disease	1	1
Congenital nystagmus	1	1
Retinal detachment	1	1
Keratoconus	1	0
Central retinal vein occlusion	1	0
Central serus retinopathy	1	0
malign myopia	1	0
stroke	1	0
Optic atrophy with cerebral visual impairment	0	2
congenital cataract	0	1
Peter's syndrome	0	1
Erdhiem Chester disease	1	0

Table 15. – Participant characteristics and their relationship with study withdraw

Variables	No withdraw group (n=37)	Withdraw group (n=20)	p value
Age, mean (SD) (y)	54.00 (17.89)	55.50 (14.71)	.97*
Male/female, n (%)	22(59)/15 (41)	11(55)/9(45)	.75
Country, n (%)			.59
USA	30 (81)	15 (75)	
Canada	7 (19)	5 (25)	
Group type			.12
Control	16 (43)	13 (65)	
Experimental	21 (57)	7 (35)	
Customer type, n (%)			.32
Renter	10 (27)	8 (40)	
Buyer	27 (73)	12 (60)	
Living situation, n (%)			.40
Student/employed	12 (33)	4 (20)	
Unemployed	9 (24)	8 (40)	
Retired	16 (43)	8 (40)	
Living arrangement,n (%)			.22
Alone	6 (16)	6 (30)	
Not alone	31 (84)	14 (70)	
Level of study, n (%)			.68
Secondary	15 (41)	7 (35)	
Post-secondary	22 (59)	13 (65)	
Visual field deficit, n (%)			.87
Peripheral	11 (30)	6 (30)	
Central	13 (35)	6 (30)	
Both	6 (16)	5 (25)	
None	7 (19)	3 (15)	
Ocular disease, n (%)			.35
Central	14 (38)	9 (45)	
Peripheral	7 (19)	1 (5)	
General	16 (43)	10 (50)	
Eye disease onset, n (%)			.93
Birth	12 (32)	6 (30)	
>10 yrs	14 (38)	7 (35)	
<6 months to 10 yrs	11 (30)	7 (35)	
Other sensory impairment, n (%)			NV
No	30 (81)	16 (80)	
Yes	7 (19)	4 (20)	
Cognitive impairment, n (%)			NV
No	37 (100)	20 (100)	
Physical impairment, n (%)			NV
No	31 (84)	16 (80)	
Yes	6 (16)	4 (20)	
Health condition, n (%)			.69
Poor to good	20 (54)	13 (65)	
Very good	11 (30)	5 (25)	
Excellent	6 (16)	2 (10)	

p values were calculated with Chi-squared; NV indicates ""no value" when statistical comparisons were not possible given the frequency distribution of the data; n indicates number of participants; * p value calculated with Mann-Whitney tests.

This table displays descriptive comparaisons between participants who withdrew from the study and those who decided to complete the follow-up period. Stastistical analysis comparisons were calculed when the frequency distribution of the data enabled it. Participant characteristics show comparable demographic and descriptive variables in groups.

Table 16. – Demographic variables and their relationship with eSight device use

Variables	eSight users (n=48)	discontinuance of eSight use (n=9)	p value
Age, mean (SD) (y)	53.35 (17.00)	60.78 (14.42)	.28*
Male/female, n (%)	26 (54)/22 (46)	7 (78)/2 (22)	0.19
Country, n (%)			<.01
USA	41 (85)	4 (44)	
Canada	7 (15)	5 (56)	
Group type			.30
Control	23 (48)	6 (67)	
Experimental	25 (52)	3 (33)	
User type, n (%)			NV
Renter	11 (23)	7 (78)	
Buyer	37 (77)	2 (22)	
Withdraw the study			NV
No	35 (73)	2 (22)	
Yes	13 (27)	7 (78)	
Living situation, n (%)			NV
Student/employed	15 (31)	1 (11)	
Unemployed	15 (31)	2 (22)	
Retired	18 (38)	6 (67)	
Living arrangement,n (%)			.33
Alone	9 (19)	3 (33)	
Not alone	39 (81)	6 (67)	
Level of study, n (%)			NV
Secondary	19 (40)	3 (33)	
Post-secondary	29 (60)	6 (67)	
Visual field deficit, n (%)			NV
Peripheral	15 (31)	2 (22)	
Central	13 (27)	6 (67)	
Both	10 (21)	1 (11)	
None	10 (21)	0 (0)	
Ocular disease, n (%)			NV
Central	18 (37)	5 (56)	
Peripheral	7 (15)	1 (11)	
General	23 (48)	3 (33)	
Eye disease onset, n (%)			NV
Birth	18 (38)	0 (0)	
>10 yrs	15 (31)	6 (67)	
<6 months to 10 yrs	15 (31)	3 (33)	
Other sensory impairment, n (%)			NV
No	39 (81)	7 (78)	
Yes	9 (19)	2 (22)	
Cognitive impairment, n (%)			
No	48 (100)	9 (100)	
Physical impairment, n (%)			NV
No	39 (81)	8 (89)	
Yes	9 (19)	1 (11)	
Health condition, n (%)			.61
Poor to good	29 (60)	4 (44)	
Very good	13 (27)	3 (33)	
Excellent	6 (13)	2 (22)	

p value calculated with Chi-squared; * p value calculated with Student t-test; n indicates number of participants; NV indicates “no value” when statistical comparisons were not possible given the frequency distribution of the data.

This table displays descriptive comparisons (number of participants and percentage are provided in the table) between participants who maintained their eSight use and those who discontinued their use. Statistical comparisons were calculated when the frequency distribution of the data allowed it. Participant characteristics show comparable demographic and descriptive variables in groups, albeit with a statistical significant majority of participants who resided in the USA in the group that maintained eSight use.

Primary Outcomes

Recruitment target

Thirty-two (more than 50%) participants were enrolled within six months, 48 (80%) participants wthin ten months, and the target number of 60 participants was nearly reached within 12 months (the last participant was enrolled on June 15, 2019). There were no major events that required exclusion of participants before the end of the study.

Retention Rates

The retention rate was 93% (n = 53) at two weeks, 68 % (n = 39) at three months, and 65% (n = 37) at six months. Of the 18 initial renters, five returned their devices after the 2-week loan. The main reason was because they were not able to be proficient in reading with their device: four of them had a central vision loss (two with age-related macular degeneration, one with Stargardt's disease and one with a retinopathy), and one had a peripheral vision loss (retinis pigmentosa). Considering all the participants who bought eSight (initial and new buyers, n = 52), the retention rate at three months was 75%, and 71% at six months. Of the 20 participants who did not complete assessments until six months, seven belonged to the experimental and 13 to the control group. In the experimental group, one participant decided not to buy the device, two had difficulty accessing the Reacts telehealth portal and lacked support from their family/friends for usage of the platform (one of them had a technical device failure), and four withdrew without giving any reason. In the control group, four participants decided not to buy the device, one participant had a decline in his health status, and eight withdrew without giving any reason. The 20 individuals that withdrew from the study did not differ statistically on any of other measures statistically comparable (e.g., previous experience with electronic video magnifier, family/friends

encouragements to use their device) from those with complete data (see Table 17).

Table 17. – Previously identified variables and their relationship with study withdraw

Variables	No withdraw group (n=37)	Withdraw group (n=15)	p value
Frequency of eSight device utilization, n (%)			NV
Several time a week to once a week	15 (41)	4 (27)	
Everyday	22 (59)	11 (73)	
Experience with electronic video magnifier, n (%)			.57
No	18 (49)	6 (40)	
Yes	19 (51)	9 (60)	
Currently use of several low vision aids, n (%)			NV
No	4 (11)	1 (7)	
Yes	33 (89)	14 (93)	
eSight is right for the user, n (%)			
Not at all to slightly	2 (5)	7 (46)	NV
Moderately to quit a bit	20 (54)	4 (27)	
Extremely	15 (41)	4 (27)	
Family/friends encouragement, n (%)			.63
A little of the time to none of the time	9 (24)	2 (13)	
A good bit of the time to some of the time	9 (24)	5 (33)	
All of the time to most of the time	19 (52)	8 (54)	
Experience with low vision rehabilitation services, n (%)			.57
No	18 (49)	6 40)	
Yes	19 (51)	9 (60)	
Satisfaction with eSkills self-training, n (%)			.81
Moderately satisfied	8 (22)	4 (27)	
Quite satisfied	10 (27)	5 (33)	
Very satisfied	19 (51)	6 (40)	
eSkills program completion, n (%)			.63
More than the half to not at all	16 (43)	7 (47)	
Half	12 (33)	3 (20)	
Entirely	9 (24)	5 (33)	

The variables concerned 52 participants instead of 57 because at two weeks, four participants withdrew from the study without completing their evaluation and one completed it only partially. n indicates number of participants; NV indicates “no value” when statistical comparisons were not possible given the frequency distribution of the data

This table displays descriptive comparisons (number of participants and percentage are provided in the table) between participants who maintained their eSight use and those who discontinued their use. Stastistical analysis comparisons were calculed when the frequency distribution of the data enabled it.

Accessibility of Telerehabilitation

All of the participants in the experimental group had their own computer on which they could install the application of the Reacts telehealth platform with the help of the low vision therapist. For four of these 28 participants, some training sessions were done while at work. Four participants received assistance from a friend or family member during some of the training sessions. Two participants withdrew from the study because they were not able to access to the platform independently of which one decided not to use the device anymore. *Audio issues.* There were no major issues with the audio component of the telerehabilitation sessions; however, for one participant in the first session the audio did not automatically connect and he had to call the telehealth platform to manually connect the audio. Three other participants had audio connection issues but only intermittently. They had a weak signal connection that resulted in inconsistent and jerky audio when joining the platform requiring them to use their phone while using the computer video until the issue was solved. *Video issues.* For six participants the video did not automatically connect when they joined the videoconference session for the first time. Again, the participants were instructed to phone the telehealth platform support service and obtained recommendations to optimize video signal quality. *Combined audio and video issues*. For two participants audio and video issues occurred together intermittently, and were associated with insufficient bandwidth at the client's connection. Audio and / or video issues never jeopardized participants' training and were not a cause for withdrawing from the study.

Acceptability of Telerehabilitation Training

*Participants' Ratings of Telerehabilitation training***.** The satisfaction survey was completed by 23 of 28 participants. All of the five participants who did not respond withdrew from the study. The respondents agreed that they were comfortable with receiving

telerehabilitation training, of which 83% strongly agreed with this statement. The majority of the participants strongly or mostly agreed that the training through videoconferencing was as efficient (16/23), as effective (16/23), and allowed them to better accomplish their goals (17/23) compared to other previous in-person rehabilitation services. Finally, most of the participants (20/23) strongly agreed that they would be interested in using telerehabilitation again if their visual needs were to change in the future. All agreed that they were satisfied overall with receiving telerehabilitation training, with 65% strongly agreeing with this statement.

Low vision therapist's Ratings of Telerehabilitation training. While participants used their device, it was moderately difficult for the low vision therapist to evaluate working distance and lighting environment. The clinician reported that no exact measurement of the working distance could be obtained but it was possible to estimate it by asking the participant to indicate the distance between his/her face and the text. However, the reading posture was observable through the camera and could be corrected by providing instructions. People with low vision often tend to bring text very close to their eyes to obtain natural magnification; using the eSight device, the challenge remained to adjust the magnification level on the device, finding the minimum magnification with the best reading distance and posture. The use of a lap desk or a reading stand was strongly recommended by the low vision therapist to offer better stability of the text and to keep a comfortable posture. In addition to working distance issues, the second major challenge was related to the assessment of the lighting environment. Although no exact measurement could be obtained, by asking the participant to use his/her computer camera to scan around the room and observe the presence and the source of natural and/or artificial light (windows or lamps) it was possible to estimate the level of lighting qualitatively. Moreover, an optional light integrated in the eSight device, providing a direct and constant light to the reading material, was easy to

manage by the low vision therapist and the participants. Finally, the low vision therapist judged the evaluation of reading speed and reading accuracy though the shared reading material as easy. Even from non-standardized text, it was possible to observe and identify reading problems. Difficulties in long words, line breaks, or confusion of some letters are often the focus of low vision rehabilitation in people with scotomas. Given these common challenges, the low vision therapist considered that six sessions over two weeks were insufficient, especifically for participants who needed eccentric fixation training.

The low vision therapist reported that goals were completely, partially and not at all achieved for sixteen, eight, and four (57%, 29% and 14%, respectively) of the twenty-eight participants. Overall, she perceived her intervention as helpful to improve eSight Eyewear use for activities of daily living in all but four participants: one had major difficulties with technology in general (i.e., Reacts platform and eSight device), one had difficulty in accessing the Reacts telehealth platform and withdrew before the end of the 2-week training program, one was already proficient in reading without any device use, and one was most proficient with her closed-circuit television. Goals were partially achieved and concerned reading skills for eight participants: two had very low vision and would have needed more than a 2-week training session, three had age-related macular degeneration and the 2-week training was not sufficient to train their eccentric fixation, one got discouraged quickly during her training, one was most proficient in hand-held magnifier usage compared to his eSight device use, and one exhibited diplopia using eSight eyewear when viewing at near. Other issues were related to the difficulty in identifying the participants' gaze position (e.g., eccentric fixation), training with dynamic or manual activities because the field of activity was reduced (e.g., cooking), adapting computer configurations because of a lack of access to the participant's screen (e.g., wallpaper, cursor size), and checking

if the eSight device was defective.

Secondary Outcomes

eSight Eyewear discontinuance

Early discontinuance in device use. Among the 57 participants, seven (12%) reported discontinuing their eSight device use early: five renters decided not to buy the device at the end of the rental period because they did not experience reading improvement, and two buyers who decided not to use the device anymore because of a decline in health and difficulty to use eSight. Three participants did not complete their questionnaire at two weeks and withdrew from the study without providing any reasons. For these participants, it was not possible to confirm if they discontinued their eSight use early. Considering their group membership, 71% (5/7) of the participants who discontinued their device use early belonged to the control group.

Late Discontinuance in device use. Two participants reported non-use of the device in the previous three months. They considered that they had not completely stopped using their device and that they simply had not needed it since their last use. At their 6-month evaluation, four participants reported non-use between 1-3-month period and three of them considered that they completely stopped using their eSight device: two did not give a reason and one reported a decline in health.

Exploration of variables related to device-non-use

The majority (63%) of participants who continued the use of eSight Eyewear *felt a reaction from people when they wore eSight,* and most of those who discontinued their use did not report feeling such reactions (56%). Interestingly, when asked what the type of reaction was, 100% expressed that it was interest and positive curiosity. Participants who sustained their device

use were mainly those who reported the highest level of satisfaction with eSkills self-training, unlike those who discontinued their use and predominantly indicated the lowest level of satisfaction. Questionnaire variables were not statistically comparable given the frequency distribution of the data (Chi-squared is not possible when some variables have no/very few cases) (see Table 18).

Table 18. – Previously identified variables and their relationship with eSight device use

Variables	eSight users (n=43)	discontinuance of eSight use (n=9)	p value
Frequency of eSight device utilization, n (%)			NV
Several time a week to once a week	15 (35)	4 (44)	
Everyday	28 (65)	5 (56)	
Experience with electronic video magnifier, n (%)			NV
No	41 (95)	9 (100)	
Yes	2 (5)	0 (0)	
Currently using of several low vision aids, n (%)			NV
No	4 (9)	1 (11)	
Yes	39 (91)	8 (89)	
Disappointed using the eSight device, n (%)			NV
Not at all to slightly	30 (70)	3 (33)	
Moderately to extremely	13 (30)	6 (67)	
Physical environment influence, n (%)			NV
No	27 (63)	7 (78)	
Yes	16 (37)	2 (22)	
Family/friends encouragement, n (%)			NV
A little of the time to none of the time	10 (23)	1 (11)	
A good bit of the time to some of the time	10 (23)	4 (44)	
All of the time to most of the time	23 (53)	4 (44)	
Experience with LV rehabilitation services			NV
No	21 (49)	3 (33)	
Yes	22 (51)	6 (67)	
Reaction from people, n (%)			NV
No	16 (37)	5 (56)	
Yes	27 (63)	4 (44)	
Satisfaction with eSkills self-training, n (%)			NV
Moderately satisfied	9 (21)	4 (44)	
Quite satisfied	12 (28)	3 (33)	
Very satisfied	22 (51)	2 (22)	
eSkills self-training completion, n (%)			NV
More than the half to not at all	19 (44)	4 (44)	
Half	12 (28)	3 (33)	
Entirely	12 (28)	2 (22)	

The variables concerned 52 participants instead of 57 because at two weeks, four participants withdrew from the study without completing their evaluation and one completed it only partially. n indicates number of participants; NV indicates “no value” when statistical comparisons were not possible given the frequency distribution of the data

This table displays descriptive comparisons (number of participants and percentage) between participants who maintained their eSight use and those who discontinued their use. Statistical comparisons were not calculated because the frequency distribution of the data did not allow it.

DISCUSSION

A feasibility study was carried out to assess the recruitment, retention, accessibility and acceptability of an eventual fully randomised trial of telerehabilitation for people with low vision using a head-mounted display. The results demonstrated that it was feasible to implement a randomized controlled study of individuals with visual impairment using eSight Eyewear receiving rehabilitation via a tele-health-platform. Once enrolled, 35 % of participants withdrew while 65% completed the entire six months of the study. High accessibility and acceptability of the telerehabilitation training sessions were observed among those completing the study, and a low usage discontinuation of the head-mounted-display, representing 16 % of all participants who were assessed across the study. The participants' choice to continue using the device was independent of the training offered.

There were no major issues with the audio and video component of the telerehabilitation probably because participants used their own computer and did not experience issues associated with less expensive android tablets as provided in a previous pilot study [23]. In addition, it was used a secure and accredited telehealth platform that has been used by various telehealth projects by public health providers within the university health network of the research team. The high accessibility and acceptability reported by the participants suggest that telerehabilitation seems a particularly promising modality for low rehabilitation services. The training delivered in the study was personalized, providing to the low vision therapist relevant insights about the participants' environment and tasks that were visually challenging. The provided telerehabilitation training was very similar to services that would be given in-office, including the same confidence level and comfort in human interaction with participants, in particular for reading, writing, other eye-hand coordination tasks (e.g., sewing, drawing) and initial eccentric

fixation training. More than six sessions would be needed for the acquisition of a stable eccentric fixation according to the low vision therapist. Few participants needed direct assistance from a friend or family member during the telerehabilitation sessions. Most were independent and, once connected, if they experienced technical challenges with the telehealth platform, it did not compromise training.

Different telerehabilitation intervention modalities should be considered. In light of an inconsistent training model for emerging head-mounted display technology in the field of low vision rehabilitation for the use of head-mounted displays, the present study compared a clinical-type intervention with a commercial self-training standard provided by the device manufacturer. A recent pilot study supported potential value and feasibility of low vision telerehabilitation in ten patients receiving a one-hour unique training session at home to use their handheld magnifier by an in-office clinician [23]. Positive accessibility feedback was gathered from both participants and providers, whereby video quality was rated as excellent to good and audio quality ratings were variable, depending on the nature of tablet type used. Encouraging results were obtained regarding accessibility, whereby none of the participants were dissatisfied with the telerehabilitation session and all agreed that they would want to have another telerehabilitation session again in the future. An alternative telerehabilitation format is currently implemented by the Buffalo Veterans Affairs low vision service, in which participants travel to an equipped location in their vicinity to receive training from a remote low vision rehabilitation therapists [41]. Considering the diversity of telerehabilitation types described, one of the next steps would be to compare our telerehabilitation training with a traditional in-office low vision service. Moreover, given these encouraging outcomes for telerehabilitation implementation using either eSight-

Eyewear or hand-held magnifiers[23], it is likely feasible to provide telerehabilitation for other head-mounted display types or electronic low vision aids.

Measures of device usage were included as secondary outcome measures. More participants of the control group discontinued device use compaired with the those of the experimental group (six versus three participants, respectively); however, we did not find any significant difference in the effect between the two intervention groups, indicating that training provided by the device manufacturer may be considered as an intervention that is as effective as the proposed personalized telerehabilitation training. Given the sample size and the frequency distributions of the participants who discontinued device use, the statistical analyses need to be interpreted with care. Insofar as low vision aid usage depends on training [42] [43], this result is perhaps not surprising. In particular, a scoping review reported that intensive training was predictive of magnifying low vision aids use [44]. Considering the sustained 30-hrs training of the self-training eSkills program, this may have produced the same effect on device use as the personalized telerehabilitation training. Yet, a cross-sectional study revealed that training was not a predicting factor of eSight device use [15] (see Article 2). It is probable that follow-up assessments, required by the present longitudinal design, positively influenceed participants' motivation regardless of their self-training compliance (Hawthorne effect). Moreover, a personalized and a more comprehensive intervention, involving a multidisciplinary team, might have succeeded in reducing the number of device discontinuances compared to the self-guided training.

Compared to the 30 % discontinuance rate (also considered as a threshold for defining low and high rates of device abandonment [45, 46]) of assistive technology use traditionally observed in the literature [47-49], the 16 % (including early and late discontinuance) in the present

study is considered as low and mirrors behaviour use measured in the online-survey addressed at eSight Eyewear users, whereby 17 % of the participants had discontinued their device use [15] (see Article 2). This finding is also exactly in line with the 17 % abandonment rate reported in the context of patients receiving magnifier devices via a novel low vision mobile clinic delivery model [32]. It can be anticipated that this low discontinuation rate may be an uderestimate given the number of participants who withdrew from the study without providing any reasons, as well as a possible social desirability bias in the responses of the remaining participants. The cost involved in obtaining the device may also influence the motivation to maintain usage over time. However, the logic that tends to associate people who withraw from the study with those who discontinued their device use, does not entirely apply to this study. The two participants who discontinued their device use late completed the entire 6-months follow-up. They reported that they had not completely stopped using their device and that they simply had not needed it since their last use. We continued to follow them for descriptive reasons (e.g., to explore the potential decision to use the device again) and also because it was a feasibility study that assessed retention rate over six months. Moreover, five participants who completely stopped using their device (but did not meet the *late discontinuance use* definition and were not categorized as non-users), did not withdraw from the study. These five participants were categorized as users not only because they had not discontinued their device for more than three months, but also because ocular or general health issues occurred (awaiting cataract surgery, illness) that they judged as transient, and that they intended to use their device again in the future.

Another relevant point to report is that among participants who discontinued their eSight use, all except two discontinued within the first three months and the majority of those were participants who rented the device and returned it after the 2-week leasing period without

providing any reason. These findings are consistent with an earlier study reporting both abandonment in the first three months after visual aid provision and also no significant difference in abandonment at three months versus one year after device provision [32]. In addition, people's positive reaction while using their device in public had been associated with sustained device use. This factor was actually expected and is aligned with previous work, whereby interest and positive curiosity were associated with people's reaction in a cross-sectional study [15] (see Article 2). The replication of this result in a prospective context suggests that participants who sustained their device use may also be more involved in social activities and attentive to people around them. In contrast, encouragement by family/friends was not associated with sustained device use, replicating previous findings [15] (see Article 2). Given the sample size and the frequency distributions, it was not possible to confirm if experience with electronic video magnifiers, or other low vision aids, family/friend encouragement, or accessing low vision rehabilitation services were associated with device use. In future studies, the question of whether telerehabilitation training will enable greater independence in activities of daily living and possibly whether this would translate into greater improvements in quality of life will need to be addressed.

Limitations of the study include self-selection bias, as participants who spontaneously decided to rent or purchase eSight Eyewear, expressed interest in research participation, own the computer equipment necessary for telerehabilitation and data collection, and were willing to try an Internet-based video conference platform were enrolled. To overcome this potential bias, it is planned to loan eSight Eyewear and Internet access tablets to participants in the next phase of this project, thereby avoiding the possibility that the participants' commitment to their purchase decision affects this bias in the study. It is worth noticing that, among users who were contacted,

nobody was excluded from this study due to a lack of Internet and / or computer / tablet access because all were already equipped. However, the participants were not representative of the general low vision population since they were already exposed to sophisticated technology, possibly leading them to be more willing to try technology used for telerehabilitation and/or videoconferencing. However, this limitation will probably be less contextual over the next decades with upcoming generations. Another limitation is that it was not always possible to differentiate device discontinuance from other types of attrition. This was specifically the case for participants that withdrew from the study without explanation. However, through regular monitoring, we hope we were able to record most reasons for leaving the study. Considering the importance of optimizing device usage measures in a future trial, it may be relevant to monitor duration of usage and the settings used by the participant with a dedicated application on the head-mounted display. Moreover, the choice to still use eSight by the participants was reported as being independent of the training offered but this does not include the opinions of the 35% who withdrew from the study. Another potential limitation is the absence of an in-office evaluation with objective visual function measures, such as visual acuity, visual field, or contrast sensitivity, which could provide complementary insights. Given the on-line survey nature of data collection, complete access to medical chart information was not feasible. The aspects that were missing from the evaluation could be added to future protocols. For example, standardized near reading or acuity cards during the telerehabilitation session had already been successfully implemented [23]. Because telerehabilitation is not intended as a substitute for in-person interventions, a hybrid resource allocation would ideally combine telerehabilitation training with an initial in-office assessment and visits at participants' home to more comprehensively understand their environment. Altogether these complementary services would be able to detect visual function decline in a timely manner, changes in patients' needs and would allow planning an in-office visit

if further visual explorations are required. Finally, given the nature of the intervention, it was not possible to mask participants to the experimental intervention. This may have introduced social desirability bias in participants' self-reports regarding usage of the head-mounted display, and their retention in the study. Randomized participant allocation, masking the researcher to group allocation, and the use of self-administered assessments minimized selection, detection and experimenter bias. Moreover, the telerehabilitation approach allowed enrolment and participation across both rural and urban environments to represent a wide range of individuals with visual impairment using eSight Eyewear.

CONCLUSIONS

The data demonstrated the feasibility of a randomized controlled study of telerehabilitation for people with low vision using a head-mounted display. Positive feedback from the participants and the low vision therapist suggest the potential value of this modality for low vision services; however, we did not find any significant difference in device usage between the two intervention groups. With the aging of the population, it is urgent to provide innovative care delivery strategies for low vision service to maintain and increase the standard of care and the quality of life for people with low vision. An important challenge is to implement low vision telerehabilitation services without compromising comprehensive care, including personalized adjustment interventions. A hybrid resource allocation for low vision rehabilitation has the potential to overcome barriers associated with existing service delivery, while maintaining human interaction. Telerehabilitation allows personalized care because patients are evaluated in their own environments. The ubiquity of the care makes it more ecologic, and potentially optimizes the compliance with care recommendations. Moreover, telerehabilitation has the potential to increase efficiency, reducing travel time and expenses for both the low vision therapist and the patients.

Altogether, this modality may increase the number of follow-up sessions to improve learning about device use and vision- and health-related outcomes. Telerehabilitation is a creative solution that allows new issues to emerge, such as the enhancement of a team approach involving highly qualified professionals. New reimbursement modes for telehealth services will need to be addressed and could open the door to future implementation of the services into current clinical practice. Finally, ethical issues related to e-health raise the importance of identifying secure telehealth platforms and protect patient privacy in accordance with local and national laws and regulations.

Acknowledgements

We thank Josée Duquette for access to the VisExc – INLB eccentric fixation program and Nancy Primeau in her support for formatting of bibliographic references.

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Article 5: Assessing changes in quality of life after personalized telerehabilitation in users of a head-mounted low vision aid

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Keywords

Low vision, Assistive technology, Head-mounted display, Telerehabilitation, Quality of life

Submitted, under review
Optometry and Vision Science

Abstract

Significance: Interest in portable head-mounted low vision devices has increased in recent years and these devices have become a viable alternative to enhance residual vision. Several studies have examined the multifactorial decision process around the use of assistive technologies, whereby transportation issues and insufficient training have emerged as important barriers. Quality of life outcomes and symptoms related to cybersickness, such as presence of headaches, were important predictors of head-mounted device abandonment. Despite encouraging preliminary outcomes, very few applications of telerehabilitation for low vision have been tested on a larger scale. **Purpose:** To help guide evidence-based practice recommendations for this rehabilitation modality, a randomised study of telerehabilitation for individuals with low vision using head mounted displays was conducted. **Methods:** Participants aged 18+ among prospective eSight Eyewear owners were recruited, randomised 1:1 into two parallel groups, whereby the experimental group received the telerehabilitation training provided by a low-vision therapist and the control group received the self-training standard offered by the device manufacturer. The primary outcome measures were the impact of telerehabilitation on validated measures that evaluate different aspects of assistive technology-related quality of life. Exploratory outcomes were the assessment of functional vision and cybersickness associated with head-mounted display use. **Results:** Assistive technology-related aspect of quality of life was improved in the 57 participants (age 21-82, mean 54.5) within the first three months, independently of training type. Overall, early functional vision improvement, independently of group types, indicated no changes in participants' cybersickness outcomes after telerehabilitation**. Conclusion:** eSight Eyewear, either with telerehabilition or with the manufacturer self-training standard, early improves functional vision and increased users' quality of life within the first three months of

device training and practice. This indicates that eSight training using telerehabilition was equally successful in improving device-related aspect of quality of life and functional vision outcomes as the self-training standard provided by the device manufacturer.

INTRODUCTION

Visual impairment (blindness and low vision) is globally prevalent across the lifespan and affects at least 2.2 billion people [1]. Low vision is defined as moderate visual impairment (i.e., best-corrected visual acuity between 0.5-1.3 logMAR [20/60 to 20/400] in the better eye, or a remaining visual field of < 20 degrees in the better eye with best possible correction [2]) that is not correctable with glasses, contact lenses, or surgical intervention, and interferes with normal everyday functioning [3]. Low vision rehabilitation is the primary intervention for individuals with reduced visual function and can improve independence, functional visual abilities and quality of life by maximizing the individual's remaining visual abilities [4]. Among the most common forms of intervention in low vision rehabilitation is the provision of and training in the use of low vision aids, including optical and electronic magnification devices [5] that are commonly recommended and provided in face-to-face rehabilitation sessions.

In recent decades, wearable head mounted displays have undergone major technological evolution (i.e., rapid miniaturization of the camera, image processing and display electronics) and have become a viable alternative to enhance residual vision in individuals with vision impairment [6, 7]. Among the new generation of head-mounted displays, eSight Eyewear (eSight Corp., Toronto, ON, Canada), a semi-immersive system (e.g. virtual reality), was designed to improve on previous devices' magnification, offering auto focus, contrast enhancement at all

distances, hands-free use, and a wide-field image through digital image processing. In 2018, a multicenter prospective trial demonstrated improvement in visual ability including activities of daily living and reading by 51 novice eSight Eyewear users followed over three months [8]. The benefits of practice and training with head-mounted displays have not been extensively studied, although the importance of training in their use has previously been demonstrated as important, specifically for distant and intermediate vision compared to traditional low vision aids [9].

Despite the functional and evidence-based benefits of magnifying low vision aid use [10, 11], a scoping review documented highly variable rates of device non-use [12]. A cross-sectional study documented that, of 109 eSight Eyewear users, 17.4 % (n=19) did not use their device in the past three months [13] (see Article 2) reporting multiple reasons. If an assistive device fails to improve functional vision, or if quality of life is not improved or even declines as a result of its use, the device tends to be abandoned. Day et al. [14] stated (p. 24) that "an assistive device should promote good quality of life for the user to the extent to which it makes the user feel competent, confident and inclined (or motivated) to exploit life's possibilities". Device users who perceived a more positive effect of the device on their quality of life, and those reporting higher satisfaction with the device, were consistently more likely to continue using eSight Eyewear [13] (see Article 2). In the context of magnification, practice and supervised personalized training provided by vision rehabilitation services increase the level of independence and function when engaging in activities of daily living, thereby promoting quality of life [10, 15]. Given the effectiveness of clinical setting interventions, users of the new generation of magnifiers should benefit as well from individualized attention by receiving training tailored to their needs. Especially in the context of head-mounted displays, device factors (e.g., interpupillary distance) [16] and general ergonomics (e.g., heavy and inappropriate fitting headsets) are responsible for physical

discomfort that can weaken the visual experience [17]. Awareness of these factors and individualized attention commonly offered by vision rehabilitation services is essential to increase the adoption of the technology. Cybersickness can be described as a range of symptoms including disorientation, vertigo, headaches, and eyestrain induce by virtual reality [18], and could be considered as an important usability issue potentially influencing the adoption of such technology [19]. Enhanced image motion, sometimes exaggerated through magnification, increases the risk of cybersickness and other symptoms of visual discomfort [20] because the camera included in a head-mounted low vision enhancement system moves with the users' head movements. The potential experiences of cybersickness felt by individuals with low vision using head-mounted displays and the possible connection with device discontinuation was measured recently [13] (see Article 2). The presence of headaches while utilizing the device was a consistant predictor of eSight Eyewear non-use. Insufficient training duration and frequency have also been identified as important predictors of magnifying low vision aid non-use [12]. The most common approach for delivering low vision rehabilitation in-office may be a barrier in the process of acquiring and incorporating magnifying low vision aids, given the need for transportation to and from the session. Travel may limit the ability of individuals to access follow-up interventions for their visual aid training and skill reinforcement [21, 22]. This is particularly a challenge given that around 70 % of this population are no longer able to drive [23], in addition to the paucity of specialty services and the limited access to care in rural areas of geographically dispersed countries, such as the United States and Canada [24, 25].

Telerehabilitation has become a viable alternative for delivering rehabilitation services, allowing individuals to remain at home while receiving services through internet-based communication technology [26]. A systematic review on telerehabilitation for a wide range of

disabilities revealed that around 70% of the interventions were successful [27], thereby providing evidence-based practice recommendations towards its implementation. However, a Cochrane systematic review reported very few applications and no published outcomes in the context of low vision [28]. The visually impaired population, however, tends to use more and more mobile mainstream devices with built-in video systems (e.g., smart phone, tablet), suggesting that they could be used to deliver telerehabilitation services [29, 30]. Recently, a pilot study conducted on ten individuals with low vision confirmed the feasibility and acceptability of training via telerehabilitation to optimize the use of handheld magnifiers while performing reading tasks [31].

Considering the absence of previous randomized controlled studies in the context of low vision telerehabilitation, and to help guide evidence-based practice recommendations, the present study was conducted with the primary objective of determining whether administering several low vision rehabilitation training sessions using an Internet-based video platform can improve device-related aspects of users' quality of life. Secondary objectives were to determine if a personalized telerehabilitation intervention plan can improve functional vision and/or reduce symptoms of cybersickness as compared to self-guided training.

METHODS

Study design

This is a parallel two-arm randomised study which consists of training individuals with low vision in the use of eSight Eyewear in their living environment when engaging in visual activities. The participants were enrolled through the School of Optometry of the *Université de Montréal,* Montreal, Quebec, Canada. The protocol has previously been published in more detail [32]. The study complied with the ethical standards defined by the Declaration of Helsinki

and its requirements for conducting research with human participants [33], and was approved by the institutional review board of the *Centre de recherche interdisciplinaire en réadaptation du Montréal métropolitain* (CRIR# 1286-1217).

Participants and eligibility criteria

Once individuals decided to buy or rent an eSight device, they were informed of the opportunity to participate in the study by an employee of eSight Corporation. Novice users of eSight Eyewear with self-reported low vision aged 18+, who were able to communicate in English or French, had a tablet, desktop or laptop computer with Internet access, and recently bought (< one month) or were renting eSight Eyewear were enrolled. Device users owning their eSight device for more than one month (therefore having completed the eSight eSkills User Guide [34]), or those self-reporting other severe sensory impairments that may interfere with communication were excluded. Based on her clinical experience, the low vision therapist involved in the study confirmed whether participants were able to follow a 20 min phone conversation, whereby it was confirmed by phone that participants had sufficient hearing and cognition to complete oral informed consent and could follow protocol procedures. Figure 7 summarizes the design of the study; each of the study aspects is described in detail.

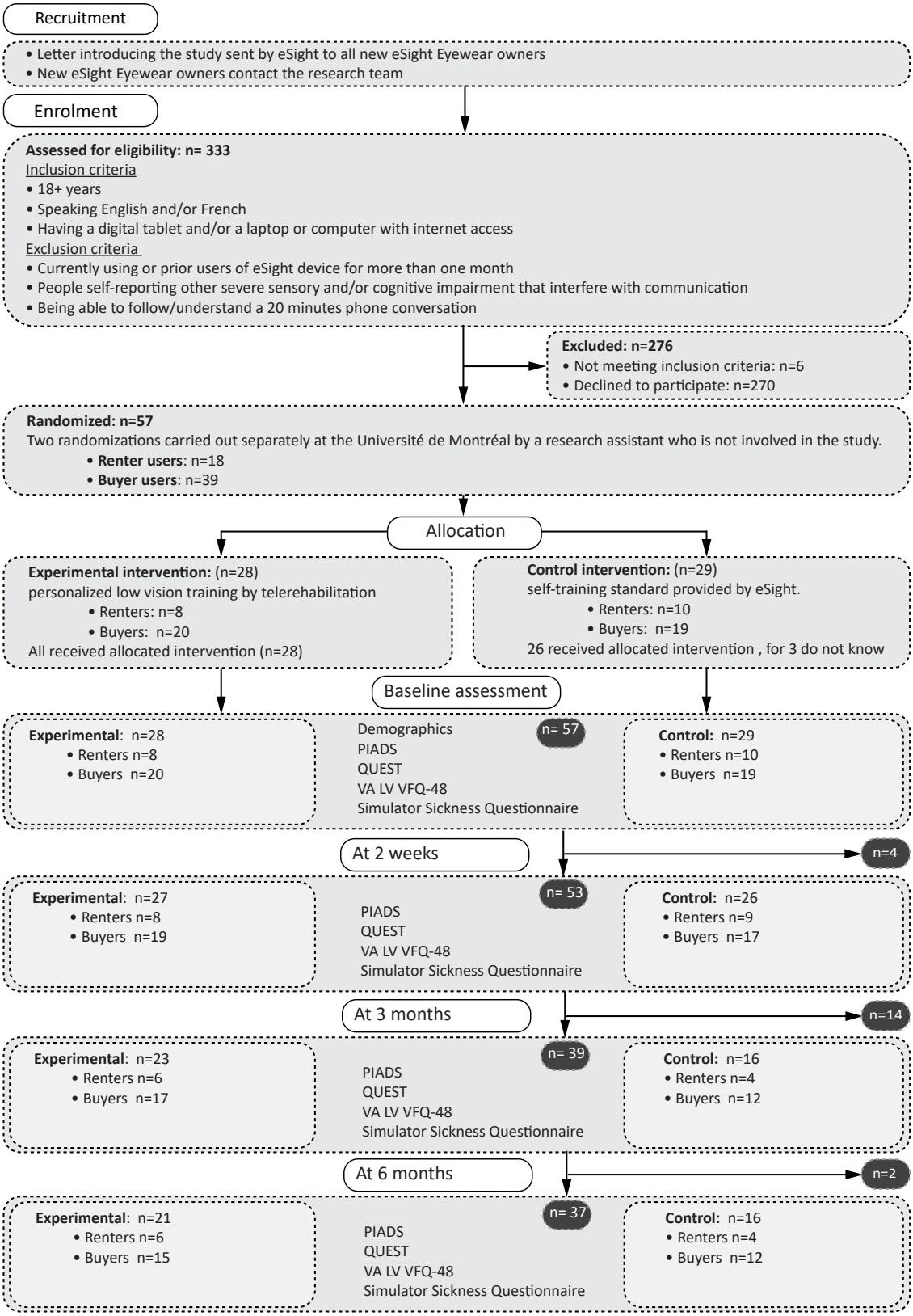

Figure 7. – Chart showing participant flow

Assignment and interventions

Allocation was at a 1:1 ratio, whereby participants received either personalized low vision training through telerehabilitation, or the self-training standard provided by eSight. Given the consumers type difference and the potential influence of the company over those who have not yet made the purchase of the device, two separate randomizations were carried out: one for the participants who bought eSight Eyewear, the other for those who rented the device.

Control intervention. The control intervention focused on the technical aspect of using the eSight device (i.e., remove and replace battery, description of different settings and their optimal usage for different visual conditions). Participants received the self-training standard provided by eSight, including the eSkills learning and training guide [34] as usually provided upon purchase. The self-training program spans one hour per day for one month (30 hours), divided into four weeks of exercises, to be performed self-guided at home. Once the training program was completed, the participants continued to use the eSight Eyewear in their environment until the end of the study five months later (and beyond).

Experimental intervention. The experimental group received personalized training through telerehabilitation that focused on the functional aspects of using eSight, considering achievement of activities of daily living with eSight Eyewear. Interacting in real time with the same low vision therapist, participants received remote training sessions delivered to their home environment via their computer or digital tablet at specific appointments (https://www.iitreacts.com), using a secure and password protected connection via the REACTS telehealth platform. The personalized training by telerehabilitation consisted of six one-hour on-line training sessions within the first two weeks (six hours), 12 additional hours of homework in parallel during the same two weeks, and an additional 12 hours of homework in the following

two weeks. Common work materials composed of exercises, the eSkills learning and training guide [34] and digitized exercises extracted from the VisExc –eccentric fixation program [35] (partially adapted from the McGill Low Vision Manual [36]) were shared between the low vision therapist and participants. According to the needs of each participant, and as would be the case in a traditional face-to-face clinical setting, individualized training was tailored. At the end of the telerehabilitation intervention (two first weeks), the participants continued their training for two further weeks (12 hours of homework remaining) and continued using their eSight device for their visual activities in their environment, until the end of the study (and beyond). After their enrolment and before the first scheduled telerehabilitation session time, the low vision therapist contacted participants by phone to confirm the setup process and help with any issues related to accessing the videoconference portal.

Outcomes

Primary outcomes.

The primary focus of this study was the effect of telerehabilitation on eSight users' device-related aspects of quality of life and encompassed two standardized measures: the Psychosocial Impact of Assistive Devices Scale [14, 37, 38], and the Quebec User Evaluation of Satisfaction with Assistive Technology [39, 40], both of which are validated in English and French. In addition, open and closed-ended questions specifically developed for this study (detailed in Supplementary materials S11 and S12) were administered.

Secondary outcomes.

The effect of personalized telerehabilitation on functional visual ability using the Veterans Affairs Low Vision Visual Functioning Questionnaire 48 [41] was assessed. The four functional

domains of this questionnaire are reading (reading newspaper, print on television, or street signs); visual information (recognizing faces, finding an item on a crowded shelf); visual motor (activities of daily living such as pouring a liquid into a cup, preparing a meal, or self-grooming; and mobility (use of public transport, navigating stairs, and getting around in unfamiliar places). Scores were converted into logit units, using the calibrated conversion table provided by Stelmack and Massof [42].

Cybersickness was measured, given its potential link to head-mounted display use, with the Simulator Sickness Questionnaire [43]. It is a widely applied measurement tool in research studying cybersickness and a standard for accessing virtual reality related sickness. It assesses 16 symptoms grouped into the three categories, namely, nausea that refers to motion sickness condition (i.e., increased salivation, sweating), disorientation related to simulator sickness (i.e., vertigo blurred vision) and oculomotor issues that make reference to cybersickness (i.e., fatigue, headache, eyestrain). All questionnaires were administered at baseline by the low vision therapist and self-administered online through a URL link at two weeks, three months and six months after randomization.

Statistical methods

Statistical analyses were conducted using JASP Version 0.9 software (University of Amsterdam, Amsterdam, The Netherlands) [44] and JAMOVI Version 1.0.5 [45]. The analysis plan consisted of three steps. In Step 1, descriptive statistics were used to present the sample and responses on all outcome measures. In Step 2, the primary outcome measures were examined to evaluate device-related aspects of quality of life, while in Step 3, possible effects within the secondary outcomes, functional vision and cybersickness were explored.

Step 1. Descriptive measures, including participants' demographic and clinical characteristics, were summarized as means and standard deviations, medians and interquartile ranges, and by counts and percentages as appropriate.

Steps 2 and 3. Primary outcomes, device-related aspects of quality of life as measured by the of Assistive Devices Scale and Quebec User Evaluation of Satisfaction with Assistive Technology, and the secondary outcomes, functional vision assessed by Veterans Affairs Low Vision Visual Functioning Questionnaire 48, and cybersickness and other visual discomfort symptoms as measured by Simulator Sickness Questionnaire, were examined according to a 2 x 2 x 4 (telerehab/comparison x buyer/renter x pre/2weeks/3months/6months) factorial design approach (see Figure 7). Given the repeated-measures component of the study, and in order to accommodate potentially missing data, the analyses were conducted using mixed-effects model, and post-hoc tests using Bonferroni correction. Linear mixed-effect-models with repeated measures design, quantified the dependent variables, *Psychosocial Impact of Assistive Devices Scale, Quebec User Evaluation of Satisfaction with Assistive Technology, Veterans Affairs Low Vision Visual Functioning Questionnaire 48* and *Simulator Sickness Questionnaire scores* as a function of the two categorical predictors: *group* (i.e., personalized telerehabilitation training and control), *consumer type* (i.e., renter and buyer), as well as their *group-by-time*, *group-by-consumer type and time-by-consumer type* interactions.

Four separate linear mixed-effects models that analyzed each of the previously cited dependent variables scores as a function of their predictors were constructed.

RESULTS

Recruitment

Recruitment took place from June 2018 to June 2019. A total of 333 eSight users were assessed for eligibility and approached by eSight Corporation. Of these, 270 declined to participate, and six did not meet inclusion criteria (one did not speak English and or French, two were under 18 years old, two had decline in their general health, one had cognitive issues interfering with communication).

Baseline Characteristics

The mean age of the participants was 54.5 years (standard deviation, 16.7; range 21-82 years). In the control group, the mean age of the participants who bought the device was 55.5 years (SD, 11.7) and was 61.4 (SD, 12.9) in those who rented the device. In the experimental group, the mean age of the participants who bought the device was 50.3 years (SD, 21.0) and was 54.1 years (SD, 18.9) in those who rented the device (see Article 4). Participant characteristics at randomization are presented in the feasibility study and show comparable descriptive characteristics, albeit with more men in the control group and more retired participants in the control-renters sub-group. Optic nerve dystrophies and central macular degeneration were the most common cause of vision impairment across groups; however, a range of ocular diseases characterizes the sample. The 20 participants that withdrew from the study (lost during the follow-up period) did not differ statistically on any of the demographic variables from those who completed the follow-up period. The nine participants that self-reported not using their eSight device anymore did not diverge statistically on any of the demographic measures from those who completed the study, except for their distribution across their country of residence. More Americans reported keeping their device after the initial assessment, whereas the non-user pool

contained more Canadians (n = 33/40) ($\chi 2$ 1 [n = 47] = 5.22, P = .02) (see Article 4).

Primary Outcomes

Assistive technology-related aspects of Quality of Life measures

The first linear mixed-effects model revealed that Psychosocial Impact of Assistive Devices Scale score improved over time across all participants, F (3, 129) = 2.83, p = .041, η^2 = .049. However, subsequent pairwise comparisons did not reveal any specific effects, given that the overall effect size was too small to render any conservative comparisons statistically significant (see Figure 8). A main effect of consumer type was observed, F (1, 58) = 5.04, p = .029, η^2 = .084, indicating that of Assistive Devices Scale mean scores from buyers were significantly higher than those renters. The mean Psychosocial Impact of Assistive Devices Scale score of the participants of the control group was not statistically significantly different than that of the experimental group. Regarding the Psychosocial Impact of Assistive Devices questionnaire subscales, three supplemental models were conducted and revealed main effects of consumer type for the competency, F (1, 55) = 6.354, p = .015, η^2 = .104, and the adaptability subscales, F (1, 57) = 6.635, p = .013, η^2 = .108, indicating that the buyers' mean was significantly higher than that of renters. No subscales improved statistically significantly over time (p > .05) (see Supplementary Graphs S15 and Supplementary tables S16 for mixed-effect model analyses).

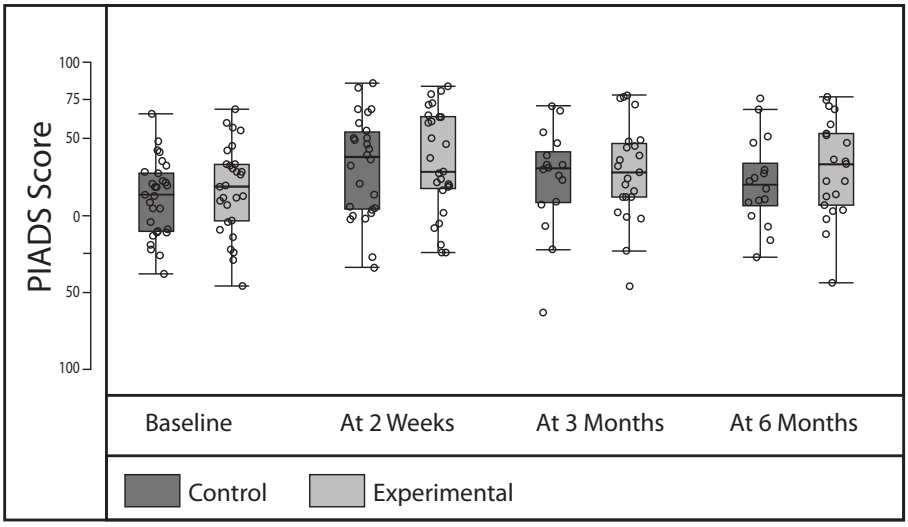

Figure 8. – Results of the Psychosocial Impact of Assistive Devices Scale at baseline, two weeks, three and six months after randomization

Because the patterns were similar in three subscales of this questionnaire, results for the self-esteem, or the competency, or the adaptability domains are not presented here. The score statistically significantly improved over time across all participants. However, subsequent pairwise comparisons did not reveal any specific effects. No subscales improved statistically significantly over time (ps > .05).

The second model revealed that Quebec User Evaluation of Satisfaction with Assistive Technology score improved over time across all participants, $F(3, 131) = 3.141$, $p = .028$, $\eta^2 = .054$. Pairwise comparisons indicated that the mean from pre-intervention was significantly lower than that from three months post-intervention, ($t(135) = 2.802$, $p = .035$, $d = .601$) (see Figure 9). No other pairwise contrast was significant ($p > .05$). Neither the main effect of group nor of consumer types was significant.

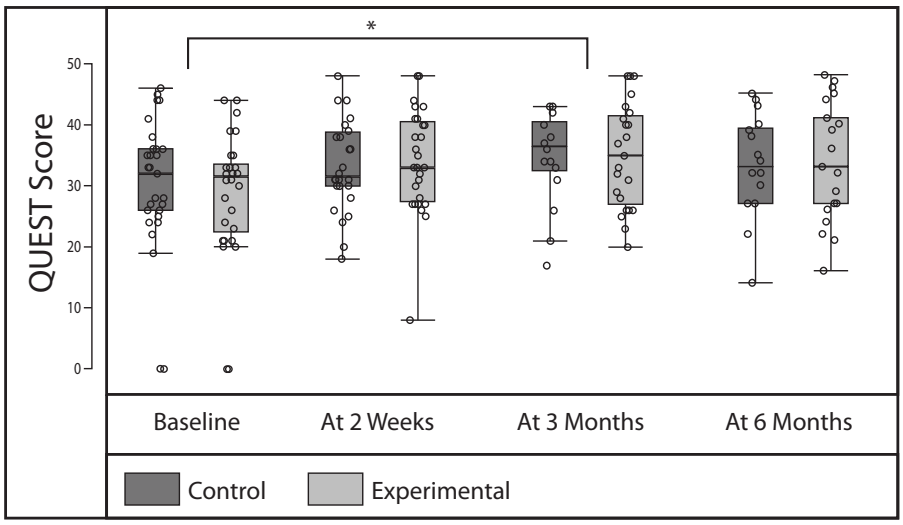

Figure 9. – Results of the Quebec User Evaluation of Satisfaction with Assistive Technology at baseline, two weeks, three and six months after randomization

The score was statistically significantly improved over time across all participants. The mean baseline score was 29.46 (SD, 10.80), which improved to 34.85 (SD, 8.19) after three months of device use and training. Score did not demonstrate a significant change after three months (ps > .05). * for $p < .05$.

Secondary Outcomes

Visual Functioning

Using the Veterans Affairs Low Vision Visual Functioning Questionnaire 48, five separate linear mixed effects models that analyzed the overall visual ability score, as well as reading, mobility, visual information and visual motor subscales were constructed using the same analysis pattern as in the previous analyses. The overall model, revealed that visual ability improved over time across all participants, $F (3, 124) = 32.538$, $p < .001$, $\eta^2 = .372$. Subsequent pairwise comparisons indicated that the mean from pre-intervention (baseline) was significantly lower than that from 2-weeks ($t(120) = 8.025$, $p < .001$), 3-months ($t(126) = 7.472$, $p < .001$) and 6-months post-intervention ($t(126) = 7.607$, $p < .001$) (see Figure 10). No other pairwise contrast was significant. A main effect of consumer type was also observed, $F (1, 58) = 4.815$, $p = .032$,

η^2 = .081, indicating that the mean of the participants who bought the eSight device was significantly higher than that of the participants who rented it. The subsequent models revealed that all the subscores (i.e., reading, visual mobility, visual information and visual motor) improved over time across all participants, $F_{reading}$ (3, 124) = 26.581, p < .001, η^2 = .326, $F_{visual\ information}$ (3, 124) = 31.934, p < .001, η^2 = .367, $F_{visual\ motor}$ (3, 124) = 22.263, p < .001, η^2 = .288, $F_{visual\ mobility}$ (3, 121) = 8.349, p < .001, η^2 = .132, respectively. Pairwise comparisons indicated that the mean from pre-intervention was significantly lower than that from 2-weeks, 3-months and 6-months post-intervention for reading, visual information, visual motor, and visual mobility (see Table 19). No other pairwise contrast was significant (p > .05). A main effect of consumer type was observed for the visual mobility-related model only (F (1, 56) = 10.112, p = .002, η^2 = .155), indicating that the mean score from the buyers were significantly higher than that of renters. Overall, in each of the five models tested, scores of the participants of experimental group were not statistically significantly different (see Supplementary Graphs S15 and Supplementary Tables S16 for mixed-effect model analyses).

Table 19. – Veterans Affairs Low Vision Visual Functioning Questionnaire 48 subscales statistical analyses pairwaise compararisons

Reading subscale	freedom degrees	t value	p value	d Cohen value
T0-T2 weeks	119	7.659	< .001	.53
T0-T3 months	126	6.513	< .001	.54
T0-T6 months	127	6.365	< .001	.54
Visual information subscale				
T0-T2 weeks	120	7.962	< .001	.54
T0-T3 months	126	6.987	< .001	.56
T0-T6 months	126	7.854	< .001	.60
Visual motor subscale				
T0-T2 weeks	120	6.610	< .001	.50
T0-T3 months	125	6.464	< .001	.53
T0-T6 months	125	6.059	< .001	.53
Visual mobility subscale				
T0-T2 weeks	118	4.395	< .001	.38
T0-T3 months	124	4.395	< .001	.44
T0-T6 months	124	2.889	.027	.36

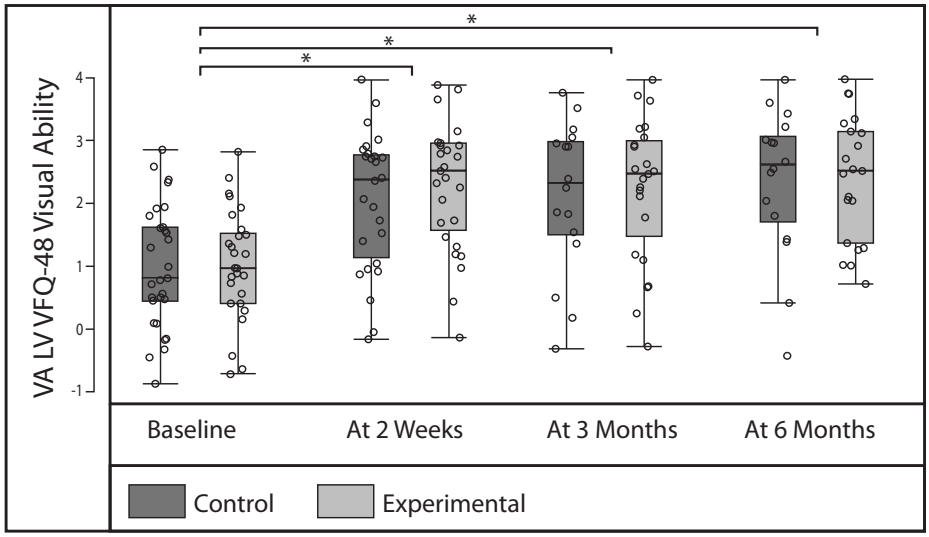

Figure 10. – Results of the Veterans Affairs Low Vision Visual Functioning Questionnaire at baseline, two weeks, three and six months after randomization

Because the patterns were similar in four subscales of the questionnaire, results for the reading, or the visual information, or the visual motor, or the mobility domains are not presented here. Visual ability statistically significantly improved over time across all participants. The mean baseline visual ability score was .99 logit units (SD, 0.93), which improved to 2.19 logits (SD, 1.07), 2.35 logits (SD, 1.05) and 2.38 logits (SD, 1.07) after two weeks, three and six months of device use and training, respectively. * for $p < .05$.

Cybersickness

A linear mixed-effects model that followed the same structure as the previous models was constructed. No effect was obtained ($p > .05$), indicating that scores were stable over the 6-month period and training type did not affect cybersickness scores (Supplementary Tables S16 for mixed-effect model analyses). When analyzing the different subscores of the questionnaire after two weeks of device use, to the question evaluating how much the symptom is affecting the user and considering the oculomotor-related symptoms subscore, 29% responded none, 43% slight, 23% moderate and 5% severe. Regarding the nausea-related symptoms subscale, 89% responded none, 8% slight, 3% moderate and 0% severe. Finally, regarding the disorientation-related symptoms subscale, 75% responded none, 17% slight, 7% moderate and 1% severe.

DISCUSSION

A randomized study of telerehabilitation for people with low vision using a head mounted display was carried out a in order to assess the effect of this rehabilitation modality on device-related aspects of quality of life, functional vision and cybersickness. It was observed that the Psychosocial Impact of Assistive Devices Scale and scores on Quebec User Evaluation of Satisfaction with Assistive Technology questionnaire increased for all participants between baseline and three months of device use, indicating that assistive technology-related aspects of quality of life improved independently of the type of training during the first months of use. Early functional vision outcome improvements were detected, using the Veterans Affairs Low Vision Visual Functioning Questionnaire 48, in all participants, regardless of group types. However, we did not observe changes in patient-reported cybersickness outcomes in either group.

Assistive technology-related aspects of Quality of Life outcomes

Quality of life did not immediately improve because this measure is related to more global changes, which would take longer to manifest. Different psycho-social factors have been related to each other in the two complementary questionnaires used that focused on assistive technology experience. They are included within the construct of quality of life, and constitute at least a portion of this complex construct that refers to well-being across multiple domains of life [46]. Currently, there is no consensus on how to define quality of life. However, valid, and reliable scales reflecting quality of life related to assistive device use can be created from three questions designed to measure improvements in safety, control, and participation due to technology [47]. There are directly related to items included in the Quebec User Evaluation of Satisfaction with Assistive Technology scores, namely "*How safe and secure your device is?*", "*How easy it is to use your device?*" and "*How effective your device (meets users's goals)?"* respectively. In

addition, the Quebec User Evaluation of Satisfaction with Assistive Technology contains other items that are not directly related to aspects of quality of life (e.g. dimension, weight, durability of the device). Therefore, this scale does not entirely represent a quality of life measure. The device-related aspects of quality of life improvement across time measured in eSight users, as reflected in improved Psychosocial Impact of Assistive Devices Scale scores (i.e., perceiving a higher positive impact of the device on their quality of life) and Quebec User Evaluation of Satisfaction with Assistive Technology scores (i.e., reporting higher satisfaction with the device), could explain the relatively low rate of eSight non-use. Indeed, this rate was reported as being 15 % in a publication focusing on the feasibility aspect of this study (see Article 4), compared with the 23 % measured in eSight users during the 3-months study period [8] and the 30 % discontinuance rate of assistive technology use traditionally observed in the literature [48-50]. These results align with predictors of head-mounted device use documented in a cross-sectional study, whereby device owners who reported higher Psychosocial Impact of Assistive Devices Scale scores, and those indicating higher Quebec User Evaluation of Satisfaction with Assistive Technology scores were consistently more likely to continue using eSight Eyewear *(*see Article 2). We did not observe a difference between the two training approaches, suggesting that the technical training offered by the company has the same effect on these device-related aspects of quality of life measures as individualized training provided by a low vision therapist.

Previous research on human factors among head-mounted display users remains rare, and recently two studies explored this topic. One study emphasized that head-mounted display users perceived ease of usability (especially of device controls and screen) as equally important as visual improvement [51]. In this study, semi-structured usability interviews documented that, among three head-mounted display types, 50 % of participants showed an overall preference for

the eSight device (versus NuEyes, or Epson). This finding supports the subjectively reported success of this device by their users. Another study [52] introduced the concept of socio-technical construction of sight in head-mounted display users, providing insights into the ways in which computer-assisted sight enabled individuals with visual impairment to see in ways previously unavailable. Visual experiences shared by eSight users were lived as something different, a new vision type, creating the perception of multiplicities of vision. Interestingly, the steps described by eSight users to build a mental model of their physical environment are similar to the strategy used by a game designer creating a virtual environment. The experience of seeing better (i.e., at greater distance, with more contrast and details, under dark light conditions) than people with normal sight was reported in the context of eSight device use, dissolving borders between assistive and augmentative technologies.

Functional vision outcomes

Unlike the device-related aspects of quality of life measures that improved after three months (intermediate effects) of practice and training with the device, eSight usage and training yielded immediate (within the first two weeks) improvements (large effect) in functional vision as reflected in the overall visual ability score and all its subscores (i.e., reading, visual information, mobility, visual motor), and continued to improve during the first three months. These results aligned with a previous multicentric study [8], whereby eSight introduction yielded immediate improvements in visual ability measured with the Melbourne Low Vision Activities of Daily Living Index [53]. Overall, participants' Veterans Affairs Low Vision Visual Functioning Questionnaire 48 scores (administered at baseline and after 3-months of use) indicated significant improvement (intermediate effect) in their visual abilities with device use and training. This improvement was largely driven by the reading subscale (large effect), followed by changes in

the visual information items (large effect), such as face perception, and the visual motor items, such as pouring liquid into a cup**.** However, there was no significant change among the mobility items. Mirroring our results, functional vision performance did not change further after the 3-month follow-up period [8].

The literature highlights that head-mounted displays improve the performance of a wide variety of visual tasks, and such devices have generated increasing interest in recent years. The use of a head-mounted low vision aids has shown the immediate improvement of basic visual functions, such as visual acuity and contract sensitivity [54] [55]. Other head-mounted displays have been developed for improving binocular vision [56] [57]. The most studied functional vision performance is reading speed [8, 54] because of its relevance for individuals with low vision. Replicating previous findings [9], a new generation of head-mounted displays being used in augmented reality improved the ability to perform timed daily living tasks at all viewing distances [58]. Research on head-mounted low vision aids reports the importance of usage and/or training, especially to improve complex functional vision tasks [59] [60].

Cybersickness and visual discomfort symptoms

The cybersickness score was stable over the 6-month period and was independent of training type. Most users reported having been slightly affected by oculomotor-related symptoms (cybersickness condition) and few were severely affected. In parallel, a low device use discontinuance rate was reported with these participants. Insofar as oculomotor-related symptoms (*headache)* associated with head-mounted display use, have been identified as a predictor of use discontinuance [13] (see Article 2), these findings are congruent. Regarding nausea-related symptoms (referring to motion sickness condition) and disorientation-related symptoms (reflecting simulator sickness condition), the large majority of users did not experience these

conditions and few of them reported having felt such symptoms severely. Among those who withdrew from the study or discontinued eSight usage, none had reported any of these symptoms as being the cause. Of the 74 participants who joined a previous multicenter trial, 17 eSight users discontinued their usage during the three-month study period, among which only one exhibited nausea [8]. Nausea represents one of the most extreme and unpleasant symptoms, and another type, transitory disorientation for example, may not necessarily have led to device use discontinuation, especially because the presence of general discomfort or eyestrain was not associated with use discontinuance [13] (see Article 2). In the reported study, it is also likely that the presence (and type and severity) of cybersickness and related symptoms were underestimated because they were not systematically investigated then. Although cybersickness was more extensively and accurately investigated in the present study, few participants were severely affected by cybersickness and visual discomfort symptoms. This may also be explained by the fact that head-mounted displays, such as eSight, do not use a complete immersive virtual environment made of a synthetic image, but a semi-immersive enviroment with a real image and an unocluded peripheral visual field. Other potential reasons may include the duration of the exposure to the virtual environment and the likely sensorial adaptation; for instance, one study documented that the experience of cybersickness mainly occured within the first ten minutes of exposure to the virtual environment [19]. A systematic review documented that the factors that impact the likelihood of users developing cybersickness include individual and device differences. Children have the greatest susceptibility to cybersickness and this rapidly decreases from adolescence to adulthood [16]. Given the older population recruited in the context of the present study, this could explain why the participants were less susceptible to exhibit notable experience of cybersickness. Device factors, such as lag [18], calibration of interpupillary distance [16], and general ergonomics can also contribute to cybersickness symptoms. For example, heavy and inappropriate fitting

headsets are responsible for physical discomfort that can weaken the visual experience [17]. Awareness of these factors is essential to increase the adoption of the technology and the continued improvement of the virtual technology.

Limitations

Self-selection bias is a limitation, insofar as participants who spontaneously decided to use eSight Eyewear and were willing to participate in research were enrolled. To overcome this potential bias, future studies should consider providing the head-mounted display and Internet access to participants. Participants were already exposed to evolved technology which may have led them to be more willing to try the video conference platform used for telerehabilitation, and they were not necessarily representative of the general low vision population. However, with an aging and increasingly tech-savvy population, this limitation will likely be less contextual over the next decades. Another potential limitation that relates to the on-line survey nature of data collection is the lack of objective visual function measures (i.e., visual acuity, or contrast sensitivity, visual field) which could contribute to a more holistic description of the participants. However, allowing enrolment and participation across both rural and urban environments, this approach made it possible to reach a wide range of individuals with visual impairment using eSight Eyewear. It is ultimately expected that the results will be relevant to a wide range of head-mounted displays and other electronic devices. Considering that a previous telerehabilitation study had already successfully implemented standardized near reading and acuity cards during the session [31], complementary insights that were missing from the evaluation could be added to future protocols. Moreover, telerehabilitation is not intended as a substitute for in-person interventions. Ideally a hybrid resource allocation would combine telerehabilitation with face-to-face assessments (in-office and/or at home) to optimize care without reducing quality of existing

services. Isolating the effect of the device and that of the telerehabilitation on the outcome measures was not possible. Adding a third group receiving a device and benefitting from no intervention would need to be considered in future studies. Finally, social desirability bias in participant's self-reports may occur given that it was not possible to mask participants to the intervention type. However, the randomized participant allocation, the masking of the researcher with respect to group allocation, and the use of self-administered assessments minimized selection, detection and experimenter bias.

CONCLUSIONS

This is the first randomized study that explored the impact of telerehabilitation on device-related aspects of quality of life and functional vision in individuals with low vision using assistive technology. Independently of the training type, head-mounted display user's visual abilities and aspects of quality of life increased over time, after two weeks and three months of device use, respectively. The data suggest the use of a head-mounted display together with telerehabilitation seems a modality particularly promising for low vision rehabilitation services. Cybersickness was not extensively reported by the participants, remained stable over the 6-month period and was independent of training type. This finding documented that, using a semi-immersive virtual environment device such as eSight with this specific population (adult users), cybersickness did not emerge as a widespread usability issue. Given the increasing use of such technologies in low vision rehabilitation and the limited literature available about the link between cybersickness and head-mounted displays for low vision, further exploration of its mechanisms and associated factors are essential. To the extent that the use of such technologies involves a physical and psychological transformation, the intervention of a multidisciplinary team as well as the systematic evaluation of the psycho-social factors and potential cybersickness

should be included during the acquisition of the head-mounted displays, to optimize their adoption.

Acknowledgements

We thank Dr. Aaron Johnson for his advice for conducting mixed effect model analyses, Josée Duquette for her permission to use the VisExc – INLB eccentric fixation program, and Nancy Primeau in her support for formatting of bibliographic references.

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DISCUSSION

The components of the present thesis (see Figure 11) improve the understanding of the use of head-mounted displays (HMDs) by individuals with low vision (LV). The scoping review provides evidence that clinicians should not rely solely on traditionally available clinical factors to predict low vision aid (LVA) use. Worsening vision, low motivation and adaptability, as well as poor accessibility to attend a clinic appear as important predictors of device non-use and should be considered from the clinician's point of view. Moreover, the provision of intensive training programs represents another important factor that contributes to optimal use of devices. The cross-sectional study informed us that none of the traditional clinical variables (i.e., demographics, ocular or general health), or LV rehabilitation experience was predictive of sustained use of an HMD. However, the administration of standardized device-impact questionnaires may be able to identify device users that could benefit from individualized attention during LV rehabilitation provision to reduce the probability of device abandonment. Considering these findings, a personalized training regime via telerehabilitation was developed to optimize the use of HMDs. The data demonstrated the feasibility of a randomized controlled study of telerehabilitation for people with LV using HMDs, and provided positive feedback from the participants and the LV therapist. eSight Eyewear, either with telerehabilition or with the manufacturer self-training standard, improves functional vision and increased users' quality of life (QoL) within the first three months of device training and practice. The next sections will discuss: 1) how the factors influencing magnifying LVA and HMD use led to identify telerehabilitation as a potential intervention to optimize the use of eSight Eyewear; 2) how other

physical telerehabilitation applications inform LV rehabilitation; 3) limits of the study; 4) clinical significance of the results; and 5) implications for research and future directions.

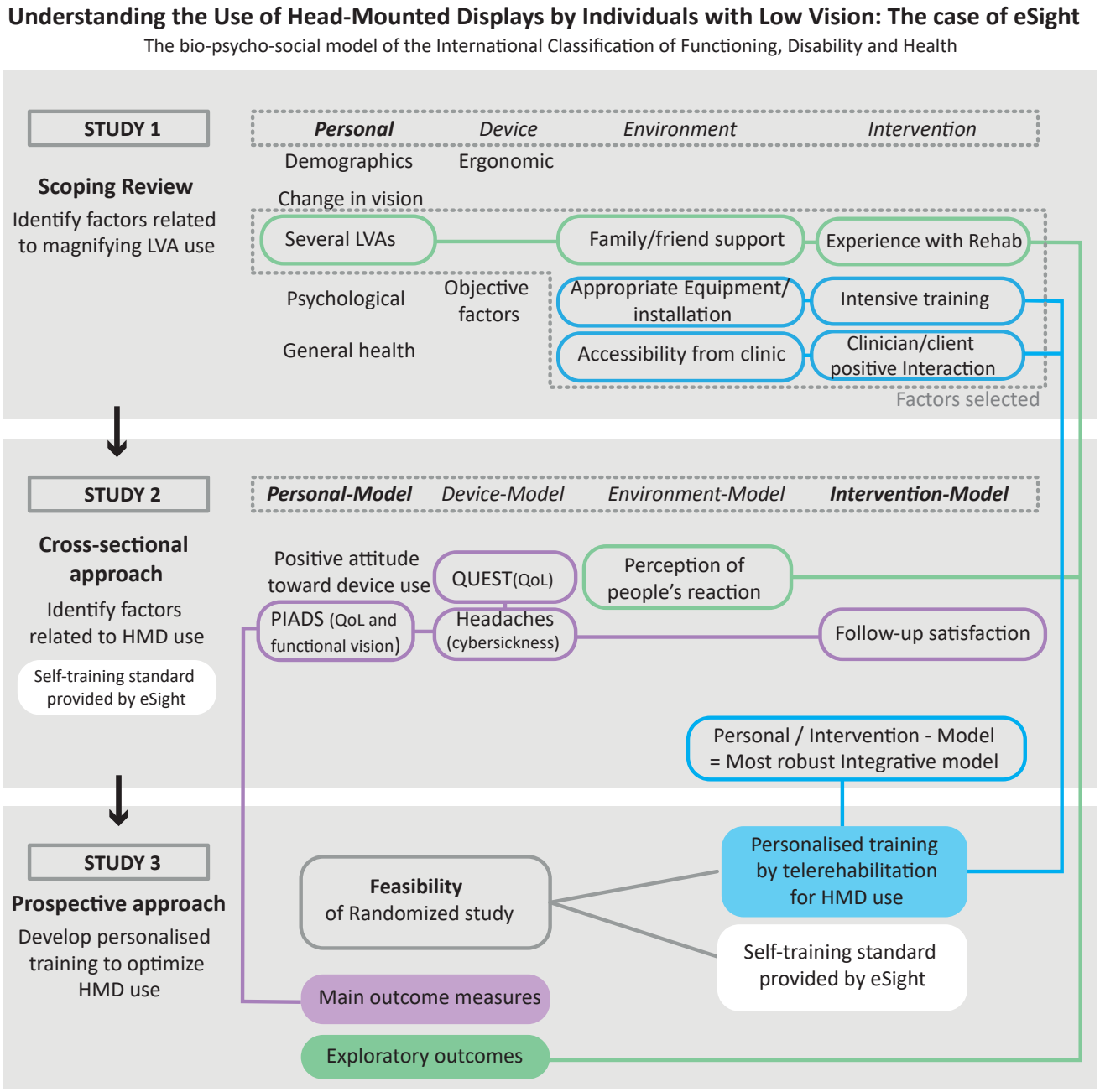

Figure 11. – Diagram describing the research study that includes the three studies

How the traditional classification of factors identified telerehabilitation as a potential modality of intervention to optimize head-mounted display use

The present thesis follows a longitudinal process of development, whereby each study builds on the previous one(s), based on their respective findings. The scoping review and the cross-sectional study were necessary steps in the development of the prospective study. The common denominators of all the studies are the four categories of factors (i.e., personal, device-related, environmnental and interventional) that influence device abandonment. The following section describes the way in which these different factors influenced each study.

Influence of the scoping review on conceptual framework and methodological choices

Most researchers agree that assistive technology (AT) abandonment is multifactorial, being the outcome of a complex interaction of four main categories of factors: *personal* (i.e., age, sex, diagnosis, motivation, health or disability evolution); *device-related* (i.e., weight, design, appearance, performance); 3) *environmental* (i.e., social support, physical barriers); and *interventional* (i.e., instruction and training, follow-up service) [1, 2]. The same categories of factors were replicated in the context of magnifying LVAs in the scoping review. In 2001, the bio-psycho-social model of the International Classification of Functioning, Disability and Health (ICF) [3] was recommended to be used in research and clinical practice. This framework has been identified as a more comprehensive model to determine the best match between person and AT [4] and is consistent with the four categories of factors previously identified. In the context of the cross-sectional and prospective studies, the ICF was selected as a conceptual framework.

Other models may be useful to study the abandonment of LVAs, whether they deal with non-compliance/adherence to treatment/intervention or AT abandonment. Health behavioural theories, such as The Theory of Planned Behaviour [5], were applied to explain the determinants that can influence the likelihood of adherence to medical intervention to eventually anticipate and improve it [6, 7] based on personal, environmental, and intervention-related factors. The same logic can be applied to AT to better understand the factors that are related to device compliance in order to optimize their use. For example, the Theory of Planned Behaviour [5] model was used to predict non-compliance with daily disposable contact lens replacement [8]. The Technology Acceptance Model (TAM) [9] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [10] are often employed to explain (non-)usage based on specific predictor variables. The UTAUT derives from the TAM, whereby performance expectancy, effort expectancy, social influence, and facilitating conditions are predictors of the acceptance of a new AT. These models are relevant but have been critized for overlooking essential variables such as biophysical and psychological factors [11]. There are four core concepts of the Human Activity Assistive Technology model (HAAT) [12]: the human; the activity; the AT and the context (i.e., physical, social, cultural and environmental). They are highly relevant and applicable in the domain of AT acceptance. However, there is limited evidence for relationships among concepts or how they impact outcomes [13] because AT system outcome is not well defined. Demonstrating the validity and reliability of outcome measures specific to the HAAT concepts would improve this relationship [14]. Another model that has been posited to be a client-centered and comprehensive approach is the Matching Person and Technology Model (MPT) [15]. The MPT Model focuses on three primary areas known to most differentiate technology use and non-use: (a) environment factors; (b) user personal and psychosocial characteristics, needs and preferences, and (c) functions and features of the technology. Although the MPT Model is compatible with the ICF [3],

it was not applied as a theoretical framework in the present research because the full MPT process needs to be validated with additional samples of individuals with sensory as well as mobility, cognitive, and communication disabilities.

Studying factors related to magnifying LVAs (scoping review) and those specific to HMDs (cross-sectional study) conceptually influenced the prospective study. First, the absence of HMD abandonment rates and identified factors related to HMD use in the literature review confirmed the need to investigate these characteristics. Studies related to tablets, smartphones and HMDs were excluded because they did not include measures of non-use or related factors. Moreover, considering the inconsistencies in the definitions of LVA non-use reported in the scoping review, a binary definition selecting the terms *utilization* and *discontinuation* limited to the past three months was used [16]. Then, with the recruitment of both renters and buyers in the prospective study, two degrees in discontinuance definition were addressed. In the context of the analyses, early discontinuance in device use was defined as abandoning a device during the first two weeks of the study and, for consistency with the cross-sectional study, late discontinuance was defined as a abandoning a device after three months. Finally, the administration of several questionnaires, initially selected/developed for the cross-sectional study from the scoping review, could be considered as an indepth but also demanding evaluation. Although 11.5% answered partially, 19.2% complete data was obtained. This rate is consistent with other studies [17, 18] and led us to use the same questionnaires for the prospective study.

Selection of relevant personal factors

The most frequently documented category reported in the scoping review consisted of factors related to the personal characteristics of the device users, especially psychosocial factors. Motivation is one of the main psychological factors, having received the most attention in the

reviewed articles, and adaptability of the person appeared to substantially affect magnifying LVA use. Given the importance of personal factors, 15 aspects that composed the *personal* family were explored and a user-centered questionnaire, the Veterans Affairs Low Vision Visual Functioning Questionnaire 48 (VA LV VFQ-48) [19], was added in the cross-sectional study protocol. This standardized questionnaire was explored in an eSight's multicenter pilot study [20], and was intended to facilitate direct comparisons. Moreover, the *personal* family reappeared in the two most robust combined statistical analysis models, confirming the importance of individualized attention focusing on the user. Several psychosocial variables emerged as consistent predictors of HMD use in these models, such as the Psychosocial Impact of Assistive Devices Scale (PIADS) [21-23] score and people's perception on whether users should use the device.

Insofar as personal characteristics of the device users emerged as important predictors of HMD use, the prospective study focused on personalized training through a needs-based intervention. A personalized training regime via telerehabilitation was developed to meet specific users' needs, providing individualizing attention to optimize the use of their HMD. Telerehabilitation approach was intended to provide valuable information to the provider, gaining insight into the patients' home environment, usual reading materials and tasks that are visually difficult [24]. None of the traditional clinical variables, such as patient demographics (e.g., age, gender) and ocular or general health information were predictive of HMD use in the cross-sectional study, suggesting the opportunity of recruiting a wide range of users in the prospective study. These variables were maintained in the questionnaires for descriptive analyses of the sample (i.e., group comparability).

Selection of relevant device-related factors

The scoping review informed the cross-sectional and prospective studies for the selection

of relevant device-related factors. The importance of objective (e.g., dimension, weight) and subjective (e.g., ergonomics, appearance) device-related factors in magnifying LVA use were reported. Given these findings, the administration of standardized device-impact questionnaires, such as PIADS and Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) [25,26], appeared as appropriate to identify device-related factors that predict HMD use among current eSight owners. Several other factors were selected for the prospective study given the findings of the cross-sectional study. First, eSight users reporting the *presence of headache* had six times the odds of discontinuing use compared to those who did not. These high odds indicated the importance to study cybersickness, defined as a range of symptoms including nausea, disorientation, vertigo, headaches, and eyestrain induced by virtual reality [27]. In some virtual environments, cybersickness could be an important usability issue potentially impacting the adoption of technology [28]. So far, limited literature is available about the potential experiences of cybersickness experienced by individuals with LV using HMDs, as well as on the possible connection with device discontinuation. Given that the absence of headaches was a robust predictor of eSight device use in the integrative statistical analysis models, it was decided to study cybersickness more systematically in the prospective study, using the Simulator Sickness Questionnaire [29]. Moreover, it was decided to focus specifically on the third generation of eSight, because no use difference was measured between the second and the third generation of eSight Eyewear. This choice was made to avoid variability, given their design and minor differences in terms of weight, ergonomics and quality of the image. Finally, the QUEST and the PIADS each measure a specific QoL aspect that considers the user's satisfaction towards the device and the psychosocial impact on the user, respectively. They were found to be robust use predictors in several of the statistical models, demonstrating their relevance as outcome measures in the prospective study.

Selection of relevant environmental factors

The results of the scoping review indicated that the immediate personal social circle, the larger-scale social environment, and the physical environment have an impact on how a person will use a magnifying LVA. Based on these findings, it was decided to include these factors and focus on family support in the cross-sectional study. Given their confirmed relevance, the same environment–related questions were administrated in the prospective study in the format in which they were asked in the survey. For example, considering the importance of people's reaction and sparcity of data on social acceptance in the literature review, this variable was retained with great interest. In contrast, the positive influence of family/friends on the device user did not emerge statistically significantly from the integrative models; however, as the success of LV telerehabilitation services depend on the willingness of family/friend to participate in the patient's session [30], such support was explored in the context of telerehabilitation. Finally, physical environment barriers did not emerge from the integrative statistical analysis models, maybe because the related questions were not contextual. Half of participants had never experienced LV rehabilitation services and were therefore not concerned about transportation issues to, for example, attend follow-up appointments.

Selection of relevant interventional factors

The scoping review indicated that proper instructions about the use and appropriate training are important components for sustained LVA use. These findings led us to explore in the cross-sectional study whether users had previous experience with LV rehabilitation, completed their eSight self-training program and whether they found the program helpful. Insofar as sustained duration and frequency of training were associated to increase device use, an intensive personalized program of 30 hours of training was offered in the prospective study. The small

number of LV rehabilitation experiences reported in the survey indicates the lack of knowledge and/or their availability. In order to promote existing LV rehabilitation programs, the LV therapist spent a few minutes in the prospective study with participants to explain her role. Finally, the questions addressed in the survey (whether participants considered the training program as helpful and whether they completed it) did not emerge as predictor of HMD use. Insofar as training was delivered within a commercial context and focused on technical aspects much like in a previous study [31], it was important to explore the impact of training provided in a clinical setting by a LV therapist while offering participants the opportunity to rate their satisfaction about telerehabilitation. Telerehabilitation is a recent field of telemedicine [32] and even more in LV, still requiring research and development. Connections between the different fields are essential to help guide future research for LV applications.

How do other physical telerehabilitation applications inform low vision rehabilitation?

Telerehabilitation has been successfully applied for assessment, training and monotoring, in fields such as neurology [33-35], cardiology [36] and physiotherapy [37]. Applications of telerehabilitation techniques will be discussed, with an emphasis on which new systems and applications can be used in the future in LV rehabilitation. Limits associated with telerehabilitation (e.g, technological, user-centered aspects) may partially explain why the intervention did not detect differences compared to the self-guided training. The successes and challenges of these applications can guide the development of new telerehabilitation protocols applied to LV and provide new directions to identify how LV services can be optimally supported by this modality.

Assessment by telerehabilition

In the telerehabilitation intervention, participants were asked about their needs, and were remotely assessed about their eccentric fixation, reading speed and reading accuracy via the shared reading material (digitized exercises extracted from the VisExc – eccentric fixation program [38, 39]). Despite high acceptability and accessibility of our telerehabilitation format, some challenges related to assessment were reported. For example, the LV therapist judged it being moderately difficult to evaluate working distance and lighting environment because no exact measurement could be obtained. Moreover, due to the image shift across the camera, the LV therapist had difficulties identifying the gaze position and eye movements. Assessing the subjects' needs and matching the user with an appropriate device are essential for successful outcomes [40]; However, HMDs were not selected according to a traditional clinical evaluation in our telerehabilitation due to the recruitment mode. Considering the emerged challenges that were associated with remote HMD users' assessment, exploring existing literature should help develop new intervention models to orient practice guidelines for LV telerehabilitation.

Previous research [41, 42] shows that AT assessment can be optimally supported by telerehabilitation. In the context of wheelchair mobility and seating provision, the difference between functional measures indicated that the remote assessment to select the best match between an AT and a user was equally effective as in-person rehabilitation [41]. Clinically, the minimal differences and variabilities between these two modalities provided evidence of equivalence when using telerehabilitation as an alternative intervention [43]. According to the authors [41], the success was partly explained by the service delivery protocol set in place. In each of the remote sites, generalist practitioners conducted the evaluation assessment, whereas the wheelchair mobility and seating expert collected additional relevant user feedback. These

findings suggest that applying a similar service delivery modality to select an appropriate LVA remotely should be applicable. LV rehabilitation was delivered via a mobile clinic to provide LV optometric care, including device evaluation [44]. Device recommendations were determined based on the assessment of patient needs, their magnification requirements and the performance they reached with their LVAs. Considering the success of this provision modality, future studies could potentially combine a mobile clinic with telerehabilitation that connects LVA experts with other clinicians to further increase efficient use of human resources. Given the increasing demand for appropriate assessment, more education and training in this emerging form of intervention will be necessary for the service providers to improve LV rehabilitation service quality and device user satisfaction.

In the case of neurological diseases such as brain injury or cognitive deficits, the optimal rehabilitation for patients remains the cognitive engagement through appropriate environmental interactions [45]. Virtual reality applications that create simulated environments can be used for the assessment of specific cognitive disabilities via telerehabilitation. The advantages consist of offering a secure, standardized and personalized framework [46]. For example, telerehabilitation was associated with a virtual urban environment to perform rehabilitation for stroke patients at home [47]. The simulated environment enabled clinicians to assess patients and then an associated progam ensured automatically analyzed rehabilitation progress. This combined telerehabilitation with virtual reality application was effective and accepted by patients and clinicians. Considering the acceptability of this combination of systems, this suggests that progress of LV telerehabilitation could be potentially measured automatically and analysed in a similar way. For example, it would be possible to develop a program that integrates an eye-tracker into the HMD. This would provide assessment of the position of each participant's pupil during a visual task and

should help analyze rehabilitation progress**.** Another telerehabilitation project was developed for individuals with stroke, traumatic brain injury, and multiple sclerosis for performing remote upper limb rehabilitation [34]. A help desk was developed and exhibited encouraging outcomes. Its purpose was to evaluate the patients' performance periodically in order to create a tailored exercise regimen. In LV rehabilitation, device users are usually asked to continue self-training at home using shared materials between each session; however, there is limited control to check for adherence and if exercises are performed appropriately. Given this requirement, we could consider developing a simulated environment program that could be projected directly into the HMD to assess users periodically to help identify the difficulties during device use. Systematic and frequent assessments would allow patients to benefit from the most appropriate exercises. For example, such a program could be applied to oculomotor skills and eccentric viewing assessment**.** A review [45] reported that virtual reality applications could be used in telerehabilitation both for the assessment and training for some disabilities. Existing training applications of this combined modality will be discussed in the next section so as to potentially inform the LV field.

Telerehabilitation used as a training modality

In the telerehabilitation protocol, individualized training in the use of the eSight Eyewear was tailored to the needs of each person, as would be the case in a face-to-face setting. Ocular motor skills (i.e., fixation, pursuit and saccades) were trained as they guarantee the correct gaze position and endurance necessary to perform more complex tasks. Moreover, eccentric viewing training is a sensory-compensation method used in LV rehabilitation for people with central scotoma that was provided in the telerehabilitation protocol. It consists of teaching persons with central visual field loss to modify the direction of their gaze to avoid using the impaired portion

of the retina, by training saccade movements and visual research strategies. The objective of this approach is to compensate for the functional deficit by modifying the fixation behaviour through the recruitment of an intact region of the retina [48, 49]. Compared to the control group, fewer participants withdrew from the study in the experimental group (13 and seven participants, respectively), and acceptability and accessibility were high. However, the LV therapist considered that six sessions over two weeks did not always allow participants to achieve optimal eccentric fixation. Moreover, due to the image shift across the camera, the LV therapist had difficulties identifying the gaze position and eye movements. Considering that the intervention could have been provided over a longer time period or included other characteristics, this would potentially have had an impact on the participants' decision to continue the study and device use. Examples of telerehabilitation training approaches will be discussed in the next section to eventually optimize future protocols for LV rehabilitation.

Telerehabilitation is primarily applied in physiotherapy [37, 50], and a systematic review reports that most of the telerehabilitation training was effective for specific physical diseases [50]. For example, Microsoft Kinect is a motion-sensing device that was used to measure patients' posture and movement. This system shows positive results in creating a customized physical exercise program for motor telerehabilitation [37]. However, the authors reported that for each patient, system operators were required to optimize the remote training according to the type of disease. This was a main disadvantage as it was not always possible to tailor the teletherapy to the needs of each patient due to high costs. Currently the LV field is not really concerned with this issue because very few virtual reality applications are available for training. However, it is possible that the intervention was not flexible enough in the offered format and did not fully meet the needs of our participants by offering an individual treatment design. This limit may partially

explain why the intervention did not allow us to detect differences compared to the self-guided training. With the likely growth of simulated environment applications for telerehabilitation in other fields, attention should be paid to their ease of use in the clinical context. This concern is central in order to make them routine tools that are suitable for a wide range of visually impaired people. Given the variability in the type of LV impairment, further research and feedback from patients will be required to improve the electronic equipment and application, and to make it as flexible as possible in order to guarantee the quality and viability of remote training in LV.

A systematic review [33] was conducted to investigate whether it would be feasible to combine virtual reality-based balance training with telerehabilitation in a community-dwelling stroke population. Evidence regarding cost–benefit of telerehabilitation therapy, as well as adherence and perceived enjoyment of virtual reality emphasizes feasibility of combining both approaches. Equal effects are reported comparing this treatment to an in-person intervention in the clinical setting on balance and functional mobility. In line with the prospective study, general improvements over time were measured, and no significant difference between the intervention and the control groups was detected. Given this evidence of feasibility and positive results, a general trend in the literature supports the use of virtual reality-based interventions in stroke rehabilitation on balance and mobility [33]. LV rehabilitation professionals can potentially learn from several positive factors in order to help optimize future protocols for remote LV services. Importantly, the systematic review [33] reported that participants perceived enjoyment while interacting with the technology. Users perceive virtual reality-based interventions as games that provide a reward when progress is achieved [51]. This results in enhancing motivation and allows for longer training sessions that might improve skill learning and compliance with rehabilitation. Considering the importance of motivation in LVA training, game-like environments should be

considered as a priority while developing future dedicated programs. Moreover, these findings confirm the need to exploit the wide technological options offered by HMDs. Considering this relevant component, it is possible that our telerehabilitation may not have been stimulating and rewarding enough in the proposed format, and may partially explain why the intervention did not allow us to find differences compared to the self-guided training. Part of eccentric viewing training is carried out with the practitioner and the other part consists of the patients' self-training and consolidation of the skills in their living environment using shared materials. In this context, coupling a virtual synthetic environment in the HMD displaying secure, personalized and ecological exercises, could provide users with an alternative method of delivering services. Enriching an environment to strengthen and/or develop new skills is increasingly used in the field of rehabilitation. Video games offer a visually enriched and stimulating environment, requiring intense sensory-motor interactions that could facilitate functional plasticity and improve the ability to learn new tasks [52]. Considering these benefits, development of future virtual reality-based training protocols is recommended to help maintain a high level of user satisfaction and potentially optimize adherence to LVA use.

Another aspect that seems to contribute to successful training by coupling telerehabilitation with virtual reality concerns the use of biofeedback that was demonstrated to facilitate learning [51]. In addition to traditional scheduled videoconferences with participants for training sessions [41, 53], telerehabilitation has been combined with other systems such as telemonitoring. These systems follow training performance based on measures of compliance to and intensity of the training [47]. For example, a program was developed to track vital signs (e.g., heart rate, blood pressure) of patients by detecting abnormal markers to ensure safety while training [53]. The promising results on combining the benefits of virtual reality-based training and

telerehabilitation together justify further research in LV. In the context of LV rehabilitation, no vital signs are involved; however, sensors to record eye movements with an eye tracker would allow the LV therapist to follow the visual exploration of the subjects in real time to provide them with more accurate instructions. This specific need was precisely identified and reported by the LV therapist during the telerehabilitation protocol, while participants trained with their HMDs. Moreover, the device manufacturer has not developed a program to adjust HMD settings remotely. Given the description of what participants were able to see through their device, they received instructions from the LV therapist on the working distance, viewing angle and level of zoom to obtain the best magnification and field of view. However, this procedure was not ideal considering the synchronization between the participant and the therapist and the reliability and accuracy on the description provided by participants. The lack of accurate monitoring may partially explain why the intervention did not differe significantly when compared to the self-guided training. Therefore, in addition to eye movement tracking, head and body position and orientation sensors would optimize posture and working distance instructions. We could consider calibrating these sensors according to measurements previously performed by the LV therapist. The use of such sensors could allow the participant to receive feedback and adjust his/her posture or gaze position during at-home exercises and potentially facilitate learning. Given the limited control we have over adherence to at-home exercises and the use of HMDs, application monitors could optimize quality of rehabilitation. Bluetooth low energy beacons have been shown to reliably detect temperature and/or humidity increases when held by LV individuals while reading with their magnifier and have been suggested to prevent LVA abandonment [54]. These sensors are potentially useful but other more optimized systems could be implemented to measure adherence with at-home exercices more accurately. As suggested by Gothwal et al. [55], we could consider using a monitoring application on the HMD, such as Moment—Screen Time Tracker. This

application tracks the type of features and exercices that have been used by the participant as well as total duration of device usage. However, privacy concerns related to this method would need to be carefully considered before its implementation. Finally, given the identified burden of the technology experienced in the context of LV telerehabilitation [24], it could be envisaged to train with the virtual reality systems in-clinic and transfer the training afterwards to the home setting if needed.

Advantages and limitations of this research project

Specific aspects related to the scoping review that inform subsequent studies

On a methodological level, several decisions warrant consideration in this section. First, it was decided to conduct a scoping and not a systematic review, to rapidly map and analyse the extent and nature of studies that have previously been conducted about magnifying LVAs. Another aspect concerns the choice to use existing categories for grouping the variables that were extracted, given their recognized involvement in AT use [1, 2, 15] instead of allowing themes to emerge and then develop into categorizations accordingly. However, within (and eventually outside) of these categories of factors were allowed to emerge in order to be compared in discussion with those found by other authors in the context of other LVAs or ATs in general. Regarding database selection, given the schedule and to assure the feasibility of this study, it was initially decided to focus on only four databases. They were selected for the following reasons: Medline and Embase access the main American and European health research databases, respectively, while Eric ProQuest is a database mainly dedicated to educational sciences. Cochrane was initially included but not reported in the methodology as no relevant articles were found for this scoping review. In order to improve the methodology, it was decided to update the

review up until and including October 10th 2018 and to include four additional databases: Cochrane, CINAHL (a database related to nursing literature), and two grey literature databases related to health and social care: NICE Evidence and Trip Database. After these searches, one new relevant article was added to the scoping review. This update was important at the stage of this research study (design conception of the subsequent studies) as it was the opportunity to verify the potential publication of new studies on relevant HMDs used for cross-sectional and prospective studies. Recently, more studies on HMDs with clinical aspects have been published in engineering sciences, computer science and mathematics journals and are available in databases such as IEEE and CiteSeerX. This could be explained by the increase of collaboration between the fields of industrial and healthcare research. Initially, it was decided not to extend the search strategies to these databases because of the limited relevance to the keywords of this research study. These databases mainly concerned studies on the technical aspects of HMD development without links to clinical issues. To the extent that partnership with industry remains an opportunity to provide clinically relevant data that drive rehabilitation towards best practices[56], it would be relevant to consider these databases in future reviews.

Challenges in this scoping review were associated with the magnifying LVA types. Although mainstream devices, such as tablets and smartphones, are increasingly used as magnifying visual aids by the visually impaired population, studies related to them were mostly excluded because all except one did not include measures of non-use. Given their multi-functionality, it will be interesting to explore how non-use will eventually be defined, as mainstream devices may be used for some activities in an adapted format (e.g., enhanced contrast) and for other functionalities without adaptations (e.g., music). Moreover, most selected studies do not make a distinction between LVA types and (non-)usage rates or factors.

Common limitations to cross-sectional and prospective studies

One of the shared limitations is directly related to the design of cross-sectional and prospective studies, and concerns the absence of objective visual function measures, such as visual acuity, visual field, contrast sensitivity, and stereopsis. Given the nature of an on-line survey, access to medical chart information was not feasible. Initially, it was planned as part of the prospective study protocol to collect visual function measures in the participants directly at the School of Optometry. It was attempted to obtain some objective information about visual function by asking participants to give the research team access to their most recent eye report but very few participants complied. Instead, it could have been asked the participants' permission to contact their eye care professional directly. Relying on such a multidisciplinary involvement, access to more data may potentially have been gained. Moreover, the limited sample size did not enable us to analyze data from different diagnostic groups separately. Future work with a larger sample and more identifiable subgroups should allow for such analyses. An important strength considers the enrolment of participants across both rural and urban environments. Given the distribution of eSight device users across North America, online survey and telerehabilitation approaches were chosen to allow for the largest possible number of device users to participate in this study. Another common limitation to the cross-sectional and prospective studies is self-selection bias, as participants who spontaneously decided to rent or purchase eSight Eyewear and expressed interest in research participation were enrolled. In the context of the prospective study, participants owned the computer equipment necessary for telerehabilitation, and were willing to try an Internet-based videoconference platform. Participants across both these studies may therefore not be representative of the general visually impaired population. To overcome this potential bias, it could be suggested loaning HMDs and tablets to participants, should there be a next phase of this project. Another point to mention concerns the fact that the research team

relied on a dense questionnaire as the main data collection tool. For participants with visual impairment, this approach can be cognitively and visually demanding and may cause fatigue. However, before its launch, the survey was pilot-tested by visually impaired individuals to confirm its accessibility. As a further potential limitation, it was suspected that those who were satisfied with their device would be more likely to respond to the survey than those who had a negative experience. This potential bias could lead to an underestimate both of the number of participants who discontinued use as well as the factors involved in discontinuance. However, the two participants who reported non-use of the device in the previous three months (i.e., late discontinuance users) completed the entire 6-month follow-up. They reported that they had not completely stopped using their device and that they simply had not needed it since their last use. Moreover, by taking a more in-depth look at the answers of the participants, we noticed that overall six more of the participants had not used their device in the past 1-3 months but none of them withrew the study. Interestingly, five participants who reported that they had completely stopped using their device (but did not meet the *late discontinuance use* definition and were not categorized as non-users), completed the entire 6-month follow-up. These findings suggest that the AT non-use concept is complex and should include both objective and subjective criteria and also consider whether the abandonment is partial (only for certain tasks) or total. The development and application of a comprehensive definition of abandonment as a concept should help to analyse and understand the issues related to the use of ATs in general in a more detailed and ecologically relevant way.

Specific aspects related to the prospective study

Vision loss is characterized by the distinction between visual functions, describing how the eye functions, and functional vision, describing how the patient functions in vision-related

activities [57]. Adequate and accurate assessment of functional vision is essential to measure outcomes of vision rehabilitation, as it corresponds to the activity and participation level of the ICF [3]. An important strength of the prospective study considers functional evaluation via the VA LV VFQ-48 [19] a scale commonly applied to assess visual rehabilitation interventions. Other relevant outcome measures are commonly used to assess functional vision, such as the MNRead [58] to evaluate reading performance, and the Melbourne Low Vision ADL Index test [59], and would bring a more dynamic evaluation if participants were assessed in clinical settings. Another limitation is that it was not always possible to differentiate all possible reasons for device discontinuance versus drop-out or other types of attrition. This was the case specifically for participants lost to follow-up without explanation. However, through regular monitoring throughout the study, an attempt was made to record most reasons for leaving the study. In addition, in the same way as participants in the experimental group were asked to rate the experience of telerehabilitation (i.e., comfort, efficiency, effectiveness), asking similar questions of the control group to rate the experience of self-training provided by the company would have been relevant. Finally, the design of the study protocol did not allow us to mask the experimenter to the participants' group membership. Therefore, in order to minimize experimenter bias, online follow-up questionnaires, via an URL link, was used. Unmasking the researcher conducting the statistical analyses to group allocation only once all analyses were conducted, provided us with a reduction in detection bias.

Clinical significance of the results

This research project has allowed for the identification of factors predicting the use of HMDs to provide vision rehabilitation therapists with new potential forms of assessment and training protocols not previously available. First, the factors identified as important (e.g., QoL, visual

performance, and the presence of cybersickness symptoms) are relevant indicators to evaluate and predict the use of such devices. Secondly, based on predictor factors of HMD and LVA use, a personalized training regime via telerehabilitation was developed as a potential intervention to optimize the use of HMDs. In this section, clinical implications of the findings will be detailed and discussed.

Predicting head-mounted display use: clinical implications

Psychosocial and quality of life related factors

The cross-sectional study highlighted that both PIADS and QUEST scores emerged as robust predictor variables. These findings intuitively support the idea that, for an HMD to be used, it should promote good QoL for the users [23]. The prospective study reported that these QoL scores increased within the first three months, independently of the training type. This indicates that instructions provided by telerehabilitation and eSight standard self-training, both are equally successful in improving QoL outcomes. To our knowledge, this study is the first to consider the effect of HMD use on QoL, indicating that no direct comparisons are possible. Overall, the research literature about human factor considerations from the perspective of HMD users remains rare. One study [60] suggested a positive effect of HMDs on the users' visual confidence, referring to their ability to estimate the reliability of their own perception. As with other LVAs, training, practice, or calibration is likely to be necessary in order for users to acquire the correct level of visual confidence. Interviews with individuals with visual impairment identified that recognizing faces and text was the most important function regarding their priority needs with HMDs [61]. HMDs enabled people with visual impairment to have visual experiences previously unavailable, both in terms of visual performances and visual perceptions [62]. Computer-assisted sight allows vision to be approached differently and introduces the concept of multiplicities of vision,

whereby technology-mediated sight refers to a skilled vision neither entirely human nor entirely digital but more like a combination of human / social and technological skills.

Clinically, to the extent that psychosocial factors influence the adoption of HMDs, they represent valuable markers and should be systematically evaluated and monitored when a new technology is acquired. Clinicians should consider the use of device-related QoL measures, such as the PIADS and QUEST, in order to identify device users that could benefit from individualized attention during LV rehabilitation provision and reduce the probability of device abandonment. Insofar as the use of such devices involves physical and psychological transformations, a multidisciplinary team seems important to optimize their proper integration.

Visual performances associated with head-mounted display use

The scoping review revealed that for a device to be used, it must be perceived as effective to the one who uses it and provide a positive level of performance when engaging in ADLs. Feeling more competent and productive was a major factor influencing device usage. The PIADS score (specifically the competency subscore) partially reflects the importance of functional competence and was reported by participants in the cross-sectional study as a strong predictor of HMD use. The prospective study documented functional vision outcome improvement using the VA LV VFQ-48, independently of training and consumer types. These results suggest that both telerehabilitation and self-training were favourable for sustained HMD use. Unlike the QoL measures, which improved after three months of practice and training with the device, HMD practice and training yielded immediate (within the first two weeks) improvements in functional vision. All together these results suggest that functional vision should be measured early and systematically after the acquisition of an HMD, in order to anticipate technology abandonment providing an opportunity to again assess users'needs.

Insofar as this study is the first to systematically investigate the abandonment of HMDs, direct comparisons with previous work are not possible. However, the literature highlights that HMDs involving augmented or virtual reality have the potential to improve a wide variety of visual performances. Significant improvements in visual acuity and contrast sensitivity were measured with the use of eSight Eyewear [20] and new mobile applications on a virtual reality device platform have been presented as an alternative to conventional LV devices at affordable cost [63]. Meaningful positive effects on ADLs had already been documented with previous generations of HMDs [16, 56] that have been replicated in the context of reading [20, 64] and mobility [20]. These findings are relevant because these measures can potentially predict the use of such technology.

Unlike virtual reality that refers to a computer-generated environment in which the user is immersed, augmented reality systems refer mainly to graphic overlays on live images of the real environment (e.g., highlighting obstacles, or captioning objects and faces). Augmented reality tends to be more and more associated with object and face recognition through artificial intelligence software, such as OrCam MyEye (OrCam Technologies Ltd, Jerusalem, Israel) and Microsoft Seeing AI application (Microsoft Corp., Redmond, WA) [65]. Recent studies mainly concern the benefits achieved in mobility (navigation) [66, 67], using sensory substitution systems that provide a live connection to a human agent who assists the user in the specified task [68] or that provide collision warnings via vibrotactile wristbands [69]. As virtual reality and augmented reality technology development expands, the LV field needs to prepare to fulfill the expectations of the users toward the HMDs. Insofar as the improvement of visual performance predicts the use of HMDs, skilled rehabilitation services will be required to develop specific training and assessment protocols to improve or maintain service quality.

Cybersickness related to head-mounted display use

According to the results of the cross-sectional study, abandonment of HMDs is highly related to the presence of headaches during use. In the prospective study, cybersickness scores were stable over the 6-month period, and training type was not related to score changes. This leads us to conclude that in this semi-immersive virtual environment context (eSight) and with this specific population (adult users), cybersickness is not considered as a widespread usability issue. Few participants were severely affected by symptoms of cybersickness and visual discomfort. This may be explained by the semi-immersive condition offered by eSight Eyewear and by the need for sensory adaptation [28]. The experience of cybersickness and other symptoms of visual discomfort is important to consider as they are inherent to the technology [27, 28, 70]. Cybersickness has been mainly explained by sensory conflict theory [27, 28, 71], during the presence of a mismatch between velocities recorded by the visual system, when viewing an angularly magnified image, and those recorded by the vestibular system [71]. Physiologically the vestibulo-ocular reflex enables individuals to adapt to a certain level of magnification and beyond that, the system can not compensate the mismatch and cybersickness symptoms appear [72]. After HMD acquisition, users should be asked about their potential discomfort, and comparison with other device types should be encouraged. For example, IrisVision (Visionize, L.L.C., Berkeley, CA) now considers the velocity of natural head movements, converting angular magnification to linear magnification in the HMD, in order to limit cybersickness. The Simulator Sickness Questionnaire [29] is easy to administer, making the inclusion of such questionnaires at the acquisition of the HMD and during the follow-up sessions a feasible recommendation to investigate potential symptoms onset.

Clinical implications of telerehabilitation for individuals with low vision

Given the importance of intensive training, as well as the role psychosocial and

accessibility factors played in the analyses, telerehabilitation approach was explored as a potential modality to optimize HMD use. In this section, the benefits and barriers will be discussed in more details.

Benefits of telerehabilitation in the context of the use of head-mounted displays

Several encouraging benefits of LV telerehabilitation emerged in terms of accessibility and acceptability, functional performances and organizational aspects. The prospective study and other telerehabilitation applications in rural American veterans [73] and in other newly prescribed magnification devices [24, 74] converge toward a high level of accessibility and acceptability. The remote training was judged as effective and efficient as in-office both by users and providers who assessed patients' reading speed and accuracy, and working distance [24]. Telerehabilitation allows LV therapists to assess individuals in their own environments; for example, asking them to walk around with the tablet to gain insight into their daily routine and tasks that are visually challenging [24]. Bittner et al. [74] documented an increase of satisfaction when assisted set-up loaner equipment was offered for telerehabilitation to overcome technology installation issues. Communication was judged by our LV therapist as comparable to face-to-face consultation on several criteria such as effectiveness, users and clinicians' comfort, and the clinician-user relationship, with the exception of non-verbal behaviours and touch. These findings replicate previous works on telepsychiatry, whereby decreased anxiety and nervousness were reported [75]. Regarding functional performances, previous studies report that the majority of users improved their reading skills after telerehabilitation, and LV therapists judged that the provided training would be helpful to improve magnifier use for most of the participants [24, 74].

On the organizational level, by removing geographical barriers and eliminating travel time for both patients and therapists, LV telerehabilitation enables more efficient system-wide

resource allocation for follow-up training and evaluation sessions. Ihrig [73] supports LV telerehabilitation as a time- and cost-saving alternative to traditional in-office treatment with American veterans living in rural regions. Within a 5-year period and combining telehealth and face-to-face modalities, the average increase in the number of consultations was 24% without increasing the number of work hours. Optimizing time and resources promotes improvement in vision- and health-related outcomes for individuals with LV. More extensively, considering that around 18% of Canadians age 65+ reside in rural regions [76], and that in 2030 they will represent 25% of the population [77], a creative solution is needed. Given the projected increase in the expected number of individuals with visual impairments due to the aging demographic, and the likely increased use of AT such as HMDs, telerehabilitation may help to overcome the economic and societal burden while increasing access to, and quality of, care. The context is optimal as internet is used by 68% of Canadians age 65+ [76], and a survey on the use of mobile applications completed by 259 participants with visual impairments mainly resided in the USA reported that smartphones and tablets are adopted by 95% and 40% of this population, respectively [78]. New exposure to the technology used for telerehabilitation may lead individuals with LV to be more willing to adopt such technology for other purposes that will also improve QoL [24]. However, several identified challenges associated with telerehabilitation (e.g., technological, user-centered aspects) partially explain why the intervention did not reveal differences when compared to the self-guided training. Proper implementation is subject to several challenges that need to be addressed.

Challenges of telerehabilitation

Important challenges often related to terehabilitation are technical and concern access and ease of use of the telehealth-platform (i.e., connecting and positioning a camera) by individuals

without technical training when using a computer use [79, 80]. In the present study, high accessibility of telerehabilitation was observed and most of the time no significant issues were associated with the video component of the telerehabilitation sessions; however, audio quality ratings were variable, often related to signal strength or technical issues during sessions. Such challenges have resulted in the use of a phone for audio as an alternative to hear the provider, as it was the case in our prospective study and other studies [24]. Ergonomically, the use of the phone while performing a manual task, can be challenging when a speaker phone option is not available. Moreover, Bittner et al. [24] encouraged investment in iPads for telerehabilitation as they provide better audio and video quality than Android tablets in a feasibility study in handheld magnifier users. Such technical aspects should specifically be considered in the context of age-related hearing loss, where communication issues occurred [81]. Having a sighted assistant available to help with the setup for the videoconferencing platform was not required for the majority of our HMD users as they had their own computer. However, assistance was necessary for most of the users that operated with other magnifiers and who received tablet loans [24]. Bittner confirmed that lending the appropriate equipment and helping set-up loaner equipment in patients' homes improves their own overall satisfaction [74]. Considering the potential burden of technology associated with telerehabilitation, it is possible that undetermined technical issues within the intervention may partly explained why training delivered through telerehabilitation did not reveal differences, regarding use behaviour, aspects of quality of life and functional vision outcomes, compared to the manufacturer self-training standard.

Telerehabilitation may challenge human contact (e.g., empathy, trust, confidentiality) due of the lack of face-to-face interaction [45]. Preference for direct contact with a clinician (e.g., home visit or clinic appointment) were reported in the context of Internet-based interventions for AT

users [80]. Although high acceptability of telerehabilition was reported by the users in the present study, and the LV therapist provided positive feedback about the therapeutic relationship was reported by the LV therapist, underestimated user preferences maybe explains why the telerehabilitation training did not improve use behaviour and AT-related aspects of QoL when compared to the self-guided intervention. Another user-related challenge that merits careful consideration concerns presonal privacy and confidentiality [80] as telerehabilitation may be perceived by participants as an intrusion into their home [79]. Although specific attention had been taken to ensure privacy (user empowerment, controlling when and how the session is initiated and terminated), these limits may have influenced the results.

Another main challenge for LV telehealth is that specific vision testing (e.g., visual acuity, refraction and visual fields measurements) and ocular health assessments cannot be performed through clinical video telehealth. However, benefits that are derived from telehealth should not be found in implementing telehealth technologies alone, but in how it associates with traditional care (i.e., best viewed as hybrid care), and how it uses these technologies to facilitate access to care [82]. Efforts to improve the standard of telerehabilitation services should be maintained, for example optimizing new protocols though adaptation of traditional tests such as visual acuity or contrast sensitivity [74].

In the research literature on HMD use that is currently available, it is unaware of any rehabilitation guidelines for their use, as there are for the use of traditional LVAs in Quebec [83] and in some European countries [84, 85]. Basically, HMD users learn on their own or rely on device manufacturers. Except for veterans, there is great variability across individual states with regard to acess to LV rehabilitation services for the provision and training of visual aids in the USA. Considering the existing and available rehabilitation services, the implementation of

telerehabilitation raises a number of issues. A major challenge is to implement this modality without compromising comprehensive LV rehabilitation care, including individualized programs [30]. Ethically, no user should be required to use telerehabilitation to access rehabilitation services. Telerehabilitation is not a substitute for traditional services [82], it is the responsibility of institutions to ensure that they schedule preliminary or follow-up face-to-face meetings with the user and the caregiver [86]. Telerehabilitation should be considered as a team-based approach [82], supported by an interdisciplinary collaboration among ophthalmologists, optometrists, audiologists, LV therapists, occupational therapists and psychologists, to only name a few of the team members in interdisciplinary LV care. Ultimately, the success of LV telerehabilitation implementation is based on an excellent coordination of highly qualified professionals dedicated to optimal vision rehabilitation [30]. These limits maybe partly explain why the intervention did not differe significantly when compared to the device manufacturer self-guided training.

With regard to the modalities of reimbursement, American Medicare payment for telehealth services is established in the Social Security Act and covered under the Medicare Fee-for-Service program (as cited in [30]). In most Canadian provinces, including Quebec, there is a reference framework for the use of telerehabilitation for visual, auditory, motor or language-related programs, whereby each health institution must establish an operating protocol for its use [87]. Upon request of the *Ministère de la Santé et des Services sociaux du Québec*, three priority areas of telehealth application, including telerehabilitation, were assessed to establish clinical guidelines and technological standards [82]. This report highlights that, although the provision of technical assistance is frequent in the context of telerehabilitation, studies dealing with AT allocation remain rare. Experts suggest that telerehabilitation could be implemented in all stages of the AT allocation process. As for other telemedicine applications, the main barriers to the

success of telerehabilitation are mainly related to the adaptation of stakeholders, and not to the equipment required for telehealth [88]. Such observations emphasize the importance of managing and accompanying implementation through adequate training of caregivers. Further investigation is required to assess whether private insurance will compensate providers for delivering LV telerehabilitation services. In situations where the patients' own technology (internet-based device equipment) is used for telerehabilitation, the question of who among insurance carriers and/or public service providers will pay the rehabilitation provider remains open.

Implications for research and future directions

Perspectives associated to low vision telerehabilitation

The findings of the present thesis suggest that instructions, provided by telerehabilitation or though the eSight self-training standard, are equally successful in improving QoL and visual ability outcomes and that telerehabilitation could be provided as a potential alternative training modality. Identified limits associated with telerehabilitation (e.g, technological, user-centered aspects) may partially explain why the telerehabilitation provided did not detect differences in the measures compared to the self-guided training. To help guide evidence-based practice recommendations for low vision telerehabilitation implementation, further studies examining benefits of practice and training are needed. Moreover, future research about telerehabilitation will be necessary to develop guidelines to better define new forms of assessment and efficient training protocols to optimize LVA use. For example, it will be relevant to determine where (e.g., public or private sites, rural clinical sites, community-based outpatient centers) and by whom (e.g., certified LV therapist, optometrist/ophthalmologist, occupational therapist) the training should be conducted/coordinated. Moreover, given the on-line survey nature of data collection, assessment of objective visual function measures (e.g., visual acuity, contrast sensitivity, visual

field) was not possible. Considering that a previous telerehabilitation study had already successfully implemented a standardized near reading acuity cards during the session [24], complementary variables could be added to future protocols. In addition, considering the possible selection bias in the present study, it would be interesting to loan both HMDs and Internet access devices to participants in future phases of this project, instead of limiting recruitment to individuals using their own computer equipment and eSight Eyewear. Including users in a living-lab [89] with an integrated knowledge translation approach to encourage the co-production of intervention programs would be a relevant strategy to optimize the adoption of telerehabilitation by the population with LV. Research would be able to better define their needs (e.g., the most appropriate number, duration, format and content of telerehabilitation sessions) and would not only be focused on users but also directed by them.

There was no significant difference between the self-training and telerehabilitation conditions on the selected outcome measures (e.g., use behaviour, QoL, cybersickness). These findings could be explained by the fact that both interventions do not require travel to attend the sessions (known as an important barrier), and/or because both interventions are equally effective. The self-guided training was developped by members of eSight staff who have a visual impairment. It is likely well adapted to the needs of the users, partially explaining why there is no difference between the two interventions. Despite hight accessibility and acceptability of the telerehabilitation, challenges (e.g., technical, user-centered aspects) may have been underestimated in the protocol. Therefore, it will be important to explore participants' experiences in depth in order to identify the most appropriate ways to address remote intervention. Moreover, it is also possible that the selected outcome measures did not allow for the differentiation of the effects of telerehabilitation compared with self-training. Exploration of most common measures,

such as reading speed (meaningfully improved in handheld magnifier users receiving telerehabilitation [24]) or evaluation of functional vision with more practical functional vision assessments, such as the Melbourne Low Vision ADL Index [59] test may have reveal a difference between the two interventions. Eventually, less complex magnifiers (e.g., handheld magnifiers, closed-circuit televisions) selected folowing a traditional clinical evaluation, according to subjects' needs and matching the user with an appropriate device, might have shown a difference between the self-training and telerehabilitation conditions on the selected outcome measures. As suggested by the LV therapist, it is likely that six sessions over two weeks were insufficient, especifically for participants who needed eccentric fixation training, to detect difference between the two interventions. Another possible interpretation is that the personalized training approach was not comprehensive enough as it did not integrate a pluri-displinary team, and therefore did not fully meet the needs of users. In order to confirm the effect of telerehabilitation, it would be relevant to conduct a randomized controlled trial to compare this modality with face-to-face training (in-office and/or at-home) commonly used when assigning traditional visual aids. Moreover, since the LV therapist focused on ADLs, it would be meaningful to follow participants beyond six months to explore if telerehabilitation has a long-term and transferable effect on other activities, compared to self-training. Although we chose to focus on a new form of visual aid that is increasingly used by the LV population, we anticipate that it could be feasible to provide telerehabilitation to optimize the use of more common LVAs (e.g., handheld magnifiers, closed-circuit televisions). With the exception of the present study, this modality has been applied to users of magnifiers in small samples where authors admitted the need to conduct a larger-scale randomized study [24, 74].

Transfer to practice has already been initiated, whereby telerehabilitation is implemented

in Veterans Affairs LV clinics throughout the USA [30] and, more recently, by some LV rehabilitation service providers in Québec [87]. The implementation of telerehabilitation is likely to increase and become more effective as new evidence is provided in the coming years. Each institution tends to establish an operating protocol for the use of telerehabilitation [82]. Implementation can be expected to be adapted to specific patients' needs and institutions' priorities, human and material resources, and thus will take different forms (e.g., teleconsulting for evaluation, training, follow-up; teleexpertise; remote support for relatives). To help guide evidence-based practice recommendations for LV telerehabilitation implementation, further randomized studies exploring the most appropriate telerehabilitation forms are needed.

Most telerehabilitation studies focus on acceptability, effectiveness and satisfaction, but there are still very few publications on the regulation of telerehabilitation and its ethical and legal issues [82]. Yet, the clinician-client relationship can be affected as much by the interactive components of telerehabilitation as by its technical aspects, which transform the interpersonal relationship in terms of space and time [75]. Thus, more ethical considerations related to the transformation of the traditional therapeutic relationship and the resources deployed will be necessary to ensure a quality comparable to face-to-face consultation. Further qualitative studies, through the lived experience of both clients and clinicians are needed to understand the elements that characterize this transformation in depth. Elements such as communication, the relationship of trust between the clinician and the client, the clinician's behaviour (e.g., empathy, professionalism) [75], interventions (e.g., evaluation, training, follow-up), as well as the measures taken to ensure confidentiality and privacy should be analyzed in the future.

Perspectives associated to head-mounted displays

Visual performance comparisons between previous generations of HMD and traditional

LVAs are available [16, 56]; however, HMDs have undergone considerable technical evolution over the past ten years. Future research should compare the new generation of HMDs to commonly prescribed LVAs in order to demonstrate their effectiveness in addressing the impairments and rehabilitation goals of diverse patient populations. Moreover, to the extent that mainstream technologies are now used as visual aids (e.g., tablet, smartphone) and can improve reading skills compared to traditional LVAs [90, 91], comparisons with HMDs are needed. In this thesis, correlations between factors related to HMD use via the example of eSight Eyewear were identified. Given the increasing availability and variability in HMD designed for individuals with LV, further studies should be conducted with other HMDs to confirm whether the same or additional variables are involved. Considering the importance of optimizing device usage measures in a future trial, it will be relevant to monitor duration of usage and the settings used by the participant with a dedicated application on the HMD.

Virtual and augmented reality systems are generating a demand for high-performance eye-tracking systems in HMDs to improve visual performance [65]. A recent study [92] tested a gaze-controlled system that magnified a portion of text while maintaining global viewing of the entire document. Reading speed improvements were obtained compared to traditionnel uniformly applied magnification. An eye-tracker application makes it possible to artificially fill in a scotoma using remapping strategies while the image is stretched around the scotoma [93]. With an integrated eye-tracking system in the future, it might be feasible to use eye movements to relocate the magnification bubble (i.e., limited central area of visual field that is magnified while the remained peripheral visual information is presented without added magnification) on the display so that it always remains superimposed on the region of the retina used for fixation. However, poor fixation stability in individuals with central vision impairment and eye-tracking systems

issues remain challenging for accurate fixation and visual search [65]. More research and development is required to determine the most effective way to include eye tracking and gaze control with magnification within HMDs when performing various tasks.

The experience of cybersickness with increased levels of magnification can be minimized reducing head motion. A proposed strategy to reduce motion sickness consists of magnifying image motion within the magnification bubble while presenting the visual information outside the bubble without added magnification. However, dynamic visual acuity limitations on resolution limit user's performance [56]. Another potential solution is the minimization of imbalances between head and image motion beyond the range of vestibulo-ocular reflex adaptation. Including features for converting angular magnification to linear magnification in HMDs, integrated accelerometers and gyroscopes into new generation of HMDs has the potential to control the symptoms for LV device users. Further exploration of the mechanisms of cybersickness and its associated factors remain essential, given the increasing variability in HMD types and the limited literature available on their link with this condition in individuals with LV.

The majority of HMDs utilize a single camera and deprive the user of binocular vision. This limitation can create a mismatch between the perceived versus the actual location of objects. HMD systems using two cameras enable stereoscopic vision, helping people to localize objects and potentially enhancing mobility [66] and restoring binocular vision by correcting certain visual field defects [94]. Binocular vision can be challenging when magnifying within a region of interest because it also magnifies binocular disparity and increases the likelihood of diplopia in individuals with fragile binocular vision [95]. Considerable innovation will be necessary to insure binocular disparity under conditions of magnification. The question about the advantages provided by binocular versus bi-ocular vision still needs to be raised. For instance, the effect of

HMDs on binocular inhibition or summation (i.e., binocular function is worse or better than monocular function, respectively) and their potential benefits should be explored.

Future HMDs may dynamically adjust certain functions (e.g., magnification, illumination and contrast) and customize functionality to adapt the changing needs of people with LV. The next generation of HMDs may use image processing algorithms individually in order to compensate for each type of vision impairment without conceding performance trade-offs (e.g., resolution, visual field, binocularity) to accommodate system limitations [96]. In parallel with the requirement to personalized functionality, there is a need to develop affordable mainstream HMDs that can be used by people with LV. The high cost of current commercially available HMDs has been reported as the most significant negative issue by users [97]. The growing trend is toward designing accessibility applications specifically created for LV, and mainstream applications with already included adjustable configurations [60, 98]. Such applications will need to be tested systematically. Further qualitative research and/or a user-centered design approach [99] that considers long-term utilization of such devices compared with traditional LVAs, is needed to better understand how people with LV experience the use of HMDs. Reports of the lived experiences should enable researchers to better understand social effects of these emergent technologies.

Conclusion

The different components of the present thesis improve the understanding of the use of HMDs by individuals with LV through the case of eSight Eyewear. The scoping review provides supporting evidence for the multifactorial decision-making process around the use of magnifying visual aids. Low motivation and adaptability, as well as poor accessibility to rehabilitation services have been identified as important barriers to magnifying LVA use. Moreover, client/clinician positive partnerships and intensive training programs are other important factors that contribute to optimal use of devices. The cross-sectional study revealed that neither the traditional clinical variables, nor LV rehabilitation experience was predictive of sustained use of an HMD. However, improving device-related aspects of users' QoL helps to maintain their device use over time. The administration of standardized questionnaires that evaluate different aspects of assistive technology-related QoL may be able to identify device users that could benefit from individualized attention during LV rehabilitation provision to reduce the probability of device abandonment. Considering these findings, a personalized training regime via telerehabilitation was developed to meet specific users' needs and optimize the use of HMDs. The data demonstrated the feasibility of a randomized controlled study of telerehabilitation for people with LV using HMDs, and provided positive feedback from the participants and the LV therapist. eSight Eyewear, either with telerehabilition or with the manufacturer self-training standard, early improves functional vision and increased device-related aspects of users' QoL within the first three months of device training and practice. This indicates that instructions, provided by telerehabilitation or though the eSight self-training standard, are equally successful in improving QoL and visual outcomes and that telerehabilitation could be provided as a potential alternative training modality. However, several identified challenges associated with

telerehabilitation (e.g., technological, user-centered aspects) may partially explain why the telerehabilitation did not detect differences, regarding use behaviour and aspects of QoL, when compared to the device manufacturer self-guided training. Further questions will need to be addressed, for example examining benefits of practice and training, to develop evidence-based assessment and training protocols for telerehabilitation to better meet the unique needs of individuals with low vision.

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Supporting information

Supplementary Table S1: MedLine research strategy

Search History Database(s): **All Ovid MEDLINE(R)** 1946 to October 2018

Concepts and Strategy	Search Strategy: #	Searches	Results
	1	exp Vision Disorders/ or Visually Impaired Persons/ (Vision Disorder* or Visual Disorder* or Visual Impairment* or visually impaired or visually disabled or Vision Disabilit* or Color Vision Defect* or Color Vision Deficienc* or Hemianopsia or Low Vision or Reduced Vision or Subnormal Vision or Sub-normal Vision or Diminished Vision or Visually Impaired or Blind Person*).mp.	68638
	2		44509
A Low vision	3	1 or 2	77049
B Assistive devices	4	Self-Help Devices/ or (Self-Help Device* or Assistive Technolog* or Assistive Device*).mp.	6882
C-1 Low vision aids	5	(visual Aid or Visual aids or Low vision aid or Low vision aids).mp.	1516
C-2 lens and glasses	6	exp Lenses/ or (lens or lenses or eye glass* or eyeglass* or Spectacles or Prescription Glasses or IOL).mp.	104736
	7	Patient Compliance/ or "No-Show Patients"/ or Withholding Treatment/ or Treatment Refusal/ (Patient Adherence or Patient Nonadherence or Patient Non-Adherence or Patient Compliance or Patient Noncompliance or Patient Non-compliance or Patient Cooperation or Patient Non-Attendance or Patient NonAttendance or No-Show Patient* or Patient Non-Attendance or Patient No Show*).mp.	74789
	8		63960
	9	(Abandon* or withdraw* or with-drawal or Withholding Treatment* or Refus* or Uptake or Discontinu* or reject* or Acceptability or Accept* or Adopt* or Retention or Willing* or Satisf* or Expectation* or integration).mp.	2042910
D1 Adherence or satisfaction - v.1	10	7 or 8 or 9	2090651
	11	3 and 4 and 10	55
1st set created ABD1	12	limit 11 to (english or french)	54
	13	(5 and 10) not 11	224
2nd set created C1D1	14	limit 13 to (english or french)	203
3rd set created C2D1 **and later ignored**	15	(6 and 10) not (11 or 13)	8131
D2 Adherence or satisfaction - v.2	16	(Patient Adherence or Patient Nonadherence or Patient Non-Adherence or Patient Compliance or Patient Noncompliance or Patient Non-compliance or Patient Cooperation or Patient Non-Attendance or Patient NonAttendance or No-Show Patient* or Patient Non-Attendance or Patient No Show* or Withholding Treatment* or Treatment refusal*).mp.	84280
	17	7 or 16	84280
	18	(6 and 17) not (11 or 13)	414
3rd set created = C2D2 (a variation of D1)	19	limit 18 to (english or french)	402

Suplementary Table S2: Embase research strategy

Search History Database(s): **Embase** 1974 to 2018 October 10

Search Strategy:

Concepts and Strategy	#	Searches	Results
	1	exp visual disorder/ or assistive technology/	208490
	2	(Vision Disorder* or Visual Disorder* or Visual Impairment* or visually impaired or visually disabled or Vision Disabilit* or Color Vision Defect* or Color Vision Deficienc* or Hemianopsia or Low Vision or Reduced Vision or Subnormal Vision or Sub-normal Vision or Diminished Vision or Visually Impaired or Blind Person* or blindness or vision disturbance* or visual disturbance*).mp.	134788
A Low vision	3	1 or 2	234967
B Assistive devices	4	Self Help Device/ or (Self-Help Device* or Assistive Technolog* or Assistive Device*).mp.	6816
C-1 Low vision aids	5	(visual Aid or Visual aids or Low vision aid or Low vision aids).mp.	2754
C-2 lens and glasses	6	exp Lenses/ or (lens or lenses or eye glass* or eyeglass* or Spectacles or Prescription Glasses or IOL).mp.	116271
	7	Patient Compliance/ or patient attendance/ or treatment withdrawal/ or Treatment Refusal/	153010
	8	(Patient Adherence or Patient Nonadherence or Patient Non-Adherence or Patient Compliance or Patient Noncompliance or Patient Non-compliance or Patient Cooperation or Patient Non-Attendance or Patient NonAttendance or No-Show Patient* or Patient Non-Attendance or Patient No Show*).mp.	132779
	9	(Abandon* or withdraw* or with-drawal or Withholding Treatment* or Refus* or Uptake or Discontinu* or reject* or Acceptability or Accept* or Adopt* or Retention or Willing* or Satisf* or Expectation* or integration).mp.	2757860
D1 Adherence or satisfaction - v.1	10	7 or 8 or 9	2851891
1st set created ABD1	11	3 and 4 and 10	369
	12	limit 11 to (embase and (english or french))	252
2nd set created C1D1	13	(5 and 10) not 11	492
	14	limit 13 to (embase and (english or french))	245
3rd set created C2D1 **and later ignored**	15	(6 and 10) not (11 or 13)	10917
D2 Adherence or satisfaction - v.2	16	((Patient? adj1 (Adherence? or Nonadherence? or Non-Adherence? or Compliance? or Noncompliance? or Non-compliance? or Cooperation or Non-Attendance? or NonAttendance? or non-attending or nonattending or No-Show? or absenteeism?)) or (treatment* adj1 (withdrawal? or Withholding or With-holding or refusal?)) or (clinic adj1 (nonattendance or non-attendance))).mp.	168306
	17	7 or 16	168702
3rd set created = C2D2 (a variation of D1)	18	(6 and 17) not (11 or 13)	686
	19	limit 18 to (embase and (english or french))	491

Supplementary Table S3: Cochrane research strategy

Search History Database(s): **Cochrane** to 2018 October 10

Search Strategy:

Concepts and Strategy	#	Searches	Results
A Low vision	1	(Vision Disorder* or Visual Disorder* or Visual Impairment* or visually impaired or visually disabled or Vision Disabilit* or Color Vision Defect* or Color Vision Deficienc* or Hemianopsia or Low Vision or Reduced Vision or Subnormal Vision or Sub-normal Vision or Diminished Vision or Visually Impaired or Blind Person* or blindness or vision disturbance* or visual disturbance*).mp.	11807
B Assistive devices	2	(Self-Help Device* or Assistive Technolog* or Assistive Device*).mp.	480
C-1 Low vision aids	3	(visual Aid or Visual aids or Low vision aid or Low vision aids).mp.	204
C-2 lens and glasses	4	(lens or lenses or eye glass* or eyeglass* or Spectacles or Prescription Glasses or IOL).mp.	8093
	5	(Patient Adherence or Patient Nonadherence or Patient Non-Adherence or Patient Compliance or Patient Noncompliance or Patient Non-compliance or Patient Cooperation or Patient Non-Attendance or Patient NonAttendance or No-Show Patient* or Patient Non-Attendance or Patient No Show*).mp.	736225
	6	(Abandon* or withdraw* or with-drawal or Withholding Treatment* or Refus* or Uptake or Discontinu* or reject* or Acceptability or Accept* or Adopt* or Retention or Willing* or Satisf* or Expectation* or integration).mp.	181947
D1 Adherence or satisfaction - v.1	7	5 or 6	784735
	8	1 and 2 and 7	18
1st set created ABD1	9	limit 8 to (english or french) [Limit not valid in ACP Journal Club,CDSR,DARE; records were retained]	16
	10	(3 and 7) not 8	156
2nd set created C1D1	11	limit 10 to (english or french) [Limit not valid in ACP Journal Club,CDSR,DARE; records were retained]	114
3rd set created C2D1 **and later ignored**	12	(4 and 7) not (8 or 10)	5213
D2 Adherence or satisfaction - v.2	13	((Patient? adj1 (Adherence? or Nonadherence? or Non-Adherence? or Compliance? or Noncompliance? or Non-compliance? or Cooperation or Non-Attendance? or NonAttendance? or non-attending or nonattending or No-Show? or absenteeism?)) or (treatment* adj1 (withdrawal? or Withholding or With-holding or refusal?)) or (clinic adj1 (nonattendance or non-attendance))).mp.	21820
	14	(4 and 13) not (8 or 10)	106
3rd set created = C2D2 (a variation of D1)	15	limit 14 to (english or french) [Limit not valid in ACP Journal Club,CDSR,DARE; records were retained]	91

Supplementary Table S4: Eric ProQuest research strategy

Search History Database(s): **Eric ProQuest** to 2018 October 10

Concepts and Strategy	Search Strategy: #	Searches	Results	Notes
A Low vision aid	1	MAINSUBJECT.EXACT.EXPLODE("Assistive Technology")	3246	
B Compliance	2	(MAINSUBJECT.EXACT("Compliance (Psychology)") OR MAINSUBJECT.EXACT("Reinforcement"))	3246	To not explode "Compliance Psychology" otherwise we include legal compliance To not explode "Reinforcement"
Set created AB	3	MAINSUBJECT.EXACT.EXPLODE("Assistive Technology") AND (MAINSUBJECT.EXACT("Compliance (Psychology)") OR MAINSUBJECT.EXACT("Reinforcement"))	19	

No need to search the other terms in ERIC, because low number of references with 2 first concepts

Supplementary Table S5: CINHAL research strategy

Search History Database(s): **CINHAL EBSCOhost** to 2018 October 10

Concepts and Strategy	#	Searches	Results	Notes
A low vision		(MH "Vision, Subnormal") OR (MH "Vision Disorders")		Vision, Low Utiliser : Vision, Subnormal, not explode (MH "Vision Disorders")
B Low vision aids		(MH "Rehabilitation of Vision Impaired")		
C Assistive technologies		(MH "Assistive Technology") OR (MH "Communication Aids for Disabled") OR (MH "Assistive Technology Devices")		not explode these terms "Self-Help Devices" use : "Assistive Technology Devices" "Low Vision Rehabilitation" use : "Rehabilitation of Vision Impaired"
D Adherence		(MH "Treatment Refusal") OR (MH "Patient Compliance")		not explode (MH "Patient Compliance")
1st set BCD		(MH "Rehabilitation of Vision Impaired") AND ((MH "Assistive Technology") OR (MH "Communication Aids for Disabled") OR (MH "Assistive Technology Devices")) AND ((MH "Treatment Refusal") OR (MH "Patient Compliance"))	0	
2nd set ACD		((MH "Vision, Subnormal") OR (MH "Vision Disorders")) AND ((MH "Assistive Technology") OR (MH "Communication Aids for Disabled") OR (MH "Assistive Technology Devices")) AND ((MH "Treatment Refusal") OR (MH "Patient Compliance"))	1	

Supplementary Table S6: Grey literature research strategy

Search History Database(s): **Trip Database and NICE Evidence** to 2018 October 10

Database name	Research date	Research Statement (s) and Limitations	Results
Trip Database	0october 2018	("Assistive Technology" or "Assistive Technologies" or "Assistive Device" or "Assistive Devices" or" self-help") AND ("low vision" or "vision disorder" or "visual disorder" or "visual impairment") AND (adherence or complian* or abandon* or withdraw* or refusal*)	319
	0october 2018	(**"low vision aid" or "low vision aids"**) AND (adherence or complian* or abandon* or withdraw* or refusal*)	14
NICE Evidence	0october 2018	(**"Assistive Technology" or "Assistive Technologies"**) AND ("low vision" or "vision disorder" or "visual disorder" or "visual impairment") AND (adherence or complian* or abandon* or withdraw* or refusal*)	43
	0october 2018	(**"Assistive Device" or "Assistive Devices" or" self-help"**) AND ("low vision" or "vision disorder" or "visual disorder" or "visual impairment") AND (adherence or complian* or abandon* or withdraw* or refusal*)	54
	0october 2018	(**"low vision aid" or "low vision aids"**) AND (adherence or complian* or abandon* or withdraw* or refusal*)	3

Supplementary Table S7: Studies' characteristics

Authors	Reference number	Design	Population/sample	Data collection	Data analysis methods	Theoretical framework
Becker et al. (2005)	30	Observational	subjects with various age-related macular degeneration, N= 71 (61% female), Median Age= 79.5 y , SD= 6.6 y	Longitudinal	Descriptive statistics, multiple regression models	Psychology: life-span theory of control (used for the methodology)
Goldstein et al. (2007)	29	Interventional, Randomized trial	subjects with AMD, N= 151 (97 females), Age= 39-92 y, Median age= 77.5	Longitudinal	Descriptive statistics, Inferential statistics (ANCOVA, Chi-square)	Psychology: cognitive restructuring approach (used for methodology)
Copolillo et al. (2005)	35	Observational	subjects with LV, N=15 (5 females), Age=56-90 y, Mean age= 75.7 y	Cross-sectional	Descriptive analysis, Qualitative analysis (principles of ethnography)	Anthropology (ethnography)
Burton et al. (2010)	32	observational	subjects with LV or other physical disabilities (sensory and motor impairment), N=24 (13 females), Age= 19-71 y	Cross-sectional (structured telephone interview)	Qualitative analysis (narrative analysis, Descriptve analysis, Inferential analysis (ANOVA, Chi-square)	None
Dougherty (2011)	8	Observational	subjects with LV, N=88, Mean age= 77.17 y	Longitudinal (a telephone survey)	Descriptive analysis, Inferential analysis (T tests and Fisher's exact tests), Multivariate logistic regression	None
Mcilwaine et al. (1991)	10	Observational	subjects with LV, N=83 (54 females), Mean age (macular disease group)= 74 y, Mean age (non-maculare disease group) = 61 y	Cross-sectional (a questionnaire and a telephone survey)	Descriptive analysis, Inferential analysis (The Mann & Whitney test)	None
Elliott (1989)	12	Observational	subjects with LV, N=34 (18 females), Age=67-88 y, Mean age= 79	Cross-sectional (a structured questionnaire)	Descriptive analysis, Inferential analysis (Chi-square)	None
Watson et al. (1997)	11	Observational	veterans with LV, N=200	Longitudinal (a telephone survey)	Descriptive analysis, Inferential analysis (Chi-square), correlation (Spearman coefficient0	None
Leat et al. (1994)	20	Observational	subjects with LV, N=57 (67% female), Age=62-92 (SD= 78.8.6)	Cross-sectional	Descriptive analysis, Inferential analysis (ANOVA, Chi-square)	None
Harper et al. (1998)	21	Observational	subjects with ARMD, N=56 (33 women), Age=52-98 y, Mean age= 81.4 y	Cross-sectional	Descriptive analysis, Inferential analysis	None
Watson et al. (1997)	31	Observational	veterans with LV, N=200, Age=27-91, Mean age= 67.4 y (SD= 11.6 y)	Longitudinal	Descriptive analysis, Inferential analysis (Chi-square)	None
Goodrich et al. (1980)	22	observational	veterans with LV, N=95, Mean age= 49.49 y (SD= 14.81 y)	Cross-sectional	Descriptive analysis, Inferential analysis (t-tests), multiple correlation	None
Rinnert et al. (1999)	27	Observational	subjects with LV, N=94 (66 females), most patients were between 80-84 y	Cross-sectional	Descriptive analysis,	None
Bischoff (1995)	23	Observational	subjects with ARMD, N=112 (84 females), Age=65-98 y, Mean age= 81.4 y (SD=0.7 y)	Cross-sectional	Descriptive analysis	None
Chan et al. (1984)	24	Observational	subjects with diabetic vitreous hemorrhage , N=30 (17 females), Age=21-73 y	Cross-sectional	Descriptive analysis	None
Demirkilinc et al. (2013)	28	Observational	subjects with LV, N=100 (43 females), Age=12-97 y	Cross-sectional	Descriptive analysis, Inferential analysis (Mann-Whitney U, chi square, and Fisher's exact tests)	None
Rosenbloom (1974)	25	Observational	subjects with LV, N=150, Age=60-89 y	Longitudinal	Descriptive analysis, qualitative analysis	None
Ryan et al. (2013)	18	Interventional	subjects with LV, N=343 (72% female), Age=75-86, median age 82 y	Longitudinal	Descriptive analysis, Inferential analysis (Wilcoxon Signed Rank), Logistic regression analysis	None
Bachofer (2013)	26	Observational	subjects with LV, N=37 (16 females), 18- 28 y (M= 21.84, SD = 2.94)	Cross-sectional	Descriptive analysis, Multiple regression analysis	None
Hanninen et al. (1977)	33	Observational	individual with LV, N=11, high school graduates students	Cross-sectional	Descriptive analysis, Qualitative analysis	None
Gothwal et al. (2018)	19	Interventional, Randomized trial	Chidren and yound adults with LV, N=40, 10-18 y	Longitudinal	Descriptive analysis, Qualitative analysis	None

Authors	Reference number	Type of magnifying LVA	usage rate	(Non-)use measurement	Term for non-use
Becker et al. (2005)	30	Magnifying glasses, long canespecial glasses, optoelectronic reading systems, large-print book, books read on cassettes, touch watch, books in Braille	None	A sum score indicating the number of ATs used based on a given list of devices	Change in assistive device use; Reduce the number of device
Goldstein et al. (2007)	29	Magnifiers, talking appliances	None	Actual use : binary question (yes/no), willingness to use : a 4 point scale	change in the use
Copolillo et al. (2005)	35	Variety of LVA types	None	None	Challenges/barriers to successful low vision aid device use decision making; Little use
Burton et al. (2010)	32	Computer-related ATDs (for visual impairment : Voice-recognition software, CCTV, telephone headset, screen reader, scanner for data imput, talking checkbook)	None	Frequency of use	Affect the optimal use of asistive technology devices; Assistive technology device abandonment
Dougherty (2011)	8	Magnification devices for near tasks : handheld magnifier (49% of all devices), Stand magnifiers (29%)	19% (95% CI, 12–26) non use	Timing and frequency of use; (non-)use within the past three months	Abandonment of devices
Mcilwaine et al. (1991)	10	Optical near LVAs (89%) (hand held magnifier (53%), spectacle magnifier (28%), stand magnifier (19%), multiple magnifier...), Optical distance LVAs (4%), Optical distance and near LVAs (7%)	32.5% never used	Frequency of use (per day)	Never use, retained but unused equipment, ,
Elliott (1989)	12	Variety of LVA types	None	Frequency of use	Less frequently used
Watson et al. (1997)	11	LVAs for reading : video magnifier, spectacle magnifiers, hand/stand magnifiers	46.7% nonuse for spectacle magnifiers; 20% for stand/hand-heldd magnifiers; 2.3% for video magnifiers	Frequency of use (per day); Non-use defined as not used with 1 year or as not helpuf.	Nonuse of LVDs, discontinuing the use
Leat et al. (1994)	20	Spectacle prescriptions with/without high additions (24.6%), hand magnifiers (21%), illuminated magnifiers (28%), stand magnifiers (8.7%), near-focusing telescope (5.3%), intermediate telescope (5.3%)	19% of patients used not regularly	Frequency of use, duration of use	decreased use
Harper et al. (1998)	21	Stand magnifiers (56), hand magnifiers (17), distance telescopic (7), spectacle mounted magnifiers (6), bar/brightfields magnifiers (2)	13% used not regularly their LVAs	Frequency of use, length of continuous use	not make use
Watson et al. (1997)	31	Stand or hand-held magnifiers (36.9%), hand-helds telescopes (19.7%) ,spectacles mounted telescopes (17.6%), spectacle magnifiers (15.4%), video magnifiers (9.5%), fields expansion devices (0.9%).	14.6% of the device were not still in use	Frequency of use, duration of use; task-specific ability with and without the LVD; discontinuous usage during the past year	nonuse; discontinuous usage
Goodrich et al. (1980)	22	CCTV	13% could not demonstrate sufficient proficiency of use	Reading duration with CCTV, lengt of time patients have their CCTV	not demonstrate sufficient proficiency of use; No effective use of aids; Not using their aids regularly
Rinnert et al. (1999)	27	Variety of LVA types CCTV, (telescopes)	20% of non-use	Frequency of use, duration of use;	Rejection; non-use
Bischoff (1995)	23	hand-held magnifying glass, increased near addition, hyperocular lenses, electronic aid, others	26% did not still used	Frequency of use, duration of use;	seldom used; never used, don't use any more
Chan et al. (1984)	24	telescopic system, microscopic system	50 % did not accepted the use of telescopic system for their distance vision; 17% decided not to use a microscopic system	Frequency of use	Could not tolerate the use; Not to use; Refuse to use
Demirkilinc et al. (2013)	28	Variety of LVA types; Of the LVAs prescribed, 3% were for distance vision only, whereas 68% were for near vision only.	29% took a LVA but never used it	Success use define as "The patient finds an aid beneficial and uses it to solve one or more visual problem"; Frequency of use; Actual use : binary question (yes/no)	Never used
Rosenbloom (1974)	25	Variety of LVA types; majority of microscopic lenses and near additions	16% had discontinued their use	Comprehensive: The extent to which an aging low vision patient continues to use a LVA and the extent of its use in his life.	Discontinued use; unsuccessful use; seldom wore the aid
Ryan et al. (2013)	18	Variety of LVA types	21% patients did not used their LVAs at least once a week	Frequency of use; non-use was defined as irregular use averaging less than twice per month	Change in LVA use; Drop-off in the use of LVAs.
Bachofer (2013)	26	Optical devices; stand magnifiers (dome), handheld magnifiers, and reading glasses.	13% were not current users	Pourcentage on amount of time of use; Frequency of use; Actual use : binary question (yes/no)	Non-users
Hanninen et al. (1977)	33	Variety of optical LVA types	None	Frequency of use; Seldom or Never= irregular use averaging less than twice per month.	Rejection of LVAs; irregular use
Gothwal et al. (2017)	19	optical and electronical LVAs (magnifiers, telescopes, mouse CCTV, portable video magnifiers, stand magnifiers	United Kingdom, 33% non used iPad at school and 67% at home at 3 months. India, 33% non used iPad at school and 11 % at home	Frequency of use (per day)	non acceptance, non usage

Authors	Reference number	Factors related to magnifying LVAs use			
		Personal factors	Device factors	Environment factors	Intervention factors
Becker et al. (2005)	30	Demographic factors (gender, age, education), Physical factors (duration of vision loss)	None	None	None
Goldstein et al. (2007)	29	Demographic factors (education)	Objective device-related factors	Physical barriers	education strategy, access to care
Copolillo et al. (2005)	35	Psycho-social factors (stimatization, efficiency, productivity, positive appraisals, adaptability, coping)	Subjective device-related factors (appearance, design), Objective device-related factors (dimension, weight)	Social environment	Role of professionnal, Positive interaction patient/clinician, Training and transfer
Burton et al. (2010)	32	Psycho-social factors (productivity, adaptability, self-esteem, n	Subjective device-related factors (ease of use))	Social environment	Training and strategy
Dougherty (2011)	8	Demographic factors, Physical factors (type of visual fields, change in vision). Psycho-social factors (productivity), Other material resources, Satisfaction.	Objective device-related factors (quality)	Social environment (personal social circle, the larger sclae social environment)	None
Mcilwaine et al. (1991)	10	Demographic factors (age), Physical factors (diagnosis, visual	Objective device-related factors (dimension, weight)	None	Training
Elliott (1989)	12	Demographic factors (age)	None	None	LVA provider
Watson et al. (1997)	11	Demographic factors (age), Physical factors (diagnosis), Other material resources, Satisfaction	Objective device-related factors (ergonomics)	Social environment (personal social circle), Physical barriers (illumination)	Training (amount)
Leat et al. (1994)	20	Demographic factors (age, gender), Physical factors (changein vision), Psycho-social factors (productivity), Satisfaction	Subjective device-related factors (frequency of use, easy reach device)	None	Provider
Harper et al. (1998)	21	None	None	None	None
Watson et al. (1997)	31	Demographic factors (age), Physical factors (diagnosis, visual acuity, change in vision), Psycho-social factors (new tasks), Other material resources	Subjective device-related factors (appearance, design), Objective device-related factors (technical performance)	Social environment (personal social circle)	Training (amount)
Goodrich et al. (1980)	22	None	None	None	None
Rinnert et al. (1999)	27	Physical factors (change in vision)	Objective device-related factors (ergonomics)	Physical barriers (illumination)	Role of professional
Bischoff (1995)	23	None	None	None	Role of professional
Chan et al. (1984)	24	Physical factors (change in vision), Psycho-social factors (motivation), Satisfaction	Objective device-related factors (ergonomics)	None	None
Demirkilinc et al. (2013)	28	Demographic factors (age), Physiscal factors (diagnosis, visual acuity), Psycho-social factors (motivation), Satisfaction	Subjective device-related factors (ease of use, frequency of use)	None	None
Rosenbloom (1974)	25	Physical factors (change in vision, other physiological changes), Psycho-social factors (adaptation, motivation)	None	None	None
Ryan et al. (2013)	18	Physical factors (functional changes), Satisfaction	None	None	None
Bachofer (2013)	26	Physical factors (type of visual fields, change in use), Psycho-social factors (social acceptance, adaptability, coping, self-esteem, motivation), combination of personal factors	Subjective device-related factors (appearance, ease of use)	Social environment (personal social circle)	None
Hanninen et al. (1977)	33	Physical factors (type of visual fields)	Subjective device-related factors (appearance, ease of use)	None	None
Gothwal et al. (2017)	19	Efficiency and Productivity	Objective device related factors (features and ease of use)	Social environment (stigmatisation), Physical environment (optimal equipment)	None

Supplementary S8: Questionnaire Study 2

Welcome to our project entitled: Understanding the use of Head-Mounted Devices: The case of eSight

The purpose of this research project consists in studying how you use your eSight device, and identifying which factors are related to your use.

As one of the 1000+ users of these eSight Eyewear, we would like to collect information about your quality of life, your satisfaction and your experience.

This study is conducted by the University of Montreal and is funded by MITACS, a national, not-for profit research organization that manages and funds research and training programs in partnership with universities, industry and Government in Canada.

This funding partnership involves eSight Corporation, the manufacturer of eSight eyewear.

It takes less than an hour to complete the survey and you will have a month to do so. This is a one-time on-line survey. Indeed, once the survey is completed your participation in this study is ended.

This survey will take less than an hour and will include different parts to complete regarding: I) Quality of life; II) Satisfaction; and III) The usage patterns of your eSight device.

Potential risks of this study

There are no known or anticipated risks associated with this project.

It should be noted that participation in this survey is not intended to affect your use of eSight device.The participants are encouraged to continue their normal usage of their device.

Advantages of this study

This study does not lead to a direct benefit to participants. However, the information obtained from it could be useful for the improvement of portable video devices for

Section A: Demographic condition

A1. Age

A2. Gender

- Female ☐
- Male ☐

A3. Are you currently a car driver?

- Yes ☐
- No ☐

A4. City

A5. Country

A6. Subject's employment/study situation

- Employed Outside of Home ☐
- Employed at Home ☐
- Unemployed ☐
- Full Time Student ☐
- Part Time Student ☐
- Retired ☐

A7. Subject's accomodations

- [ ] House
- [ ] Apartment
- [ ] Townhouse
- [ ] Living/Retirement Community
- [ ] Nursing Home
- [ ] Mobile home
- [ ] Other

Other

A8. Subjects living arrangement

- [ ] Alone
- [ ] With spouse/companion
- [ ] With young children
- [ ] With adult children
- [ ] With sibling or other relatives
- [ ] With parents
- [ ] With guardian
- [ ] Other

Other

A9. Level of study

- [ ] Elementary School (up to 8th grade)
- [ ] Secondary school (completion of high school)
- [ ] Postsecondary school (university)

Section B: Health condition

B1. Do you have a restriction of your visual field?

- Central field loss (I can not see clearly what is in front of me so I need to enlarge, and I see better using the sides of my vision) ☐
- Peripheral field loss (I do not see clearly on the sides of my vision but I see more clearly what is in front of me) ☐
- Both (I can not see clearly what is in front of me so I need to enlarge, and I do not see clearly on the sides of my vision) ☐
- None ☐

B2. What is your ocular diagnosis?

- Retinal detachment ☐
- Diabetic Retinopathy ☐
- Retinopathy of Prematurity ☐
- Stargardt's Disease ☐
- Age Related Macular Degeneration ☐
- Leber's Disease ☐
- Glaucoma ☐
- Ocular Albinism ☐
- Cone Rod Dystrophy ☐
- Choroideremia ☐
- Other ☐

Other

B3. **When did your eye condition develop? (number of months or years that have elapsed since the development of your eye condition)**

- Less than 3 months ago ☐
- Less than 6 months ago ☐
- Between 6 months and 1 year ago ☐
- Between 1 and 2 years ago ☐
- Between 2 and 5 years ago ☐
- Between 5 and 10 years ago ☐
- More than 10 years ago ☐
- At birth ☐

B4. **Do you have another sensory impairment (example : deafness or other)?**

- Yes ☐
- No ☐

B5. **If yes at the previous question, please indicate : (you need to write in the boxes)**

which other sensory impairment ? ☐☐☐☐☐☐☐☐☐☐

when did it occur ? ☐☐☐☐☐☐☐☐☐☐

B6. **Do you have any memory or cognitive impairment?**

- Yes ☐
- No ☐

B7. **If yes at the previous question, please indicate : (you need to write in the boxes)**

which memory or other cognitive impairment ? ☐☐☐☐☐☐☐☐☐☐

when did it occur ? ☐☐☐☐☐☐☐☐☐☐

B8. **Do you have physical (motor) impairment?**

- Yes ☐
- No ☐

B9. **If yes at the previous question, please indicate : (you need to write in the boxes)**

which physical (motor) impairment ? ☐☐☐☐☐☐☐☐☐☐

when did it occur ? ☐☐☐☐☐☐☐☐☐☐

B10. In general, would you say that your overall health is :

- ☐ Excellent
- ☐ Very good
- ☐ Good
- ☐ Fair
- ☐ Poor

B11. Compared to 3 months ago, would you say that your overall health is :

- ☐ Much better now than three months ago
- ☐ Somewhat better now than three months ago
- ☐ About the same
- ☐ Somewhat worse now than three months ago
- ☐ Much worse now than three months ago

B12. During the 3 past months, have you had any of the following problems with your work or other regular daily activities as a result of your <u>physical health</u> (unrelated to your vision loss)?

	Yes	Uncertain	No
Cut down the amount of time you spent on work or other activities	☐	☐	☐
Accomplished less than you would like	☐	☐	☐
Were limited in the kind of work or other activities	☐	☐	☐
Had difficulty performing the work or other activities (for example, it took extra effort)	☐	☐	☐

B13. During the 3 past months, have you had any of the following problems with your work or other regular daily activities as a result of any <u>emotional problems</u> (such as feeling depressed or anxious)?

	Yes	Uncertain	No
Cut down the amount of time you spent on work or other activities	☐	☐	☐
Accomplished less than you would like	☐	☐	☐
Did not do work or other activities as carefully as usual	☐	☐	☐

B14. During the 3 past weeks,

	All of the time	Most of the time	A good bit of the time	Some of the time	None of the time
Did you have a lot of energy?	☐	☐	☐	☐	☐
Have you been a very nervous person?	☐	☐	☐	☐	☐

	All of the time	Most of the time	A good bit of the time	Some of the time	None of the time
Have you felt calm and peaceful?	☐	☐	☐	☐	☐
Have you felt downhearted and blue?	☐	☐	☐	☐	☐
Did you feel worn out?	☐	☐	☐	☐	☐
Did you feel tired?	☐	☐	☐	☐	☐

Section C: PART I : Quality of Life

The purpose of this part is to evaluate how satisfied you are with your eSight Eyewear and the related services you received. The questionnaire consists of 12 satisfaction items.

For each of the 12 items, rate your satisfaction with your esight Eyewear and the related services you received by using the following scale graduated from "not satisfied at all" to "very satisfied".

Please select the field that best describes your degree of satisfaction with each of the 12 items.

D**o not** leave any question unanswered.

C1. Regarding your eSight Eyewear...

How satisfied are you with,

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the dimensions (size, height, length, width) of your eSight?	☐	☐	☐	☐	☐
the weight of your eSight?	☐	☐	☐	☐	☐
the ease in adjusting (fixing, fastening) the parts of your esight?	☐	☐	☐	☐	☐
how safe and secure your eSight is?	☐	☐	☐	☐	☐
the durability (endurance, resistance to wear) of your eSight?	☐	☐	☐	☐	☐
how easy it is to use your eSight?	☐	☐	☐	☐	☐
how comfortable your eSight is?	☐	☐	☐	☐	☐
how effective your eSight is (the degree to which your device meets your needs)?	☐	☐	☐	☐	☐

C2. Regarding services...

How satisfied are you with,

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the service delivery program (procedures, length of time) in which you obtained your eSight?	☐	☐	☐	☐	☐

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the repairs and servicing (maintenance) provided for your eSight?	☐	☐	☐	☐	☐
the quality of the professional services (information, attention) you received for using your eSight?	☐	☐	☐	☐	☐
the follow-up services (continuing support services) received for your eSight?	☐	☐	☐	☐	☐

C3. **Below is t**
he list of the same 1
2 satisfaction items. PLEASE
SELECT THE THREE ITEMS
that you consider to be
the most important to you. Please select the 3 boxes of your choice.

- Dimensions ☐
- Weight ☐
- Adjustments ☐
- Safety ☐
- Durability ☐
- Easy to use ☐
- Comfort ☐
- Effectiveness ☐
- Service delivery ☐
- Repairs/servicing ☐
- Professional service ☐
- Follow-up services ☐

Section D: PART II : Satisfaction with your eSight Eyewear

D1. **Each word or phrase below describes how using an assistive device may affect you. Some may seem unusual but it is important that you answer every one of the 26 items. So, for each word or phrase please select the appropriate box to show how you are affected by using your eSight Eyewear. The boxes are graduated from "-3" (the level you feel affected decreases) and "+3" (the level you feel affected increases).**

	-3	-2	-1	0	+1	+2	+3
1. Competence	☐	☐	☐	☐	☐	☐	☐

	-3	-2	-1	0	+1	+2	+3
2. Happiness	☐	☐	☐	☐	☐	☐	☐
3. Independence	☐	☐	☐	☐	☐	☐	☐
4. Adequacy	☐	☐	☐	☐	☐	☐	☐
5. Confusion	☐	☐	☐	☐	☐	☐	☐
6. Efficiency	☐	☐	☐	☐	☐	☐	☐
7. Self-esteem	☐	☐	☐	☐	☐	☐	☐
8. Productivity	☐	☐	☐	☐	☐	☐	☐
9. Security	☐	☐	☐	☐	☐	☐	☐
10. Frustration	☐	☐	☐	☐	☐	☐	☐
11. Usefulness	☐	☐	☐	☐	☐	☐	☐
12. Self-confidence	☐	☐	☐	☐	☐	☐	☐
13. Expertise	☐	☐	☐	☐	☐	☐	☐
14. Skillfulness	☐	☐	☐	☐	☐	☐	☐
15. Well-being	☐	☐	☐	☐	☐	☐	☐
16. Capability	☐	☐	☐	☐	☐	☐	☐
17. Quality of life	☐	☐	☐	☐	☐	☐	☐
18. Performance	☐	☐	☐	☐	☐	☐	☐
19. Sense of power	☐	☐	☐	☐	☐	☐	☐
20. Sense of control	☐	☐	☐	☐	☐	☐	☐
21. Embarrassment	☐	☐	☐	☐	☐	☐	☐
22. Willingness to take chances	☐	☐	☐	☐	☐	☐	☐
23. Ability to participate	☐	☐	☐	☐	☐	☐	☐
24. Eagerness to try new things	☐	☐	☐	☐	☐	☐	☐
25. Ability to adapt to the activities of daily living	☐	☐	☐	☐	☐	☐	☐

	-3	-2	-1	0	+1	+2	+3
26. Ability to take advantage of opportunities	☐	☐	☐	☐	☐	☐	☐

Section E: PART III : How you currently use your eSight Eyewear

E1. Step 1: You and your eSight device

Which eSight device version do you own?

- ☐ eSight 2 (bought before April 2017)
- ☐ eSight 3 (bought after April 2017)

E2. When did you buy the eSight device?

- ☐ Less than 3 months ago
- ☐ Between 3 and 6 months ago
- ☐ Between 6 and 12 months ago
- ☐ Between 12 and 18 months ago
- ☐ Between 18- and 24 months ago
- ☐ More than 24 months ago

E3. When did you start using your eSight device?

- ☐ Less than 3 months ago
- ☐ Between 3 and 6 months ago
- ☐ Between 6 and 12 months ago
- ☐ Between 12 and 18 months ago
- ☐ Between 18 and 24 months ago
- ☐ More than 24 months ago

E4. If you started to use it more than 1 month after the purchase, please explain why in the box below?

E5. What is your frequency of utilization?

- Everyday ☐
- Between 2 and 3 a week ☐
- Between 4 and 5 a week ☐
- Once a week ☐
- Between 2 and 3 a month ☐
- Between 4 and 5 a month ☐
- Once a month ☐
- Less than once a month ☐

E6. What is the average consecutive time of your eSight device utilization?

- Less than half an hour ☐
- Between 30 minutes and 1 hour ☐
- Between 1 and 2 hours ☐
- Between 2 and 4 hours ☐
- Between 4 and 8 hours ☐
- More than 8 hours ☐

E7. When did you use your eSight device the last time?

- Today ☐
- Less than a week ago ☐
- During the past 4 weeks ☐
- Between 2 and 3 months ago ☐
- More than 3 months ago ☐

E8. If you did not use it for more than 3 months, please explain why in the box below?

E9. What is the nature of tasks for which the eSight device was purchased? (Check all that apply)

- Watching TV ☐

Reading books, Newspaper print, Typed letter… ☐

Shopping ☐

Getting around ☐

Using my computer ☐

Watching events (sports, church, theatre, etc...) ☐

Cooking ☐

Personal care (washing, makeup, etc...) ☐

Socializing with others ☐

Meetings, classrooms, etc... ☐

Other ☐

Other

E10. What is the nature of tasks for which the eSight device is <u>actually used</u>?

Watching TV ☐

Reading books, Newspaper print, Typed letter… ☐

Shopping ☐

Getting around ☐

Using my computer ☐

Watching events (sport, church, theatre, etc…) ☐

Cooking ☐

Personal care (washing, makeup, etc…) ☐

Socializing with others ☐

Meetings, classrooms, etc… ☐

I do not use my eSight device anymore. ☐

Other

Other

E11. What are the most effective activities for which you use the eSight device? (you need to write in the box below)

E12. For which activities is the eSight device not effective or useful? (you need to write in the box below)

E13. What activities are you disappointed the eSight device does not help you accomplish? (you need to write in the box below)

E14. How much is each of the following symptoms affecting you while or just after using the eSight?

	None	Slight	Moderate	Severe
General discomfort	☐	☐	☐	☐
Headache	☐	☐	☐	☐
Eyestrain	☐	☐	☐	☐
Nausea	☐	☐	☐	☐

	None	Slight	Moderate	Severe
Vertigo	☐	☐	☐	☐
Dizziness eyes open	☐	☐	☐	☐
Dizziness eyes closed	☐	☐	☐	☐
Vomiting	☐	☐	☐	☐

E15. STEP 2: eSight user's characteristics

Have you ever used an electronic video magnifier other than electronic eyewear (head-mounted display)?

Yes ☐

No ☐

E16. Have you ever used another type of electronic eyewear (head-mounted display) other than the eSight device?

Yes ☐

No ☐

E17. If you have used another type of electronic eyewear (head-mounted display) other than the eSight device, please indicate (you need to write in the box following each question) :

Which one(s)? ☐

How often? ☐

Why did you stop to use it? ☐

E18. Do you currently use several low vision aids?

Yes ☐

No ☐

E19. If your are using several low vision aids, please indicate which :

Table-top video magnifier ☐

Hand-held video magnifier ☐

Magnifier software ☐

Special glasses ☐

Hand-held telescope for distance ☐

Hand-held optical magnifier for reading ☐

Smartphone or tablet computer as low vision aid ☐

Cane ☐

Other ☐

Other

E20. To what extent have you adapted to your visual handicap?

Not at all ☐

Slightly ☐

Moderately ☐

Quit a bit ☐

Extremely ☐

E21. During the 3 past months, to what extent has your visual condition worsened?

Not at all ☐

Slightly ☐

Moderately ☐

Quit a bit ☐

Extremely ☐

Other ☐

Other

E22. Do you enjoy using the eSight device?

Not at all ☐

Slightly ☐

Moderately ☐

Quite a bit ☐

Extremely ☐

E23. **Regarding the previous question, explain why? (you need to write in the box below) (Optional)**

E24. **To what extent have you been disappointed using the eSight device?**

- Not at all ☐
- Slightly ☐
- Moderately ☐
- Quit a bit ☐
- Extremely ☐

E25. **Regarding the previous question, please explain why? (you need to write in the box below) (Optional)**

E26. **In general, to what extent do you think the eSight is right for you?**

- 0: Not at all ☐
- 1: Slightly ☐
- 2: Moderately ☐
- 3: Quit a bit ☐
- 4: Extremely ☐

E27. **To what extent do you think you have the ability to control your usage of the eSight?**

- 0: Not at all ☐
- 1: Slightly ☐
- 2: Moderately ☐
- 3: Quit a bit ☐
- 4: Extremely ☐

E28. How did you finance the eSight device?

- [ ] Self pay
- [ ] Family
- [ ] Donation
- [ ] Public government
- [ ] Agency
- [ ] Borrowed
- [ ] Rented
- [ ] Other, please indicate :
- [ ] Other

Other

E29. STEP 3: eSight use changes

To what extent do you consider you have integrated the eSight device into your life?

- [ ] Not at all
- [ ] Slightly
- [ ] Moderately
- [ ] Quit a bit
- [ ] Extremely

E30. Regarding the previous question, what are the reasons? (you need to write in the box below) (Optional)

E31. Have you have completely stopped using the eSight device?

- [ ] Yes
- [ ] No

E32. **If you have completely stopped using the eSight device, please write in the box following each question :**

Since when? ☐

What are the reasons? (optional) ☐

E33. **Overall, do you now use the eSight device more or less than at the beginning?**

More ☐

Less ☐

Same ☐

E34. **If you now use the eSight device less than at the beginning, please write in the box following each question :**

Since when? ☐

What are the reasons? (optional) ☐

E35. **Have you reduced using the eSight device for certain tasks?**

Yes ☐

No ☐

E36. **If you have reduced using the eSight device for certain tasks, please write in the box following each question :**

Since when? ☐

What are the reasons? (optional) ☐

E37. **Have you stopped using the eSight device for certain tasks?**

Yes ☐

No ☐

E38. **If you have stopped using the eSight device for certain tasks, please write in the box following each question :**

For which one? ☐

Since when? ☐

What are the reasons? (optional) ☐

E39. **Do you use the eSight device for new tasks that you did not expect before buying?**

Yes ☐

No ☐

E40. **If you use the eSight device for new tasks that you did not expect before buying, please write in the box following each question :**

Since when? ☐

What are the reasons if any? ☐

E41. Part 4: Social and physical environment

Who made the choice to buy your eSight device?

Yourself ☐

Family, friends ☐

Clinician (Ophthalmologist, Optometrist, Specialist in low vision…) ☐

Other ☐

Other

E42. Do your family or friends encourage you to wear the eSight device?

All of the time ☐

Most of the time ☐

A good bit of the time ☐

Some of the time ☐

A little of the time ☐

None of the time ☐

E43. Does your family help you to carry out activities of daily living?

All of the time ☐

Most of the time ☐

A good bit of the time ☐

Some of the time ☐

A little of the time ☐

None of the time ☐

E44. **To what extent do you think that the majority of people that are close to you think you should use the eSight?**

- 0: Not at all ☐
- 1: Slightly ☐
- 2: Moderately ☐
- 3: Quit a bit ☐
- 4: Extremely ☐

E45. **Have elements in the physical environment (architecture, infrastructure, public transports,...) ever influenced your use of eSight?**

- Yes ☐
- No ☐

E46. **If you have elements in the physical environment that have ever influenced your use of eSight, please write which one in the box below :**

E47. **Have you ever felt a reaction from people around you towards your eSight device?**

- Yes ☐
- No ☐

E48. **If you have ever felt a reaction from people around you towards your eSight device, please write in the box following each question :**

- The type of reaction? ☐
- Has this reaction led to a change in the use of your eSight in a social setting? ☐

E49. **Have strangers ever asked you about your eSight device?**

- Yes ☐
- No ☐
- No answer ☐

E50. **If yes, please write in the box following each question :**

- If it was a positive or negative response? ☐
- What were their and your reactions? ☐

E51. STEP 5: Training/Intervention

Have you received vision rehabilitation services?

- [ ] Yes
- [ ] No

E52. Who introduced you to the eSight device?

- [ ] Clinician (Ophthalmologist, Optometrist, Specialist in low vision…)
- [ ] Family or friends
- [ ] Advertising, social media
- [ ] Associations
- [ ] Other

Other

E53. Would you have prefered it to be another person?

- [ ] Yes
- [ ] No

E54. If you would have prefered it to be another person, please indicate who?

- [ ] Clinician (Ophthalmologist, Optometrist, Specialist in low vision…)
- [ ] Family or friends
- [ ] Advertising, social media
- [ ] Associations
- [ ] Other

Other

E55. **If you would you have prefered it to be another person, what are the reasons? (please write in the box below) (optional)**

E56. **Regarding the training program proposed by eSight (eSkills), to what extent would you consider it helpful?**

- Very useful ☐
- Moderately useful ☐
- Slightly useful ☐
- Not useful ☐

E57. **Can you explain your choice regarding the "helpful" aspect? (Please write in the box below) (Optional)**

E58. **Regarding the training program proposed by eSight (eSkills), are you satisfied with this training program?**

- Very satisfied ☐
- Satisfied ☐
- Moderately satisfied ☐
- Not satisfied at all ☐
- No answer ☐

E59. **Can you please explain your choice regarding the satisfaction with this training program? (you need to write in the box below) (Optional)**

E60. **Have you completed the training program (eSkills)?**

- Entirely ☐
- Half ☐
- More than the half ☐
- Not at all ☐

E61. **If you have not entirely completed the training program, please explain why? (you need to write in the box below)**

E62. **Who or what contributed the most to your training, please write the reasons if any in the boxes following the items?**

- Yourself ☐
- Clinicians ☐
- Professional from eSight ☐
- eSkills program from eSight ☐
- Family ☐
- Friends ☐
- Other, please indicate : ☐

E63. **Ideally, who or what should have contributed the most to your training, please write the reasons if any in the boxes following the items?**

- Yourself ☐
- Clinicians ☐
- Professional from eSight ☐

eSkills program from eSight ☐

Family ☐

Friends ☐

Other, please indicate : ☐

No answer ☐

E64. Are you satisfied with the eSight device follow-up service?

All of the time ☐

Most of the time ☐

A good bit of the time ☐

Some of the time ☐

A little of the time ☐

None of the time ☐

E65. Is there anything else we did not ask you that you wish you would have asked you? (Please write in the box follow)

Yes ☐

No ☐

E66. If there is anything else we did not ask you that you wish we would have asked you, please write in the box below :

E67. You have the option of receiving a summary of the survey results once the study is complete, and including your name for a $20 Starbucks gift card for your participation, as well as including your name in a draw for a $100 Amazon gift card. Check all that apply, and enter your name and your e-mail address (if applicable) (This will not be utilized to link you to your individual survey response in any way.)

I would like to receive a summary sheet of the survey results once the study is complete, my name and my e-mail address are (please write in the box) : ☐

I would like to receive a 20$ Starbucks gift card for your participation and to be entered into a draw for a 100 dollars gift card (to Amazon store), my name and my e-mail address are (please write in the box if it has not already done) : ☐

You have now completed all the questions, thank you for your participation.

Supplementary Table S9: Grouping of the questions of the survey into families and selection for statistical analyses

	Personal factors
1	Age
2	Gender
3	Are you currently a car driver?
4	City
5	Country
6	Subject's employment/study situation
7	Subject's accomodations
8	Level of study
9	Do you have a restriction of your visual field?
10	What is your ocular diagnosis?
11	When did your eye condition develop? (number of months or years that have elapsed since the development of your eye condition)
12	Do you have another sensory impairment (example : deafness or other)?
13	If yes at the previous question, please indicate :
	which other sensory impairment ?
	when did it occur ?
14	Do you have any memory or cognitive impairment?
15	If yes at the previous question, please indicate :
	which memory or other cognitive impairment ?
	when did it occur ?
16	Do you have physical (motor) impairment?
17	If yes at the previous question, please indicate :
	which physical (motor) impairment ?
	when did it occur ?
18	In general, how is your overall health?
19	Compared to 3 months ago, how is your overall health?
20	During the 3 past months, have you had any of the following problems with your work or other regular daily activities as a result of your physical health (unrelated to your vision loss)?
21	During the 3 past months, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?
22	During the 3 past weeks,
	Did you have a lot of energy?
	Have you been a very nervous person?
	Have you felt calm and peaceful?
	Have you felt downhearted and blue?
	Did you feel worn out?
	Did you feel tired?
23	PIADS questionnaire
24	When did you buy the eSight device?
25	When did you start using your eSight device?
26	If you started to use it more than 1 month after the purchase, please explain why?
27	What is your frequency of utilization?
28	What is the average consecutive time of your eSight device utilization?
29	When did you use your eSight device the last time?
30	If you did not use it for more than 3 months, please explain why?
31	What is the nature of tasks for which the eSight device was purchased? (Check all that apply)
32	What is the nature of tasks for which the eSight device is actually used?
33	What are the most effective activities for which you use the eSight device?
34	For which activities is the eSight device not effective or useful?
35	What activities are you disappointed the eSight device does not help you accomplish?
36	Have you ever used an electronic video magnifier other than electronic eyewear (head-mounted display)?
37	Have you ever used another type of electronic eyewear (headmounted display) other than the eSight device?
38	If you have used another type of electronic eyewear (head-mounted display) other than the eSight device, please indicate:
39	Do you currently use several low vision aids?
40	If your are using several low vision aids, please indicate which one(s).

41	To what extent have you adapted to your visual handicap?
42	During the 3 past months, to what extent has your visual condition worsened?
43	Do you enjoy using the eSight device?
44	Regarding the previous question, explain why? (you need to write in the box below) (Optional)
45	To what extent have you been disappointed using the eSight device?
46	Regarding the previous question, please explain why? (you need to write in the box below) (Optional)
47	In general, to what extent do you think the eSight is right for you?
48	To what extent do you think you have the ability to control your usage of the eSight?
49	How did you finance the eSight device?
50	To what extent do you consider you have integrated the eSight device into your life?
51	Regarding the previous question, what are the reasons? (Optional)
52	Have you have completely stopped using the eSight device?
53	If you have completely stopped using the eSight device, please write in the box following each question :
54	Overall, do you now use the eSight device more or less than at the beginning?
55	If you now use the eSight device less than at the beginning, please write in the box following each question :
	Since when?
	What are the reasons? (optional)
56	Have you reduced using the eSight device for certain tasks?
57	If you have reduced using the eSight device for certain tasks, please write in the box following each question :
	Since when?
	What are the reasons? (optional)
58	Have you stopped using the eSight device for certain tasks?
59	If you have stopped using the eSight device for certain tasks, please write in the box following each question :
	For which one?
	Since when?
	What are the reasons? (optional)
60	Do you use the eSight device for new tasks that you did not expect before buying?
61	If you use the eSight device for new tasks that you did not expect before buying, please write in the box following each question :
	Since when?
	What are the reasons if any?
	Device related factors
62	Which eSight device version do you own?
63	QUEST questionnaire
64	How much general discomfort affecting you while or just after using the eSight?
65	How much headache affecting you while or just after using the eSight?
66	How much eyestrain affecting you while or just after using the eSight?
67	How much nausea affecting you while or just after using the eSight?
	Social and physical environment factors
68	Subjects living arrangement
69	Who made the choice to buy your eSight device?
70	Do your family or friends encourage you to wear the eSight device?
71	Does your family help you to carry out activities of daily living?
72	To what extent do you think that the majority of people that are close to you think you should use the eSight?
73	Have elements in the physical environment (architecture, infrastructure, public transports,...) ever influenced your use of eSight?
74	If you have elements in the physical environment that have ever influenced your use of eSight, please write which one in the box below
75	Have you ever felt a reaction from people around you towards your eSight device?
76	If you have ever felt a reaction from people around you towards your eSight device, please write in the box following each question :
	The type of reaction?
	Has this reaction led to a change in the use of your eSight in a social setting?
77	Have strangers ever asked you about your eSight device?
78	If yes, please write in the box following each question :
	If it was a positive or negative response?
	What were their and your reactions?
	Training/Intervention
79	Have you received vision rehabilitation services?
80	Who introduced you to the eSight device?
81	Would you have prefered it to be another person?

82	If you would have prefered it to be another person, please indicate who?
83	If you would you have prefered it to be another person, what are the reasons?
84	Regarding the training program proposed by eSight (eSkills), to what extent would you consider it helpful?
85	Can you explain your choice regarding the "helpful" aspect? (Optional)
86	Regarding the training program proposed by eSight (eSkills), are you satisfied with this training program?
87	Can you please explain your choice regarding the satisfaction with this training program?
88	Have you completed the training program (eSkills)?
89	If you have not entirely completed the training program, please explain why?
90	Who or what contributed the most to your training, please write the reasons if any?
91	Ideally, who or what should have contributed the most to your training, please write the reasons if any?
92	Are you satisfied with the eSight device follow-up service?
93	Is there anything else we did not ask you that you wish you would have asked you?
94	If there is anything else we did not ask you that you wish we would have asked you, please write in the box:

included in the analyses because based on litterature or for explanatory reasons (independent variables)

dependant variable for logistic regression analysis

only for descriptiive statistics

not included because did meet the requirements for logistic regression methods (incomplete information, complete separation, multicollinearity)

Supplementary Tables S10: Logistic regression analyses

Table: Summary statistics for the 1st step logistic regression analyses in personal variables

Variables Included		95% CI for Exp(B)				
		B(SE)	Lower	Exp(B)	Upper	p value
Demographic						
Block 1						
Sex	Female			Reference		
	Male	0.331 (0.546)	0,478	1,393	4,057	0,544
Education						0,473
	Primary school graduate			Reference		
	Secondary school graduate	0.929 (0.760)	0,571	2,532	11,219	0,221
	Postsecondary school graduate	0.576 (0.769)	0,394	1,779	8,037	0,454
Age		0.0221 (0.013)	0,995	1,779	1,048	0,454
Constant		-0.064 (0.650)		0,938		0,922
Variables entered: Sex, Education and Age						
Omnibus Tests of Model Coefficients : **p = 0.123**						
Model Summary: Nagelkerke R Square: 0.107; -2 Log likelihood= 93.602						
Ocular condition						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.024 (0.013)	0,999	1,024	1,049	0,062
Sex	Female			Reference		
	Male	0.349 (0.542)	0,491	1,418	4,1	0,519
Ocular diagnosis						0,866
	Central			Reference		
	Peripheral	0.10 (1.230)	0,091	1,010	11,261	0,993
	General	-0.313 (0.606)	0,223	0,731	2,398	0,606
Eye disease beginning	> 10 years			Reference		
	6 months- 5 years	0.057 (0.866)	0,194	1,059	5,779	0,947
Vision evolution had worsed						0,949
	Not at all			Reference		
	Slightly	-0.205 (0.638)	0,233	0,814	2,843	0,747
	Moderately to Extremely	-0.074 (0.760)	0,21	0,929	4,116	0,922
Constant		0.607 (0.830)		1,835		0,465
Variables entered : Sex, Age, Ocular diagnosis, Eye disease beginning and Vision evolution						
Omnibus Tests of Model Coefficients : **p = 0.525**						
Model Summary: Nagelkerke R Square: 0.091; -2 Log likelihood= 94.731						
General health						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.031 (0.012)	1,007	1,031	1,057	0,012
Sex	Female			Reference		
	Male	0.324 (0.696)	0,480	1,383	3,981	0,548
Other impairment	No			Reference		
	Yes	0.855 (0.696)	0,601	2,352	9,205	0,219
General healh	Fair to Poor			Reference		
	Good to Excellent	1.557 (0.871)	0,861	4,743	26,132	0,074
Constant		-1.489 (1.136)		0,226		0,19
Variables entered: Sex, Age, Other impairment and General health						
Omnibus Tests of Model Coefficients : **p = 0.052**						
Model Summary: Nagelkerke R Square: 0.137; -2 Log likelihood=91.453						
Low vision aids experience						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.026 (0.012)	1,004	1,027	1,050	0,023
Sex	Female			Reference		
	Male	0.421 (0.547)	0,521	1,523	4,454	0,442
Magnifier utilization	No			Reference		
	Yes	0.116 (0.590)	0,353	1,123	3,570	0,844

Use of another HMD type	No			Reference		
	Yes	-0.852 (0.854)	0,08	0,426	2,273	0,318
Constant		0.293 (0.636)		1,341		0,645
Variables entered: Sex, Age, Magnifier utilization and Use of another HMD type						
Omnibus Tests of Model Coefficients : **p = 0.150**						
Model Summary: Nagelkerke R Square = 0.099; -2 Log likelihood = 94.119						
Material resources						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.026 (0.110)	1,004	1,026	1,050	0,023
Sex	Female			Reference		
	Male	0.332 (0.532)	0,491	1,393	3,951	0,533
Multiple LVAs	No			Reference		
	Yes	-0.121 (0.766)	0,255	0,886	3,073	0,848
Constant		0.397 (0.766)		1,487		0,605
Variables entered: Sex, Age, Magnifier utilization and Multiple LVAs						
Omnibus Tests of Model Coefficients : **p = 0.123**						
Model Summary: Nagelkerke R Square = 0.086; -2 Log likelihood = 95.082						
Psychological aspects						
Block 1						
Age		0.026 (0.11)	1,004	1,026	1,050	0,023
Sex	Female			Reference		
	Male	0.281 (0.532)	0,467	1,325	3,760	0,597
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.056**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 94.311						
Block 2						
Age		0.206 (0.091)	1,028	1,229	1,470	0,024
Sex	Female			Reference		
	Male	6.698 (3.471)	0,901	810,848	44,758	729827,573
PIADS total		0.163 (0.068)	1,031	1,177	1,343	0,016
Ability to control eSight						0,375
	Not at all to Slightly			Reference		
	Moderately	5.906 (4.220)	0,094	367,000	1436088,3	0,162
	Quite a bit to extremely	1.779 (2.112)	0,094	5,922	372,052	0,400
People think eSight is good for you						0,345
	Not at all			Reference		
	Slightly	16.914 (8.5620	1,142	22164457	4,30E+14	0,048
	Moderately	12.425 (6.908)	0,328	248878	1,89E+11	0,072
	Quit a bit	13.049 (7.565)	0,955	464500	2,26E+11	0,051
	Extremely	15.185 (7.565)	1,432	3935203	1,08E+13	0,045
eSight is right for you						
	Not at all to Slightly			Reference		
	Moderately	5.028 (2.376)	1,45	152,690	16082,10	0,034
	Quite a bit to extremely	5.224 (3.003)	0,516	185,747	66899,339	0,082
Constant		-41.565 (18.091)		0,000		0,022
Variables entered: Sex, Age, Ability to control eSight, People think eSight is good for you and eSight is right for you						
Omnibus Tests of Model Coefficients : **p < 001**						
Model Summary: Nagelkerke R Square = 0.821; -2 Log likelihood = 26.133						

None of the predictor variables were significantly correlated.

Table: Summary statistics for the 1sr step logistic regression analyses in device variables

Variables Included		95% CI for Exp(B)				
		B(SE)	Lower	Exp(B)	Upper	p value
Device objective factors						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.29 (0.014)	1,001	1,029	1,059	0,043
Sex	Female			Reference		
	Male	1.111 (0.832)	0,594	3,036	15,515	0,182
QUEST		0.220 (0.57)	1,115	1,246	1,392 < 0.001	
eSight version	eSight 2			Reference		
	eSight 3	1.059 (0.735)	0,682	2,882	12,174	0,150

Constant		-6497 (1.787)		0,002		< 0.001
Variables entered: Sex, Age, QUEST and eSight version Omnibus Tests of Model Coefficients : **p < 001** Model Summary: Nagelkerke R Square = 0.595; -2 Log likelihood = 52.367						
Device subjective factors						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057** Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.020 (0.013)	0,993	1,02	1,047	0,14
Sex	Female			Reference		
	Male	0.16 (0.623)	0,300	1,016	3,443	0,980
General discomfort	None to slight			Reference		
	Moderate to severe	-1.694 (0.646)	0,052	0,184	0,652	0,009
Headache	None to slight			Reference		
	Moderate to severe	-2.090 (0.825)	0,025	0,124	0,624	0,011
Eyestrain	None to slight			Reference		
	Moderate to severe	1.547 (0.845)	0,896	4,686	24,61	0,067
Constant		1.802 (0.838)		6,063		0,032
Variables entered: Sex, Age, General discomfort , Headache and Eyestrain Omnibus Tests of Model Coefficients : **p < 001** Model Summary: Nagelkerke R Square = 0.347; -2 Log likelihood = 75.271						
None of the predictor variables were significantly correlated.						

Table: Summary statistics for the 1sr step logistic regression analyses in environment variables

Variables Included		B(SE)	95% CI for Exp(B) Lower	Exp(B)	Upper	p value
Social envronmental factors						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057** Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.0409 (0.014)	1,012	1,041	1,071	0,005
Sex	Female			Reference		
	Male	0.839 (0.620)	0,686	3,313	7,801	0,176
Person who choiced the eSight	Yourself			Reference		
	Family/friends	0.286 (0.773)	0,293	1,331	6,052	0,712
Living arrangement	Alone			Reference		
	Not alone	-1.627 (1.227)	0,018	0,196	2,178	0,185
Family/friends encouragement	No			Reference		
	Yes	1.528 (0.760)	1,040	4,607	20,416	0,044
Family carry ADL						0,514
	None of the time			Reference		
	Little to Some of the time	-0.772 (0.982)	0,067	0,462	3,167	0,432
	A good bit to All of the time	-0.67 (0.993)	0,134	0,935	6,541	0,946
People reaction	No			Reference		
	Yes	1.951 (0.676)	1,869	7,033	26,471	0,004
Constant		-1.116 (1.690)		0,328		0,509
Variables entered: Sex, Age, Person who choiced the eSight, Living arrangement, Family/friends encouragement, Family carry ADL and People recation Omnibus Tests of Model Coefficients : **p = 005** Model Summary: Nagelkerke R Square = 0.301; -2 Log likelihood = 79.007						
Physical envronmental factors						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057** Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.029 (0.012)	1,006	1,029	1,053	0,013
Sex	Female			Reference		
	Male	0.539 (0.558)	0,575	1,715	5,116	0,333
Physical environment interfere	No			Reference		
	Yes	1.467 (0.815)	0,877	4,335	21,413	0,072
Constant		-0.183 (0.644)		0,833		0,777
Variables entered: Sex, Age and Physical environment interfere						

Omnibus Tests of Model Coefficients : **p = 019**						
Model Summary: Nagelkerke R Square = 0.144; -2 Log likelihood = 90.913						
None of the predictor variables were significantly correlated.						

Table: Summary statistics for the 1sr step logistic regression analyses with interventional variables

Variables Included		95% CI for Exp(B)				
		B(SE)	Lower	Exp(B)	Upper	p value
LV rehabilitation experience						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.0409 (0.014)	1,005	1,041	1,052	0,005
Sex	Female			Reference		
	Male	0.839 (0.620)	0,490	3,313	3,944	0,176
LV rehab	No			Reference		
	Yes	0.396 (0.537)	0,519	1,486	4,253	0,460
Constant		0.031 (0.690)		1,031		0,965
Variables entered: Sex, Age and LV rehab						
Omnibus Tests of Model Coefficients : **p = 0.098**						
Model Summary: Nagelkerke R Square = 0.093; -2 Log likelihood = 94.569						
Training with eSkills						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.023 (0.012)	1,000	1,023	1,048	0,055
Sex	Female			Reference		
	Male	0.552 (0.580)	0,557	1,737	5,411	0,341
eSkills is helpful	No			Reference		
	Yes	2.074 (1.105)	0,912	7,953	69,369	0,061
eSkills is completed						0,607
	Not at al			Reference		
	Not entirely	0.512 (1.073)	0,204	1,669	13,671	0,633
	Entirely	-0,296 (0.843)	0,143	0,744	3,88	0,725
Constant		-1.448 (1.011)		0,235		0,152
Variables entered: Sex, Age, eSkills is helpful and eSkills is completed						
Omnibus Tests of Model Coefficients : **p = 034**						
Model Summary: Nagelkerke R Square = 0.174; -2 Log likelihood = 88.770						
Follow-up service						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : **p = 0.057**						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.036 (0.014)	1,009	1,036	1,065	0,01
Sex	Female			Reference		
	Male	0.841 (0.656)	0,641	2,318	8,382	0,200
Satisfaction with eSight follow-up service						< 0.001
	None of the time			Reference		
	Little to Some of the time	2.575 (1.018)	1,788	13,134	96,491	0,011
	A good bit to All of the time	3.106 (0.765)	4,988	22,326	99,939	< 0.001
Constant		-2.647 (1.062)		0,071		0,013
Variables entered: Sex, Age and Satisfaction with eSight follow-up service						
Omnibus Tests of Model Coefficients : **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.346; -2 Log likelihood = 75.299						
None of the predictor variables were significantly correlated.						

Table: Summary statistics for the 1st step logistic regression analyses with Personal model

Variables Included		B(SE)	95% CI for Exp(B) Lower	Exp(B)	Upper	p value
Personal-related Model						
Block 1						
Age		0.026 (0.11)	1,004	1,026	1,050	0,023
Sex	Female			Reference		
	Male	0.281 (0.532)	0,467	1,325	3,760	0,597
Constant		0.296 (0.586)		1,345		0,613
Omnibus Tests of Model Coefficients : p=0.053						
Model Summary: Nagelkerke R Square: 0.086; -2 Log likelihood= 94.311						
Block 2						
Age		0.133 (0.054)	1,027	1,143	1,271	0,014
Sex	Female			Reference		
	Male	3.621 (2.071)	0,645	37,384	2167,262	0,080
PIADS		0.134 (0.051)	1,035	1,144	1,264	0,009
eSight is right for you						0,085
	Not at all to Slightly			Reference		
	Moderately	4.387 (1.984)	1,647	80,419	3927,126	0,027
	Quite a bit to extremely	3.120 (1.770)	0,706	22,646	726,853	0,078
People think eSight is good for you						0,203
	Not at all			Reference		
	Slightly	9.562 (4.424)	2,436	14213,829	8,29E+07	0,031
	Moderately	5.913 (3.200)	0,699	369,647	195600	0,065
	Quit a bit	7.317 (3.348)	2,128	1505,627	1,07E+06	0,029
	Extremely	8.109 (3.393)	4,304	3324,277	2,57E+06	0,017
Constant		-26.769 (10.302)		<0.001		0,009
Variables entered: Sex, Age, PIADS, eSight is right for you, People think esight is right for you and Health condition						
Omnibus Tests of Model Coefficients : **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.801; -2 Log likelihood = 28.743						

None of the predictor variables were significantly correlated.

Table: Summary statistics for the 1st step logistic regression analyses with Device-related model

Variables Included		B(SE)	95% CI for Exp(B) Lower	Exp(B)	Upper	p value
Device-related Model						
Block 1						
Age		0.026 (0.110)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : p=0.057						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.028 (0.016)	0,997	1,029	1,061	0,077
Sex	Female			Reference		
	Male	1.160 (0.925)	0,520	3,19	19,553	0,21
General discomfort	No			Reference		
	Yes	0.128 (0.834)	0,221	1,137	5,831	0,878
Headache	No			Reference		
	Yes	-1.726 (0.862)	0,033	0,178	0,964	0,046
QUEST		0.297 (0.077)	1,157	1,346	1,566	<0.001
Constant		-6.260 (2.315)		0,002		0,007
Variables entered: Sex, Age, General discomfort, Headache and QUEST						
Omnibus Tests of Model Coefficients : **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.624; -2 Log likelihood = 49.373						

None of the predictor variables were significantly correlated.

Table: Summary statistics for the 1st step logistic regression analyses with Environment-related model

Variables Included		B(SE)	95% CI for Exp(B) Lower	Exp(B)	Upper	p value
Environment-related Model						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : p=0.057						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.040 (0.014)	1,014	1,041	1,069	0,003
Sex	Female			Reference		
	Male	0.886 (0.611)	0,733	2,426	8,029	0,147
Family/friend encouragement	No			Reference		
	Yes	1.368 (0.715)	0,967	3,926	15,942	0,056
People reaction	No			Reference		
	Yes	1.529 (0.618)	1,374	4,614	15,489	0,013
Environment interference	No			Reference		
	Yes	0.990 (0.847)	0,512	2,693	14,173	0,242
Constant		-2.734 (1.137)		0,065		0,016
Variables entered: Sex, Age, Family/friend encouragement, People reaction and Environment interference						
Omnibus Tests of Model Coefficients : **p = 0.001**						
Model Summary: Nagelkerke R Square = 0.284; -2 Log likelihood = 80.351						

None of the predictor variables were significantly correlated.

Table: Summary statistics for the 1st step logistic regression analyses with Intervention-related model

Variables Included		B(SE)	95% CI for Exp(B) Lower	Exp(B)	Upper	p value
Intervention-related Model						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : p=0.057						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.035 (0.014)	1,008	1,036	1,065	0,013
Sex	Female			Reference		
	Male	0.883 (0.675)	0,644	2,418	9,082	0,191
eSkills is helpful	No			Reference		
	Yes	0.357 (1.143)	0,152	1,429	13,435	0,755
Follow-up service satisfaction						0,001
	None of the time			Reference		
	Little to Some of the time	2.493 (1.046)	1,558	12,100	93,958	0,017
	A good bit to All of the time	2.997 (0.835)	3,899	20,029	102,884	<0.001
Constant		-2.877 (1.311)		0,056		0,280
Variables entered: Sex, Age, eSkills is helpful and Follow-up service satisfaction						
Omnibus Tests of Model Coefficients : **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.347; -2 Log likelihood = 75.202						

None of the predictor variables were significantly correlated.

Table: Summary statistics for the 2nd step logistic regression analyses with personal and device factors

Variables Included		95% CI for Exp(B)				
		B(SE)	Lower	Exp(B)	Upper	p value
Personal-Device Model						
Block 1						
Age		0.026 (0.11)	1,004	1,026	1,050	0,023
Sex	Female			Reference		
	Male	0.281 (0.532)	0,467	1,325	3,760	0,597
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : p=0.056						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 94.311						
Block 2						
Age		0.301 (0.156)	0,995	1,351	1,834	0,054
Sex	Female			Reference		
	Male	8.425 (4.665)	0,488	4561,489	42655640,7	0,071
People think eSight is good for you						0,270
	Not at all			Reference		
	Slightly	27.197 (12.557)		6,48E+11		0,030
	Moderately	17.088 (7.861)		26378141,1		0,030
	Quit a bit	22.625 (10.333)		6,70E+09		0,029
	Extremely	25.555 (11.859)		1,26E+14		0,031
eSight is right for you						0,448
	Not at all to Slightly			Reference		
	Moderately	7.033 (5.550)		1133,384		0,205
	Quite a bit to extremely	3.539 (3.255)		34,421		0,277
PIADS		0.322 (0.170)		1,380		0,058
Headache	No			Reference		
	Yes	-7.519 (3.767)		1843,388		0,046
QUEST		0.424 (0.270)		1,528		0,116
Constant		-80.543 (36.610)		< 0.001		0,028
Variables entered: Sex, Age, People think eSight is good for you, eSight is right for you, PIADS, Headache and QUEST						
Omnibus Tests of Model Coefficients : **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.901; -2 Log likelihood = 15.307						

None of the predictor variables were significantly correlated.

Table: Summary statistics for the 2nd step logistic regression analyses with environment and intervention factors

Variables Included		95% CI for Exp(B)				
		B(SE)	Lower	Exp(B)	Upper	p value
Environment-Intervention Model						
Block 1						
Age		0.026 (0.11)	1,003	1,026	1,049	0,024
Sex	Female			Reference		
	Male	0.336 (0.531)	0,494	1,400	3,964	0,527
Constant		0.303 (0.586)		1,353		0,605
Omnibus Tests of Model Coefficients : p=0.057						
Model Summary: Nagelkerke R Square: 0.085; -2 Log likelihood= 95.119						
Block 2						
Age		0.051 (0.016)	1,02	1,052	1,086	0,001
Sex	Female			Reference		
	Male	1.277 (0.714)	0,884	3,585	14,536	0,074
Family/friend encouragement	No			Reference		
	Yes	1.420 (0.900)	0,709	4 136	24,143	0,115
People reaction	No			Reference		
	Yes	1.933 (0.701)	1,749	6,909	27,297	0,006
Follow-up service satisfaction						0,001
	None of the time			Reference		
	Little to Some of the time	2.945 (1.125)	2,095	19,010	172,483	0,009
	A good bit to All of the time	3.261 (0.861)	4,820	26,071	141,008	< 0.001
Constant		-5.852 (1.680)		0,003		< 0.001
Variables entered: Sex, Age, Family/friend encouragement, People reaction and Follow-up service satisfaction						
Omnibus Tests of Model Coefficients : **p < 0.001**						
Model Summary: Nagelkerke R Square = 0.483; -2 Log likelihood = 63.329						

None of the predictor variables were significantly correlated.

Supplementary S11: Initial Questionnaire for Study 3

Section A: Demographic condition

A1. Name and firstname

A2. Age

A3. Gender

- Female ☐
- Male ☐

A4. City

A5. Country

A6. Subject's employment/study situation

- Employed ☐
- Student ☐
- Unemployed ☐
- Retired ☐

A7. Subject's accomodations

- House ☐
- Apartment ☐
- Townhouse ☐
- Living/Retirement Community ☐
- Nursing Home ☐

Other ☐

Other

A8. Subjects living arrangement

With spouse/companion ☐

With children ☐

With sibling or other relatives ☐

With parents ☐

Other ☐

Other

A9. Level of study

Elementary School (up to 8th grade) ☐

Secondary school (completion of high school) ☐

Postsecondary school (university) ☐

A10. Which eSight device version do you own? Please choose only one of the following:

eSight 2 (i.e., old version) ☐

eSight 3 (i.e., new version) ☐

A11. User type. Are you :

a renter of the eSight eyewear (at-home trial) ☐

a buyer of the eSight eyewear (sale) ☐

A12. What is the nature of tasks for which the eSight device was purchased/rented?

Watching TV ☐

Reading books, Newspaper print, Typed letter… ☐

Shopping ☐

Getting around ☐

Using my computer ☐

Watching events (sports, church, theatre, etc...) ☐

Cooking ☐

Personal care (washing, makeup, etc...) ☐

Socializing with others ☐

Meetings, classrooms, etc... ☐

Other ☐

Other

Section B: Health condition

B1. At the present time, would you say your eyesight using both eyes (with glasses or with your assistive device other than your eSight device) is:

Excellent ☐

Good ☐

Fair ☐

Poor ☐

Very Poor ☐

Completely Blind ☐

B2. Do you have a restriction of your visual field?

Central field loss (I can not see clearly what is in front of me so I need to enlarge, and I see better using the sides of my vision) ☐

Peripheral field loss (I do not see clearly on the sides of my vision but I see more clearly what is in front of me) ☐

Both (I can not see clearly what is in front of me so I need to enlarge, and I do not see clearly on the sides of my vision) ☐

None None ☐

B3. What is your ocular diagnosis?

Retinal detachment ☐

Diabetic Retinopathy ☐

Retinopathy of Prematurity ☐

Stargardt's Disease ☐

Age Related Macular Degeneration ☐

Leber's Disease ☐

Glaucoma ☐

Optic atrophy or hypophasia ☐

Ocular Albinism ☐

Cone Rod Dystrophy ☐

Choroideremia ☐

Other ☐

Other

B4. When did your eye condition develop? (number of months or years that have elapsed since the development of your eye condition)

Less than 6 months ago ☐

Between 6 months and 2 years ago ☐

Between 2 and 10 years ago ☐

More than 10 years ago ☐

At birth ☐

B5. Do you have another sensory impairment (example : deafness or other)?

Yes ☐

No ☐

B6. If yes at the previous question, please indicate (you need to write in the boxes) :

which other sensory impairment?

when did it occur?

B7. Do you have any memory or cognitive impairment?

Yes ☐

No ☐

B8. **If yes at the previous question, please indicate (you need to write in the boxes) :**

which memory or other cognitive impairment? | | | | | | | | | | |

when did it occur? | | | | | | | | | | |

B9. **Do you have physical (motor) impairment?**

Yes ☐

No ☐

B10. **If yes at the previous question, please indicate (you need to write in the boxes) :**

which physical (motor) impairment? | | | | | | | | | | |

when did it occur? | | | | | | | | | | |

B11. **In general, would you say that your overall health is :**

Excellent ☐

Very good ☐

Good ☐

Fair ☐

Poor ☐

B12. **Compared to 3 months ago, would you say that your overall health is :**

Much better now than three months ago ☐

Somewhat better now than three months ago ☐

About the same ☐

Somewhat worse now than three months ago ☐

Much worse now than three months ago ☐

B13. **During the 3 past weeks, Please choose the appropriate response for each item :**

	All of the time	Most of the time	A good bit of the time	Some of the time	None of the time
Did you have a lot of energy?	☐	☐	☐	☐	☐
Have you been a very nervous person?	☐	☐	☐	☐	☐
Have you felt calm and peaceful?	☐	☐	☐	☐	☐
Have you felt downhearted and blue?	☐	☐	☐	☐	☐
Did you feel worn out?	☐	☐	☐	☐	☐

	All of the time	Most of the time	A good bit of the time	Some of the time	None of the time
Did you feel tired?	☐	☐	☐	☐	☐

Section C: Quality of life and low vision

Have the subject answer the following questions with the following responses: NOT difficult; MODERATELY difficult; EXTREMELY difficult; IMPOSSIBLE; Don't do for NON-VISUAL reasons

C1. These questions relate to reading/near vision activities. Remember if you use a low vision device or adaptive technique (different of the eSight device) to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Read newspaper headlines	☐	☐	☐	☐	☐
Read newspaper or magazine articles	☐	☐	☐	☐	☐
Read mail	☐	☐	☐	☐	☐
Read menus	☐	☐	☐	☐	☐
Read small print on package labels	☐	☐	☐	☐	☐
Keep your place while reading	☐	☐	☐	☐	☐
See photographs	☐	☐	☐	☐	☐
Find something on a crowded shelf	☐	☐	☐	☐	☐
Identify medicine	☐	☐	☐	☐	☐
Identify money	☐	☐	☐	☐	☐
Tell time	☐	☐	☐	☐	☐

C2. These questions relate to distance visual activities. Remember if you use a low vision device or adaptive technique (different of the eSight device) to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO:

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Read street signs and store names	☐	☐	☐	☐	☐
Read signs (example: grocery store aisle)	☐	☐	☐	☐	☐
Watch TV	☐	☐	☐	☐	☐
Read print on TV	☐	☐	☐	☐	☐

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Play table and card games	☐	☐	☐	☐	☐
Work on your favorite hobby	☐	☐	☐	☐	☐
Recognize people up close	☐	☐	☐	☐	☐
Recognize people from across the room	☐	☐	☐	☐	☐
Go to the movies	☐	☐	☐	☐	☐
Go to spectator events	☐	☐	☐	☐	☐
Do yard work	☐	☐	☐	☐	☐

C3. These questions are about other daily living activities. Remember if you use a low vision device or adaptive technique (different of the eSight device) to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Handle finances	☐	☐	☐	☐	☐
Make out a check	☐	☐	☐	☐	☐
Sign your name	☐	☐	☐	☐	☐
Take a message	☐	☐	☐	☐	☐
Match clothes	☐	☐	☐	☐	☐
Physically get dressed	☐	☐	☐	☐	☐
Keep your clothes clean	☐	☐	☐	☐	☐
Identify food on a plate	☐	☐	☐	☐	☐
Fix a snack	☐	☐	☐	☐	☐
Prepare meals	☐	☐	☐	☐	☐
Use appliance dials	☐	☐	☐	☐	☐
Groom yourself	☐	☐	☐	☐	☐
Eat and drink neatly	☐	☐	☐	☐	☐
Clean the house	☐	☐	☐	☐	☐

C4. **The last set of questions deal with issues of mobility. Remember if you use a low vision device or adaptive technique (different of the eSight device) to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO**

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Get around indoors in places you know	☐	☐	☐	☐	☐
Get around outdoors in places you know	☐	☐	☐	☐	☐
Get around in unfamiliar places	☐	☐	☐	☐	☐
Go down steps in dim light	☐	☐	☐	☐	☐
Go out at night	☐	☐	☐	☐	☐
Get around in a crowd	☐	☐	☐	☐	☐
Avoid bumping into things	☐	☐	☐	☐	☐
Cross street at a traffic light	☐	☐	☐	☐	☐
Use public transportation	☐	☐	☐	☐	☐
Find public restrooms	☐	☐	☐	☐	☐
Play sports	☐	☐	☐	☐	☐
Adjust to bright light	☐	☐	☐	☐	☐

Section D: Satisfaction with your current visual aid (other than the eSight device)

The purpose of this part is to evaluate how satisfied you are with your assistive device that you used the most currently (choose only one of your assistive device, it must not be the eSight device) and the related services you received. The questionnaire consists of 12 satisfaction items. For each of the 12 items, rate your satisfaction with your assistive device that you used the most currently (not the eSight device) and the related services you received by using the following scale graduated from "not satisfied at all" to "very satisfied". Please select the field that best describes your degree of satisfaction with each of the 12 items.

D1. **Regarding the assistive device that you used the most currently (this assistive device must not be the eSight Eyewear) ... How satisfied are you with, Please choose the appropriate response for each item:**

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the dimensions (size, height, length, width) of your assistive device?	☐	☐	☐	☐	☐
the weight of your assistive device?	☐	☐	☐	☐	☐
the ease in adjusting (fixing, fastening) the parts of your assistive device?	☐	☐	☐	☐	☐
how safe and secure your assistive device is?	☐	☐	☐	☐	☐

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the durability (endurance, resistance to wear) of your assistive device?	☐	☐	☐	☐	☐
how easy it is to use your assistive device?	☐	☐	☐	☐	☐
how comfortable your assistive device is?	☐	☐	☐	☐	☐
how effective your assistive device is (the degree to which your device meets your needs)?	☐	☐	☐	☐	☐

D2. Regarding services... How satisfied are you with, Please choose the appropriate response for each item :

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the service delivery program (procedures, length of time) in which you obtained your assistive device?	☐	☐	☐	☐	☐
the repairs and servicing (maintenance) provided for your assistive device?	☐	☐	☐	☐	☐
the quality of the professional services (information, attention) you received for using your assistive device?	☐	☐	☐	☐	☐
the follow-up services (continuing support services) received for your assistive device?	☐	☐	☐	☐	☐

D3. Below is the list of the same 12 satisfaction items. PLEASE SELECT THE THREE ITEMS that you consider to be the most important to you. Please select the 3 boxes of your choice. Please choose all that apply:

- Dimensions ☐
- Weight ☐
- Adjustments ☐
- Safety ☐
- Durability ☐
- Easy to use ☐
- Comfort ☐
- Effectiveness ☐
- Service delivery ☐
- Repairs/servicing ☐
- Professional service ☐
- Follow-up services ☐

Section E: Quality of life with all of your assistive device(s) (except the eSight device)

E1. **Each word or phrase below describes how using your current assistive device(s) may affect you (this question concerns all of your assistive device(s) (except the eSight device). Some may seem unusual but it is important that you answer every one of the 26 items. So, for each word or phrase please select the appropriate box to show how you are affected by using your current assistive/s technology/ies. The boxes are graduated from "-3" (the level you feel affected decreases) and "+3" (the level you feel affected increases).**

	-3 (the level you feel affected is minimal)	-2	-1	0	+1	+2	+3 (the level you feel affected is maximum)
1. Competence	☐	☐	☐	☐	☐	☐	☐
2. Happiness	☐	☐	☐	☐	☐	☐	☐
3. Independence	☐	☐	☐	☐	☐	☐	☐
4. Adequacy	☐	☐	☐	☐	☐	☐	☐
5. Confusion	☐	☐	☐	☐	☐	☐	☐
6. Efficiency	☐	☐	☐	☐	☐	☐	☐
7. Self-esteem	☐	☐	☐	☐	☐	☐	☐
8. Productivity	☐	☐	☐	☐	☐	☐	☐
9. Security	☐	☐	☐	☐	☐	☐	☐
10. Frustration	☐	☐	☐	☐	☐	☐	☐
11. Usefulness	☐	☐	☐	☐	☐	☐	☐
12. Self-confidence	☐	☐	☐	☐	☐	☐	☐
13. Expertise	☐	☐	☐	☐	☐	☐	☐
14. Skillfulness	☐	☐	☐	☐	☐	☐	☐
15. Well-being	☐	☐	☐	☐	☐	☐	☐
16. Capability	☐	☐	☐	☐	☐	☐	☐
17. Quality of life	☐	☐	☐	☐	☐	☐	☐
18. Performance	☐	☐	☐	☐	☐	☐	☐

	-3 (the level you feel affected is minimal)	-2	-1	0	+1	+2	+3 (the level you feel affected is maximum)
19. Sense of power	☐	☐	☐	☐	☐	☐	☐
20. Sense of control	☐	☐	☐	☐	☐	☐	☐
21. Embarrassment	☐	☐	☐	☐	☐	☐	☐
22. Willingness to take chances	☐	☐	☐	☐	☐	☐	☐
23. Ability to participate	☐	☐	☐	☐	☐	☐	☐
24. Eagerness to try new things	☐	☐	☐	☐	☐	☐	☐
25. Ability to adapt to the activities of daily living	☐	☐	☐	☐	☐	☐	☐
26. Ability to take advantage of opportunities	☐	☐	☐	☐	☐	☐	☐

You have now completed all the questions of this initial questionnaire, thank you!

Supplementary S12: Follow-up Questionnaire for Study 3

Section A: Health condition

A1. **Name and firstname**

A2. **At the present time, would you say that your overall health is:**

- Excellent ☐
- Very good ☐
- Good ☐
- Fair ☐
- Poor ☐

A3. **Since the last questionnaire evaluation (2 past weeks or 3 past months), to what extent has your overall health worsened?**

- Not at all ☐
- Slightly ☐
- Moderately ☐
- Quit a bit ☐
- Extremely ☐

A4. **Since the last questionnaire evaluation, Please choose the appropriate response for each item:**

	All of the time	Most of the time	A good bit of the time	Some of the time	None of the time
Did you have a lot of energy?	☐	☐	☐	☐	☐
Have you been a very nervous person?	☐	☐	☐	☐	☐
Have you felt calm and peaceful?	☐	☐	☐	☐	☐
Have you felt downhearted and blue?	☐	☐	☐	☐	☐
Did you feel worn out?	☐	☐	☐	☐	☐
Did you feel tired?	☐	☐	☐	☐	☐

A5. **Since the last questionnaire evaluation (2 past weeks or 3 past months), to what extent has your visual condition worsened?**

- ☐ Not at all
- ☐ Slightly
- ☐ Moderately
- ☐ Quit a bit
- ☐ Extremely

A6. **At the present time, would you say your eyesight using both eyes with your eSight device is:**

- ☐ Excellent
- ☐ Good
- ☐ Fair
- ☐ Poor
- ☐ Very Poor
- ☐ Completely Blind

Section B: Quality of life and low vision

Have the subject answer the following questions with the following responses: NOT difficult; MODERATELY difficult; EXTREMELY difficult; IMPOSSIBLE; Don′t do for NON-VISUAL reasons

B1. **These questions relate to reading/near vision activities. Remember if you use the eSight device or any low vision aids or adaptive technique to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO:**

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don′t do for non-visual reasons
Read newspaper headlines	☐	☐	☐	☐	☐
Read newspaper or magazine articles	☐	☐	☐	☐	☐
Read mail	☐	☐	☐	☐	☐
Read menus	☐	☐	☐	☐	☐
Read small print on package labels	☐	☐	☐	☐	☐
Keep your place while reading	☐	☐	☐	☐	☐
See photographs	☐	☐	☐	☐	☐
Find something on a crowded shelf	☐	☐	☐	☐	☐
Identify medicine	☐	☐	☐	☐	☐

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Identify money	☐	☐	☐	☐	☐
Tell time	☐	☐	☐	☐	☐

B2. These questions relate to distance visual activities. Remember if you use the eSight device or any low vision aids or adaptive technique to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO:

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Read street signs and store names	☐	☐	☐	☐	☐
Read signs (example: grocery store aisle)	☐	☐	☐	☐	☐
Watch TV	☐	☐	☐	☐	☐
Read print on TV	☐	☐	☐	☐	☐
Play table and card games	☐	☐	☐	☐	☐
Work on your favorite hobby	☐	☐	☐	☐	☐
Recognize people up close	☐	☐	☐	☐	☐
Recognize people from across the room	☐	☐	☐	☐	☐
Go to the movies	☐	☐	☐	☐	☐
Go to spectator events	☐	☐	☐	☐	☐
Do yard work	☐	☐	☐	☐	☐

B3. These questions are about other daily living activities. Remember if you use the eSight device or any low vision aids or adaptive technique to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO:

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Handle finances	☐	☐	☐	☐	☐
Make out a check	☐	☐	☐	☐	☐
Sign your name	☐	☐	☐	☐	☐
Take a message	☐	☐	☐	☐	☐
Match clothes	☐	☐	☐	☐	☐

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Physically get dressed	☐	☐	☐	☐	☐
Keep your clothes clean	☐	☐	☐	☐	☐
Identify food on a plate	☐	☐	☐	☐	☐
Fix a snack	☐	☐	☐	☐	☐
Prepare meals	☐	☐	☐	☐	☐
Use appliance dials	☐	☐	☐	☐	☐
Groom yourself	☐	☐	☐	☐	☐
Eat and drink neatly	☐	☐	☐	☐	☐
Clean the house	☐	☐	☐	☐	☐

B4. The last set of questions deal with issues of mobility. Remember if you use a low vision device or adaptive technique (different of the eSight device) to assist with the activity, please respond as though you were using the device or technique. HOW DIFFICULT IS IT TO

	Not difficult	Moderately difficult	Extremely difficult	Impossible	Don't do for non-visual reasons
Get around indoors in places you know	☐	☐	☐	☐	☐
Get around outdoors in places you know	☐	☐	☐	☐	☐
Get around in unfamiliar places	☐	☐	☐	☐	☐
Go down steps in dim light	☐	☐	☐	☐	☐
Go out at night	☐	☐	☐	☐	☐
Get around in a crowd	☐	☐	☐	☐	☐
Avoid bumping into things	☐	☐	☐	☐	☐
Cross street at a traffic light	☐	☐	☐	☐	☐
Use public transportation	☐	☐	☐	☐	☐
Find public restrooms	☐	☐	☐	☐	☐
Play sports	☐	☐	☐	☐	☐
Adjust to bright light	☐	☐	☐	☐	☐

Section C: Satisfaction with the eSight device

The purpose of this part is to evaluate how satisfied you are with the eSight device and the related services you received. The questionnaire consists of 12 satisfaction items. For each of the 12 items, rate your satisfaction with the eSight device and the related services you received by using the following scale graduated from "not satisfied at all" to "very satisfied". Please select the field that best describes your degree of satisfaction with each of the 12 items.

C1. Regarding the eSight device... How satisfied are you with, Please choose the appropriate response for each item:

	Not satisfied at all	Not very satisfied	More or less satisfied	Quite satisfied	Very satisfied
the dimensions (size, height, length, width) of your eSight?	☐	☐	☐	☐	☐
the weight of your eSight?	☐	☐	☐	☐	☐
the ease in adjusting (fixing, fastening) the parts of your esight?	☐	☐	☐	☐	☐
how safe and secure your eSight is?	☐	☐	☐	☐	☐
the durability (endurance, resistance to wear) of your eSight?	☐	☐	☐	☐	☐
how easy it is to use your eSight?	☐	☐	☐	☐	☐
how comfortable your eSight is?	☐	☐	☐	☐	☐
how effective your eSight is (the degree to which your device meets your needs)?	☐	☐	☐	☐	☐

C2. Regarding services... How satisfied are you with, Please choose the appropriate response for each item :

	Not satisfied at all	Not very satisfied	More or less satisfied Quite satisfied	Very satisfied
the service delivery program (procedures, length of time) in which you obtained your eSight?	☐	☐	☐	☐
the repairs and servicing (maintenance) provided for your eSight?	☐	☐	☐	☐
the quality of the professional services (information, attention) you received for using your eSight?	☐	☐	☐	☐
the follow-up services (continuing support services) received for your eSight?	☐	☐	☐	☐

C3. Below is the list of the same 12 satisfaction items. PLEASE SELECT THE THREE ITEMS that you consider to be the most important to you. Please select the 3 boxes of your choice.

- ☐ Dimensions
- ☐ Weight
- ☐ Adjustments
- ☐ Safety
- ☐ Durability
- ☐ Easy to use

Comfort	☐
Effectiveness	☐
Service delivery	☐
Repairs/servicing	☐
Professional service	☐
Follow-up services	☐

Section D: Quality of life and the eSight device

D1. Each word or phrase below describes how using the eSight device. Some may seem unusual but it is important that you answer every one of the 26 items. So, for each word or phrase please select the appropriate box to show how you are affected by using the eSight device. The boxes are graduated from "-3" (the level you feel affected decreases) and "+3" (the level you feel affected increases).

	-3 (the level you feel affected is minimal)	-2	-1	0	+1	+2	+3 (the level you feel affected is maximum)
1. Competence	☐	☐	☐	☐	☐	☐	☐
2. Happiness	☐	☐	☐	☐	☐	☐	☐
3. Independence	☐	☐	☐	☐	☐	☐	☐
4. Adequacy	☐	☐	☐	☐	☐	☐	☐
5. Confusion	☐	☐	☐	☐	☐	☐	☐
6. Efficiency	☐	☐	☐	☐	☐	☐	☐
7. Self-esteem	☐	☐	☐	☐	☐	☐	☐
8. Productivity	☐	☐	☐	☐	☐	☐	☐
9. Security	☐	☐	☐	☐	☐	☐	☐
10. Frustration	☐	☐	☐	☐	☐	☐	☐
11. Usefulness	☐	☐	☐	☐	☐	☐	☐
12. Self-confidence	☐	☐	☐	☐	☐	☐	☐
13. Expertise	☐	☐	☐	☐	☐	☐	☐
14. Skillfulness	☐	☐	☐	☐	☐	☐	☐

	-3 (the level you feel affected is minimal)	-2	-1	0	+1	+2	+3 (the level you feel affected is maximum)
15. Well-being	☐	☐	☐	☐	☐	☐	☐
16. Capability	☐	☐	☐	☐	☐	☐	☐
17. Quality of life	☐	☐	☐	☐	☐	☐	☐
18. Performance	☐	☐	☐	☐	☐	☐	☐
19. Sense of power	☐	☐	☐	☐	☐	☐	☐
20. Sense of control	☐	☐	☐	☐	☐	☐	☐
21. Embarrassment	☐	☐	☐	☐	☐	☐	☐
22. Willingness to take chances	☐	☐	☐	☐	☐	☐	☐
23. Ability to participate	☐	☐	☐	☐	☐	☐	☐
24. Eagerness to try new things	☐	☐	☐	☐	☐	☐	☐
25. Ability to adapt to the activities of daily living	☐	☐	☐	☐	☐	☐	☐
26. Ability to take advantage of opportunities	☐	☐	☐	☐	☐	☐	☐

Section E: Elements felt with the eSight device

E1. How much is each of the following symptoms affecting you while or just after using the eSight?

	None	Slight	Moderate	Severe
General discomfort	☐	☐	☐	☐
Fatigue	☐	☐	☐	☐
Headache	☐	☐	☐	☐
Eye strain	☐	☐	☐	☐
Difficulty focusing	☐	☐	☐	☐
Salivation increasing	☐	☐	☐	☐
Sweating	☐	☐	☐	☐
Nausea	☐	☐	☐	☐

	None	Slight	Moderate	Severe
Difficulty concentrating	☐	☐	☐	☐
« Fullness of the Head »	☐	☐	☐	☐
Blurred vision	☐	☐	☐	☐
Dizziness with eyes open	☐	☐	☐	☐
Dizziness with eyes closed	☐	☐	☐	☐
Vertigo (a loss of orientation with respect to vertical upright)	☐	☐	☐	☐
Stomach awareness (a feeling of discomfort which is just short of nausea)	☐	☐	☐	☐
Last	☐	☐	☐	☐
Burping	☐	☐	☐	☐

Section F: You and your eSight device

F1. What is your frequency of utilization of your eSight device?

- ☐ Everyday
- ☐ Several time a week
- ☐ Once a week
- ☐ Several time a month
- ☐ Once a month
- ☐ Less than once a month

F2. What is the average consecutive time of your eSight device utilization?

- ☐ Less than half an hour
- ☐ Between 30 minutes and 1 hour
- ☐ Between 1 and 2 hours
- ☐ Between 2 and 4 hours
- ☐ More than 4 hours

F3. When did you use your eSight device the last time?

- ☐ Today
- ☐ Less than a week ago
- ☐ During the past 4 weeks
- ☐ Between 1 and 3 months ago
- ☐ More than 3 months ago

F4. If you did not use it between 2 and 3 months or for more than 3 months, please explain why in the box below?

F5. What is the nature of tasks for which the eSight device is actually used?

- ☐ Watching TV
- ☐ Reading books, Newspaper print, Typed letter…
- ☐ Shopping
- ☐ Getting around
- ☐ Using my computer
- ☐ Watching events (sport, church, theatre, etc…)
- ☐ Cooking
- ☐ Personal care (washing, makeup, etc…)
- ☐ Socializing with others
- ☐ Meetings, classrooms, etc…
- ☐ I do not use my eSight device anymore.
- ☐ Other

Other

F6. **What are the most effective activities for which you use the eSight device? (you need to write in the box below)**

F7. **For which activities is the eSight device not effective or useful? (you need to write in the box below)**

F8. **What activities are you disappointed the eSight device does not help you accomplish? (you need to write in the box below)**

Section G: Your characteristics

G1. **Have you ever used an electronic video magnifier other than electronic eyewear (head-mounted display)?**

Yes ☐

No ☐

G2. **Have you ever used another type of electronic eyewear (head-mounted display) other than the eSight device?**

Yes ☐

No ☐

G3. **If you have used another type of electronic eyewear (head-mounted display) other than the eSight device, please indicate (you need to write in the box following each question :**

Which one(s)? ☐

How often? ☐

Why did you stop to use it? ☐

G4. Do you currently use several low vision aids?

Yes ☐

No ☐

G5. If your are using several low vision aids, please indicate which:

Table-top video magnifier ☐

Hand-held video magnifier ☐

Magnifier software ☐

Special glasses ☐

Hand-held telescope for distance ☐

Hand-held optical magnifier for reading ☐

Smartphone or tablet computer as low vision aid ☐

Cane ☐

Other ☐

Other

G6. To what extent have you adapted to your visual handicap?

Not at all ☐

Slightly ☐

Moderately ☐

Quit a bit ☐

Extremely ☐

G7. Do you enjoy using the eSight device?

Not at all ☐

Slightly ☐

Moderately ☐

Quite a bit ☐

Extremely ☐

G8. **Regarding the previous question, explain why? (you need to write in the box below) (Optional)**

G9. **To what extent have you been disappointed using the eSight device?**

- Not at all ☐
- Slightly ☐
- Moderately ☐
- Quit a bit ☐
- Extremely ☐

G10. **Regarding the previous question, please explain why? (you need to write in the box below) (Optional)**

G11. **In general, to what extent do you think the eSight is right for you?**

- Not at all ☐
- Slightly ☐
- Moderately ☐
- Quit a bit ☐
- Extremely ☐

G12. **To what extent do you think you have the ability to control your usage of the eSight?**

- Not at all ☐
- Slightly ☐
- Moderately ☐
- Quit a bit ☐
- Extremely ☐

G13. How did you finance the eSight device?

- [ ] Self pay or Family
- [ ] Donation, crowd founding, association
- [ ] Public government
- [ ] Borrowed
- [ ] Rented
- [ ] Other, please indicate :
- [ ] Other

Other

Section H: eSight use changes

H1. To what extent do you consider you have integrated the eSight device into your life?

- [ ] Not at all
- [ ] Slightly
- [ ] Moderately
- [ ] Quit a bit
- [ ] Extremely

H2. Have you have completely stopped using the eSight device?

- [ ] Yes
- [ ] No

H3. If you have completely stopped using the eSight device, please write in the box following each question:

- [ ] Since when?
- [ ] What are the reasons? (optional)

H4. **Overall, do you now use the eSight device more or less than at the beginning?**

More ☐

Same ☐

Less ☐

H5. **If you now use the eSight device less than at the beginning, please write in the box following each question:**

Since when? ☐

What are the reasons? (optional) ☐

H6. **Have you reduced using the eSight device for certain tasks?**

Yes ☐

No ☐

H7. **If you have reduced using the eSight device for certain tasks, please write in the box following each question:**

For which one? ☐

Since when? ☐

What are the reasons? (optional) ☐

H8. **Have you stopped using the eSight device for certain tasks?**

Yes ☐

No ☐

H9. **If you have stopped using the eSight device for certain tasks, please write in the box following each question :**

For which one? ☐

Since when? ☐

What are the reasons? (optional) ☐

H10. **Do you use the eSight device for new tasks that you did not expect before buying?**

Yes ☐

No ☐

H11. **If you use the eSight device for new tasks that you did not expect before buying, please write in the box following each question:**

Which one? ☐

Since when? ☐

What are the reasons if any? ☐

Section I: Social and physical environment

I1. Who made the choice to buy/rent your eSight device?

- [ ] Yourself
- [ ] Family, friends
- [ ] Clinician (Ophthalmologist, Optometrist, Specialist in low vision…)
- [ ] Other

Other

I2. Do your family or friends encourage you to wear the eSight device?

- [ ] All of the time
- [ ] Most of the time
- [ ] A good bit of the time
- [ ] Some of the time
- [ ] A little of the time
- [ ] None of the time

I3. Does your family help you to carry out activities of daily living?

- [ ] All of the time
- [ ] Most of the time
- [ ] A good bit of the time
- [ ] Some of the time
- [ ] A little of the time
- [ ] None of the time

I4. **To what extent do you think that the majority of people that are close to you think you should use the eSight?**

- Not at all ☐
- Slightly ☐
- Moderately ☐
- Quit a bit ☐
- Extremely ☐

I5. **Have elements in the physical environment (architecture, infrastructure, public transports, road signs...) ever influenced your use of eSight?**

- Yes ☐
- No ☐

I6. **If you have elements in the physical environment that have ever influenced your use of eSight, please write which one in the box below:**

I7. **Have you ever felt a reaction from people around you towards your eSight device?**

- Yes ☐
- No ☐

I8. **If you have ever felt a reaction from people around you towards your eSight device, please write in the box following each question:**

- The type of reaction? ☐
- Has this reaction led to a change in the use of your eSight in a social setting? ☐

I9. **Have strangers ever asked you about your eSight device?**

- Yes ☐
- No ☐

I10. **If yes, please write in the box following each question:**

- If it was a positive or negative response? ☐
- What were their and your reactions? ☐

Section J: Training and Intervention

J1. Have you received vision rehabilitation services before participating to this study?

- [ ] Yes
- [ ] No

J2. Who introduced you to the eSight device?

- [ ] Clinician (Ophthalmologist, Optometrist, Specialist in low vision…)
- [ ] Family or friends
- [ ] Advertising, social media
- [ ] Associations
- [ ] Other

Other

J3. Would you have prefered it to be another person?

- [ ] Yes
- [ ] No

J4. If you would have prefered it to be another person, please indicate who?

- [ ] Clinician (Ophthalmologist, Optometrist, Specialist in low vision…)
- [ ] Family or friends
- [ ] Advertising, social media
- [ ] Associations
- [ ] Other

Other

J5. **If you would you have prefered it to be another person, what are the reasons? (please write in the box below) (optional)**

J6. **Regarding the training program proposed by eSight (eSkills), to what extent would you consider it helpful?**

- Very useful ☐
- Moderately useful ☐
- Slightly useful ☐
- Not useful ☐

J7. **Regarding the training program proposed by eSight (eSkills), are you satisfied with this training program?**

- Very satisfied ☐
- Satisfied ☐
- Moderately satisfied ☐
- Not satisfied at all ☐

J8. **Have you completed the training program (eSkills)?**

- Entirely ☐
- Half ☐
- More than the half ☐
- Not at all ☐

J9. **Who or what contributed the most to your training, please write the reasons if any in the boxes following the items?**

- Yourself ☐
- Low vision therapist (by tele-readaptation if any) ☐
- Professional from eSight ☐
- eSkills program from eSight ☐
- Family ☐
- Friends ☐
- Other, please indicate : ☐

J10. **Ideally, who or what should have contributed the most to your training, please write the reasons if any in the boxes following the items?**

- Yourself ☐
- Low vision therapist (by tele-readaptation if any) ☐
- Professional from eSight ☐
- eSkills program from eSight ☐
- Family ☐
- Friends ☐
- Other, please indicate : ☐
- No answer ☐

J11. **Are you satisfied with the eSight device follow-up service?**

- All of the time ☐
- Most of the time ☐
- A good bit of the time ☐
- Some of the time ☐
- A little of the time ☐
- None of the time ☐

You have now completed all the questions of this follow-up questionnaire, thank you!

Supplementary S13: Participants' Ratings of Telerehabilitation

Participants' Ratings of Telerehabilitation

Please indicate to which level you agree with the following statements:

1.I am comfortable with receiving tele-rehabilitation training.

☐**Strongly agree,** ☐**Somewhat agree,** ☐**Somewhat disagree,** ☐**Strongly disagree**

2.The training through videoconferencing **took a lot of time** compared to other in-person low vision rehabilitation services.

☐**Strongly agree,** ☐**Somewhat agree,** ☐**Somewhat disagree,** ☐**Strongly disagree**
☐**Non applicable**

3.The training through videoconferencing took **a lot of effort** compared to other in-person low vision rehabilitation services.

☐**Strongly agree,** ☐**Somewhat agree,** ☐**Somewhat disagree,** ☐**Strongly disagree**
☐**Non applicable**

4.The training through the videoconferencing allowed me **to better accomplish my goals** compared to other in-person low vision rehabilitation services.
☐**Strongly agree,** ☐**Somewhat agree,** ☐**Somewhat disagree,** ☐**Strongly disagree**
☐**Non applicable**

5. I would be interested in using telerehabilitation again if my visual needs change in the future.
☐**Strongly agree,** ☐**Somewhat agree,** ☐**Somewhat disagree,** ☐**Strongly disagree**

6. I am satisfied with receiving low vision rehabilitation training via videoconferencing?
☐**Strongly agree,** ☐**Somewhat agree,** ☐**Somewhat disagree,** ☐**Strongly disagree**

7. Is there anything else we did not ask you that you wish you would have asked you regarding your low vision rehabilitation training?

Supplementary S14: Therapist's Ratings of Telerehabilitation

Low vision therapist's Ratings of Telerehabilitation

<u>To complete for each participant</u>

1. While participant use their eSight Eyewear, how it is difficult for you to evaluate:

Moderate difficulty, Little difficulty, No difficulty

-Working distance

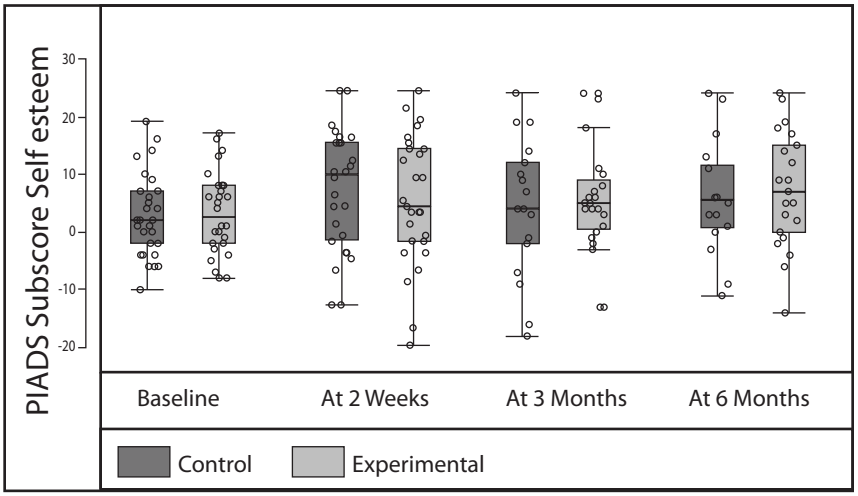
-Illumination

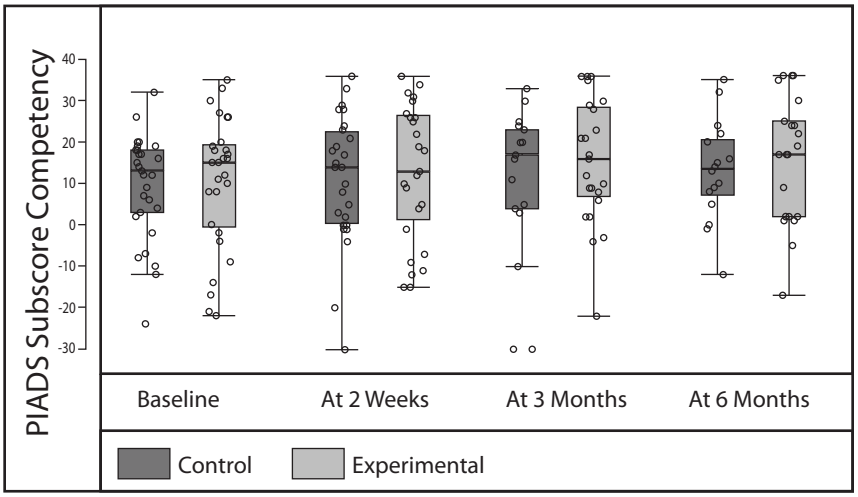
-Reading speed

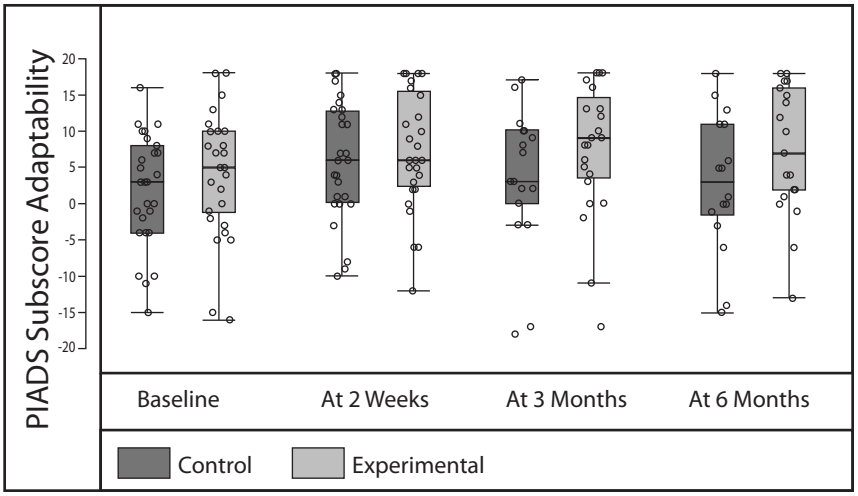
-Reading accuracy

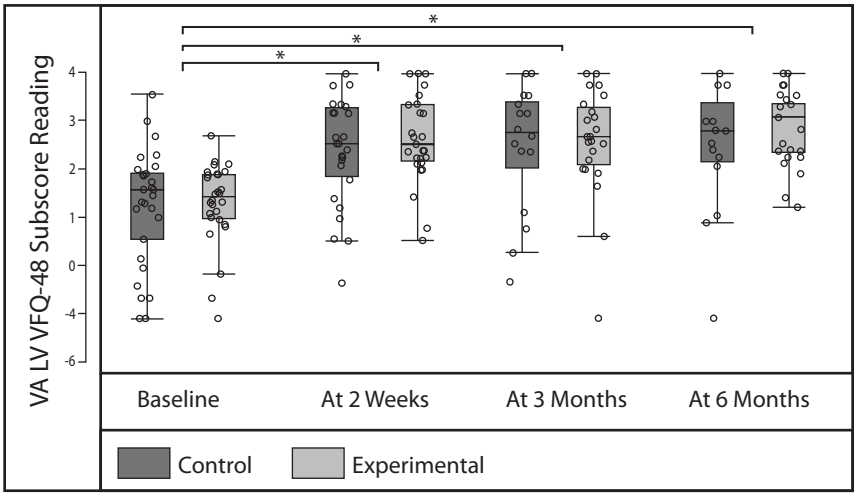
2. *Training that you provided was helpful to improve eSight Eyewear use.*

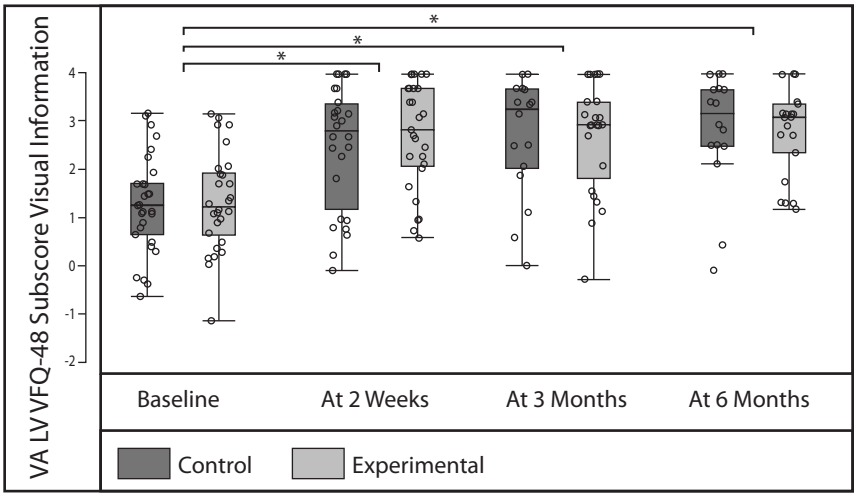
Supplementary S15: Additional graphs for Study 3

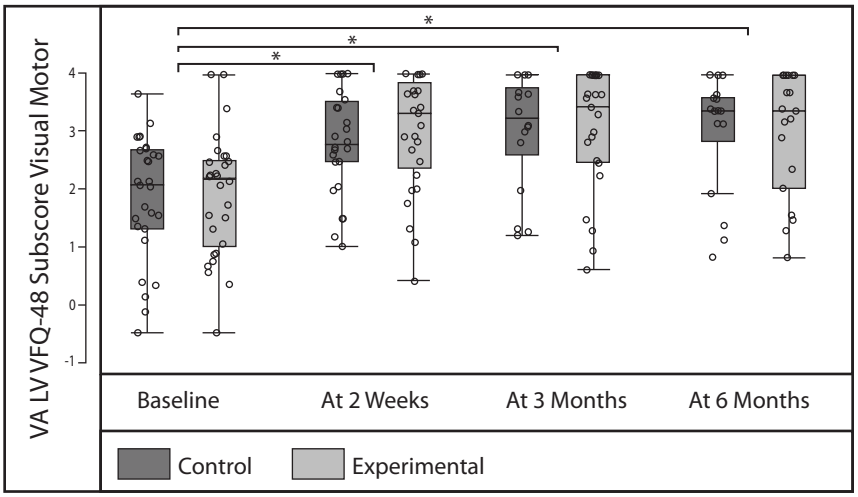


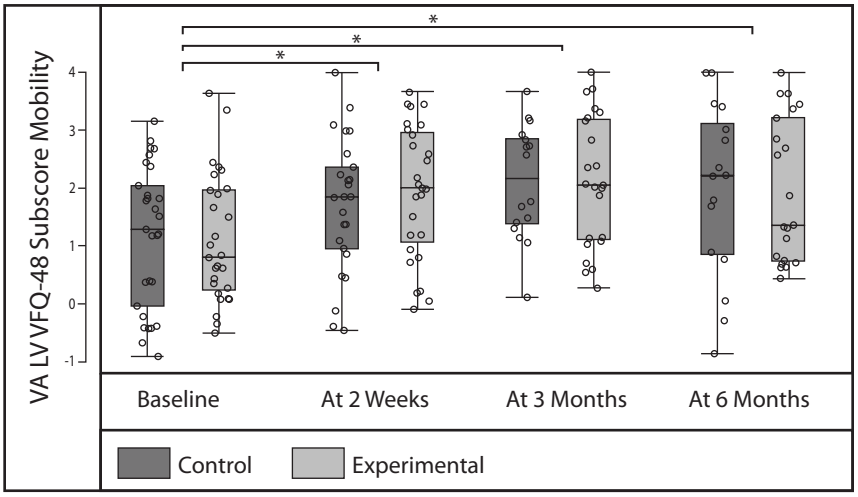


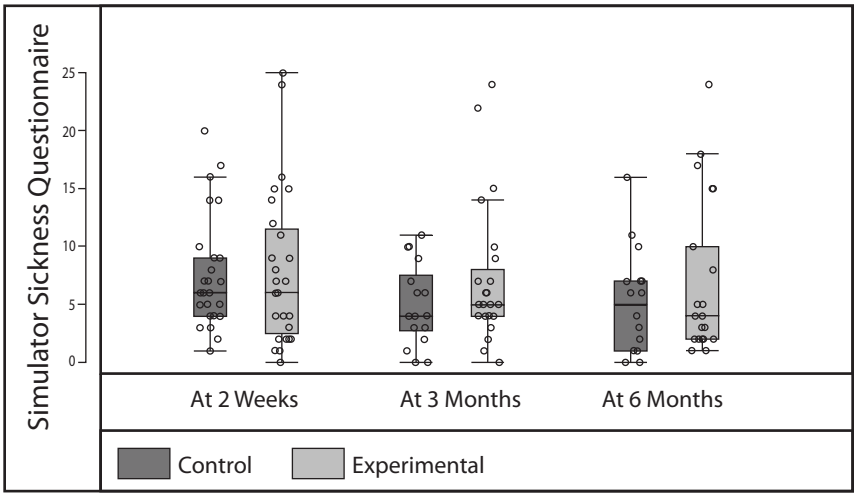



VA LV VFQ-48 Subscore Reading
4
3
2
1
0
-4
-6
*
*
*
Baseline
At 2 Weeks
At 3 Months
At 6 Months
Control
Experimental


VA LV VFQ-48 Subscore Visual Information
4
3
2
1
0
-1
-2
*
*
*
Baseline
At 2 Weeks
At 3 Months
At 6 Months
Control
Experimental


VA LV VFQ-48 Subscore Visual Motor
4
3
2
1
0
-1
*
*
*
Baseline
At 2 Weeks
At 3 Months
At 6 Months
Control
Experimental


VA LV VFQ-48 Subscore Mobility
4
3
2
1
0
-1
*
*
*
Baseline
At 2 Weeks
At 3 Months
At 6 Months
Control
Experimental


Simulator Sickness Questionnaire
25
20
15
10
5
0
At 2 Weeks
At 3 Months
At 6 Months
Control
Experimental

Supplementary Tables S16: Mixed-effect model analyses

LINEAR MIXED-EFFECT MODEL ANALYSES

QUEST

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	QUEST score ~ 1 + Group + Consumer type + Time + Group :Consumer type + Group :Time + Consumer type:Time + Group :Consumer type:Time+(1 | Subjects)
AIC	1271.4770
R-squared Marginal	0.0787
R-squared Conditional	0.2665

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.2482	1	56.4	0.620
Consumer type	0.0276	1	56.4	0.869
Time	3.1413	3	130.6	0.028
Group ✻ Consumer type	1.4704	1	56.4	0.230
Group ✻ Time	0.0735	3	130.6	0.974
Consumer type ✻ Time	1.5152	3	130.6	0.214
Group ✻ Consumer type ✻ Time	0.2279	3	130.6	0.877

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-3.375	1.72	-1.966	122	0.309
0	-	3	-5.630	2.01	-2.802	135	0.035
0	-	6	-4.267	2.02	-2.114	135	0.218
2	-	3	-2.255	2.03	-1.113	133	1.000
2	-	6	-0.893	2.04	-0.439	133	1.000
3	-	6	1.362	2.21	0.616	120	1.000

PIADS

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	PIADS score ~ 1 + Group + Consumer type + Time + Group :Consumer type + Group :Time + Consumer type:Time + Group :Consumer type:Time+(1 | Subjects)
AIC	1663.379
R-squared Marginal	0.115
R-squared Conditional	0.367

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.3457	1	57.5	0.559
Consumer type	5.0429	1	57.5	0.029
Time	2.8266	3	129.2	0.041
Group ✻ Consumer type	0.0608	1	57.5	0.806
Group ✻ Time	0.2523	3	129.2	0.860
Consumer type ✻ Time	1.7913	3	129.2	0.152
Group ✻ Consumer type ✻ Time	0.3834	3	129.2	0.765

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-11.092	5.26	-2.107	121	0.223
0	-	3	-14.833	6.19	-2.395	133	0.108
0	-	6	-14.082	6.22	-2.263	133	0.152
2	-	3	-3.742	6.24	-0.600	131	1.000
2	-	6	-2.990	6.27	-0.477	131	1.000
3	-	6	0.752	6.77	0.111	119	1.000

PIADS subscore Competency

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	PIADS subscore Competency ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	1439.124
R-squared Marginal	0.107
R-squared Conditional	0.309

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.4440	1	54.9	0.508
Time	1.5952	3	129.9	0.194
Consumer type	6.3542	1	54.9	0.015
Group ✻ Time	0.2839	3	129.9	0.837
Group ✻ Consumer type	3.05e-5	1	54.9	0.996
Time ✻ Consumer type	1.9618	3	129.9	0.123
Group ✻ Time ✻ Consumer type	0.0885	3	129.9	0.966

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-2.76	2.72	-1.016	123	1.000
0	-	3	-4.65	3.08	-1.511	133	0.799
0	-	6	-6.55	3.20	-2.047	135	0.256
2	-	3	-1.89	3.11	-0.610	131	1.000
2	-	6	-3.79	3.22	-1.174	132	1.000
3	-	6	-1.89	3.43	-0.551	122	1.000

PIADS subscore Adaptability

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	PIADS subscore Adaptability ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	1251.315
R-squared Marginal	0.108
R-squared Conditional	0.289

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	3.5716	1	56.7	0.064
Time	1.7981	3	132.0	0.151
Consumer type	6.6349	1	56.7	0.013
Group ✻ Time	0.6276	3	132.0	0.598
Group ✻ Consumer type	0.0593	1	56.7	0.809
Time ✻ Consumer type	0.0927	3	132.0	0.964
Group ✻ Time ✻ Consumer type	0.2485	3	132.0	0.862

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-3.644	1.58	-2.302	123	0.138
0	-	3	-2.076	1.79	-1.158	133	1.000
0	-	6	-1.461	1.86	-0.785	135	1.000
2	-	3	1.568	1.81	0.867	131	1.000
2	-	6	2.183	1.88	1.164	133	1.000
3	-	6	0.615	2.00	0.308	123	1.000

PIADS subscore Self-esteem

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	PIADS subscore Self-esteem ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	1276.8715
R-squared Marginal	0.0739
R-squared Conditional	0.3742

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	5.46e-5	1	57.5	0.994
Time	1.6872	3	129.5	0.173
Consumer type	3.5558	1	57.5	0.064
Group ✻ Time	0.3662	3	129.5	0.778
Group ✻ Consumer type	0.0321	1	57.5	0.858
Time ✻ Consumer type	0.8307	3	129.5	0.479
Group ✻ Time ✻ Consumer type	0.0850	3	129.5	0.968

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-2.753	1.63	-1.693	122	0.558
0	-	3	-2.064	1.85	-1.114	131	1.000
0	-	6	-3.937	1.92	-2.045	132	0.257
2	-	3	0.689	1.87	0.369	129	1.000
2	-	6	-1.183	1.94	-0.611	130	1.000
3	-	6	-1.872	2.05	-0.912	121	1.000

VA LV VFQ 48 Visual abilities

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	Visual Ability ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	461.416
R-squared Marginal	0.315
R-squared Conditional	0.691

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.546	1	57.6	0.463
Time	32.538	3	124.2	< .001
Consumer type	4.815	1	57.6	0.032
Group ✻ Time	0.497	3	124.2	0.685
Group ✻ Consumer type	0.790	1	57.6	0.378
Time ✻ Consumer type	1.726	3	124.2	0.165
Group ✻ Time ✻ Consumer type	0.627	3	124.2	0.599

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-1.1007	0.137	-8.025	120	< .001
0	-	3	-1.2215	0.163	-7.472	126	< .001
0	-	6	-1.2499	0.164	-7.607	126	< .001
2	-	3	-0.1208	0.164	-0.736	124	1.000
2	-	6	-0.1492	0.165	-0.904	124	1.000
3	-	6	-0.0284	0.176	-0.162	118	1.000

VA LV VFQ 48 reading subscore

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	Reading ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	662.904
R-squared Marginal	0.298
R-squared Conditional	0.643

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	2.069	1	58.6	0.156
Time	26.581	3	124.2	< .001
Consumer type	2.611	1	58.6	0.112
Group ✻ Time	0.383	3	124.2	0.766
Group ✻ Consumer type	2.881	1	58.6	0.095
Time ✻ Consumer type	1.615	3	124.2	0.189
Group ✻ Time ✻ Consumer type	0.332	3	124.2	0.802

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-1.9729	0.258	-7.6593	119	< .001
0	-	3	-1.9949	0.306	-6.5125	126	< .001
0	-	6	-2.0618	0.324	-6.3650	127	< .001
2	-	3	-0.0220	0.308	-0.0715	125	1.000
2	-	6	-0.0889	0.325	-0.2733	125	1.000
3	-	6	-0.0669	0.345	-0.1937	118	1.000

VA LV VFQ 48 visual information subscore

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	Visual Information ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	489.159
R-squared Marginal	0.300
R-squared Conditional	0.688

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.482	1	57.7	0.490
Time	31.934	3	124.3	< .001
Consumer type	3.701	1	57.7	0.059
Group ✻ Time	0.420	3	124.3	0.739
Group ✻ Consumer type	1.733	1	57.7	0.193
Time ✻ Consumer type	1.598	3	124.3	0.193
Group ✻ Time ✻ Consumer type	0.972	3	124.3	0.408

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-1.1823	0.148	-7.962	120	< .001
0	-	3	-1.2369	0.177	-6.987	126	< .001
0	-	6	-1.3974	0.178	-7.854	126	< .001
2	-	3	-0.0546	0.178	-0.307	124	1.000
2	-	6	-0.2151	0.179	-1.204	124	1.000
3	-	6	-0.1605	0.190	-0.844	118	1.000

VA LV VFQ 48 visual motor subscore

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	Visual Motor ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	469.456
R-squared Marginal	0.211
R-squared Conditional	0.664

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.15075	1	57.9	0.699
Time	22.26310	3	123.5	< .001
Consumer type	0.02906	1	57.9	0.865
Group ✻ Time	0.22022	3	123.5	0.882
Group ✻ Consumer type	0.00384	1	57.9	0.951
Time ✻ Consumer type	1.77429	3	123.5	0.156
Group ✻ Time ✻ Consumer type	0.55189	3	123.5	0.648

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-0.9434	0.143	-6.610	120	< .001
0	-	3	-1.0807	0.167	-6.464	125	< .001
0	-	6	-1.0181	0.168	-6.059	125	< .001
2	-	3	-0.1373	0.168	-0.815	122	1.000
2	-	6	-0.0747	0.169	-0.441	122	1.000
3	-	6	0.0626	0.179	0.349	117	1.000

VA LV VFQ 48 visual mobility subscore

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	Mobility ~ 1 + Group + Time + Consumer type + Group :Time + Group :Consumer type + Time:Consumer type + Group :Time:Consumer type+(1 | Subjects)
AIC	497.841
R-squared Marginal	0.198
R-squared Conditional	0.638

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.0644	1	56.0	0.801
Time	8.3492	3	121.3	< .001
Consumer type	10.1123	1	56.0	0.002
Group ✻ Time	0.4433	3	121.3	0.722
Group ✻ Consumer type	0.1145	1	56.0	0.736
Time ✻ Consumer type	1.9281	3	121.3	0.129
Group ✻ Time ✻ Consumer type	0.6702	3	121.3	0.572

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
0	-	2	-0.6154	0.156	-3.937	118	< .001
0	-	3	-0.8127	0.185	-4.395	124	< .001
0	-	6	-0.5369	0.186	-2.889	124	0.027
2	-	3	-0.1973	0.186	-1.058	122	1.000
2	-	6	0.0785	0.187	0.419	122	1.000
3	-	6	0.2758	0.199	1.388	116	1.000

Simulator Sickness Questionnaire

Model Info

Info	
Estimate	Linear mixed model fit by REML
Call	Cynersickness score ~ 1 + Group + Time + Consumer type + Group:Time + Group:Consumer type + Time:Consumer type + Group:Time:Consumer type+(1 | Subjects)
AIC	740.5143
R-squared Marginal	0.0399
R-squared Conditional	0.5927

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Group	0.7955	1	51.3	0.377
Time	1.6943	2	74.1	0.191
Consumer type	2.15e-4	1	51.3	0.988
Group ✻ Time	0.2115	2	74.1	0.810
Group ✻ Consumer type	0.0108	1	51.3	0.918
Time ✻ Consumer type	0.7035	2	74.1	0.498
Group ✻ Time ✻ Consumer type	0.8944	2	74.1	0.413

Note. Satterthwaite method for degrees of freedom

Post Hoc Comparisons - Time

Comparison							
Time		Time	Difference	SE	t	df	$p_{bonferroni}$
2	-	3	1.058	0.971	1.090	78.6	0.837
2	-	6	1.765	0.976	1.809	78.6	0.223
3	-	6	0.707	1.013	0.698	69.0	1.000