ADITUM

Journal of Ophthalmology and Vision Care

Open Access Research Article

Performance of an Augmented Reality Device on Functional Activities of Low Vision Patients with Age Related Macular Degeneration

Rebecca Kammer

University of California, Irvine 850 Health Sciences Road Irvine, CA 92697.

Article Info

Received: August 03, 2021
Accepted: August 10, 2021
Published: August 17, 2021

***Corresponding author:** Rebecca Kammer, University of California, Irvine 850 Health Sciences Road Irvine, CA 92697.

Citation: Rebecca Kammer. (2021) "Performance of an Augmented Reality Device on Functional Activities of Low Vision Patients with Age Related Macular Degeneration", Ophthalmology and Vision Care, 1(3); DOI: http;//doi.org/08.2021/1.1015.

.

Abstract

Introduction:

Visual impairment impacts the daily living activities of billions of people globally, and over 5 million in the U.S. by 2020 [1] potentially limiting their inclusion in education, employment and more generally society. In the U.S. and many countries, low vision rehabilitation includes an evaluation of the visual function deficit along with assessment of the most important and realistic activities for the patient to improve performance through rehabilitation [2]. The evaluation services, enhancement devices, and training or strategies to improve activities of daily life and indirectly patient quality of life usually include a trained low vision optometrist or ophthalmologist and a vision therapist (e.g., low vision trained occupational therapist, orientation and mobility specialist). Classically, within rehabilitation, there are devices or tools that fit into categories of optical devices, video magnification devices, and vision substitution or non-optical devices [2]. Software driven options such as smartphones, options on computers, and virtual reality advances have created other hybrid categories. Optical magnification devices are used most often and are usually categorized for purposes of enhancing vision at distance, intermediate or near and have a fixed magnification determined through evaluation of a low vision physician [3]. Devices are usually sub-categorized as to the type of tasks addressed such as spot viewing (e.g., identifying a medication label) or sustained viewing (e.g., reading a book). These same categories of spotting or sustained viewing apply to intermediate and distance (e.g., recognizing faces) and sustained viewing (e.g., television or event viewing). Through a specific evaluation process, singular devices are prescribed to meet patient goals which means several devices are usually needed to assist someone in all areas of life [3]. The most common devices include handheld magnifiers, high addition spectacle lenses, tinted lenses/filters, telescopes, and video magnifiers. Recently, head mounted low vision devices have become more common due to advancing camera and display technology, image processing, and improvement in wearable hardware. Head mounted devices include some type of camera, near-eye displays, and enhancing software to modify the information for the user. The software can manipulate the image to enhance contrast, enhance only certain parts of the image or potentially replace the image with a different version. These devices provide a hands-free magnified (or minified if necessary) image to the user with autofocus capacity for task performance at any distance. With classical low vision devices designed for one distance and one type of task (e.g., near, spot viewing), a device that can assist a user in completing more than one task at a time is closer to replicating the function of the human visual system prior to impairment. Although the cost is usually higher for a head mounted device than for a singular optical device, the convenience and efficiency may provide the value necessary for such an investment. Devices can utilize virtual reality in which the display adapts and replaces the user's natural vision, or augmented reality, in which the display adds to, or overlays parts of, the natural vision. Although typologies have been proposed for different types of head mounted devices [4, 5], the expansion of devices has been rapid recently and conclusive terminology has not been adopted.

Eyedaptic created a new device that is described as an Augmented Reality (AR) spectacle or head mounted device, the Eye-01, which seamlessly integrates high performance hardware with proprietary software to support visual tasks for visually impaired persons at distance, intermediate and near and essentially replace multiple unique devices. Available magnification ranges from 0.25 to beyond 6X, with higher

magnification levels limited by image sensor resolution. The weight is 180 grams in the current hardware with approximately 30-degree field of view (diagonally). The Eye-01 has bi-ocular displays with a hybrid see-through design that combines the two common "optical see-through" and "video see-through" AR methodologies. Video see-through is most commonly used in VR (Virtual Reality) approaches where the user is completely isolated from real world inputs except what is processed through the camera and then displayed to the user. Optical see-through is employed in the traditional AR (Augmented Reality) approach where the image on the displays is over laid on top of the real world. In the Eyedaptic hybrid see-through approach the images manipulated and displayed before the user's eyes are enhanced but not see-through and not conflicting with the real world. The displayed images are then blended by software with the real-world periphery by the Portal™ feature, which reduces magnification gradually to transition with the real world in a seamless manner, therefore maintaining peripheral vision and the anchor to the real world. This hybrid see-through design introduces something new to the traditional definitions of augmented reality. The patent pending software is currently housed within hardware (frame) that is available commercially, but it can be configured within modern AR or VR hardware as the camera resolution, field of vision, and image processing speeds improve.

Further embedded software features will also be explored such as Britext™ edge enhancement technology. This form of contrast specifically enhances the boundaries of text and objects to further aid visual function tasks and acuity. Other settings include a round magnification area (Portal™) embedded within the view, and a feature called Warp™ which shifts information from a customizable size area that matches the user's scotoma to a more peripheral location.

The peripheral portion can allow for mobility while wearing the device although it is recommended with caution and with training only. The device was designed to assist any person with vision impairment in both eyes from any cause whether congenital or acquired. For the initial study, one condition, Age Related Macular Degeneration (AMD), was selected to reduce variables and learn how to optimize the final design of the device for the most people prior to commercialization. AMD is the leading cause of reduced vision in older adults, whether dry or exudative. The condition causes deficits in visual function impacting the central visual field while leaving peripheral visual function largely intact. AMD impacts visual function that cause the greatest difficulty regarding patient complaints in reading, self-care, facial recognition, and other broadly defined categories of Activities of Daily life or ADLs. Those visual functions include visual acuity (VA), visual fields in the form of absolute or relative central scotomata, and contrast sensitivity function (CSF) and each of these areas are explored in the current study along with the outcome measures or endpoints.

The primary study objectives include comparing reading performance and time to complete tasks of daily life between standard near correction alone and the Eye-01 device set at 3X magnification alone and then with various software features (e.g., Britext™). Secondary objectives include 1) exploring the relationship between severity of vision impairment (as measured by BCVA, scotoma size and location, contrast sensitivity, and vision related quality of life) or age and performance with the Eye-01 device set at 3X and 2) understanding qualitative feedback from subjects regarding the training process and each of the Eye-01 features.

The information gained from the exploratory study will be valuable in determining what features of Eye-01 are most useful to AMD patients and in designing future studies comparing Eye-01 to other low vision devices or rehabilitation approaches.

Materials and Methods:

The study is designed as a single arm, crossover study with 20 subjects who have age related macular degeneration with mean age of 85 (range 74 to 92) and mean best corrected acuity of 20/125 (range 20/63 to 20/250). Informed consent procedures followed the guidelines of the local Institutional Review Board and each patient gave written informed consent on a form that complied with Health Insurance Portability and Accountability Act and adhered to the Tenants of the Declaration of Helsinki.

Study subjects were referred from retina specialists and low vision optometrists in the geographic region of the single study site. Study visits included two in-office visits with the first visit incorporating baseline visual function measures (e.g., BCVA, Contrast sensitivity), reading performance with standard add alone, and training time with the Eye-01. The second visit included a training refresher and study outcomes with the Eye-01. A qualitative component to the study also included participant feedback on the training process and on the unique Eye-01 settings (e.g., Britext™).

Tests and Study Components:

The MNREAD, a standardized reading test, has several sizes of print displayed on a paper card in paragraphs of 10 words each [6]. When the subject cannot read the print any further, the adjusted times are used to produce a reading curve that maps reading function by print size. A plateau of fastest reading times is called the maximum reading speed (MRS) and the point on the curve just before function starts to drop rapidly is called the critical prints size (CPS). The CPS represents the size of text where visually impaired persons are still reading at a comfortable pace. Reading performance using the MNREAD was compared between standard near correction alone and the Eye-01 device set at 3X magnification. Additional features of the device were also tested against near correction alone. Although the device can be set at a wide range of magnification, 3X was selected to minimize participant to participant and device setting variables.

There are a few timed task inventories that have been used with visually impaired persons but they often have many tasks that may not be relevant to use with a head mounted device such as the Eye-01 or may require significant time to administer [7]. The TIADL Test was developed to assess the performance of low vision patients on real world activities that are potentially affected by visual impairment [8]. The test provides results in seconds as subjects perform a series of tasks. The original version has six tasks including finding an amount due on a bill, writing a check, making change with dollars, finding a phone number in a phone book, dialing the number, and finding queens in cards laid out on a table.

The revised version designed for this study incorporates the essential principles of the timed tasks but was revised to add new tasks based on relevance with the device for three task distances of 40cm, 1m, and 3m. One of the six original tasks in the inventory was used which involved searching a bill for amount due. The two added tasks include viewing a shelf at arm's length (1 meter) and identifying cans by the print on their labels and reading an overhead sign simulating grocery store aisles. Each task allows a maximum of 2 min before moving to the next task so the total time to administer is 6 minutes. Total time for all three tasks is compared as an endpoint.

A cognitive test modified for visual impairment, the Mini-Mental State Exam modified for sensory deficit (MMSE-Blind) [9], was used to determine eligibility with any person who scored equal or less than 23 being excluded from the study. There is a potential increase in cognitive impairment with those who have visual impairment from AMD [10]. The Mini-Mental is often used to diagnose dementia and so it was used in this study to screen participants who may not be able to learn and recall the training steps used with the Eye-01 device.

The clock dial test was created for the study to determine approximate location and size of the participant's scotoma by asking each person to identify missing numbers on a series of increasingly large clocks printed on standard letter size paper while fixating on a central dot. Diameters of each clock correspond to 5 degrees, 10 degrees, and 15 degrees. Scotoma location was determined by the radius (where the missing numbers on the clock were located) and approximate size depended on which clock was used. Essentially central scotomas from AMD should keep the participant from seeing the fixation dot but with eccentric viewing or use of a preferred retinal location, the scotoma becomes shifted to a new position [11]. This information can be useful for understanding reading and fixation in AMD.

Contrast provides critical information about edges, borders, and variations in luminance and is correlated to performance on many real-world tasks such as reading and performance of activities of daily life. Similar in design to the Pelli-Robson, the Ridgevue Contrast Sensitivity test [12], was administered on an iPad to measure peak CS in both eyes (OU) or just on the study eye in the case of retinal rivalry.

A 48-item questionnaire, the VA LV VFQ-48 (VFQ), was used to explore what areas of life were most impacted by vision loss. The VFQ is a valid and reliable questionnaire used in low vision rehabilitation to capture changes in patients' self-report of their difficulty reading and performing other daily living activities affected by visual impairment [13]. Visual ability is a score that represents all the scales of reading, visual information, visual motor, and mobility. The reading scale includes items about reading at near and distance (e.g., reading newspaper print, seeing signs). For a study population of AMD, it was expected that visual ability overall and then reading may be the scores more relevant to exploring relationships with performance using the Eye-01.

Training:

Training in the use of the Eye-01 device was conducted using a set magnification of 3X and included a) steady head posture to stabilize viewing, b) spotting with the device for intermediate and near, c) reading continuous text short paragraphs, and d) a brief introduction of features such as Britext™ and Portal™(Figures 1 and 2) Although the Eye-01 has a range of magnification capabilities, the examiner set the device to 3X to minimize the many variables that could influence subject performance. For some patients 3X may be more than needed and for some in the 20/200 BCVA range, it may not be enough for very small print reading. But by selecting one magnification throughout all visits and then adding in the various features (e.g., Portal™) at various points in the study visits, any gains in performance with the features could be compared to magnification alone.

Study Visits:

The first visit included testing best corrected visual acuity (BCVA) using a trial frame refraction and an ETDRS non-illuminated chart. Once the subject was consented/enrolled, their testing included, contrast sensitivity testing with best correction, assessment of scotoma size and location, and the VFQ. Training with the Eye-01 was conducted for approximately 30 minutes but total time did depend on the needs of each participant. Practice with both endpoint measures was conducted at the end of the first visit to reduce any potential practice effects with both the MNREAD and the TIADL tests on the second visit.

A second visit one week later (a window of 4-10 days) included a brief review of training steps from the prior visit and the examiner recorded qualitative notes on what the subject recalled or what topics required the most re-training. Both endpoint tests (CPS and TIADL times) were performed with spectacle correction only and then various EYE-01 settings. The order of testing for the timed outcomes using spectacles only vs. the 3X Eye-01 was randomized during testing. This step was intended to reduce impact of the initial practice effect on the timed test performance. Testing continued using both the timed tasks and reading using the Eye-01 device set at 3X and Britext™ and then with 3X and Portal™, and finally with 3X, Portal™ and Britext™. Although times and ability to complete tasks with each feature are important, participant qualitative responses to each of the features were also recorded.

Results:

For the primary objective for understanding differences in reading performance (CPS) and time to complete tasks, between standard near correction alone and the Eye-01 device set at 3X magnification alone, mean critical print size (CPS) improved from 0.93 logMar with near correction alone compared to mean CPS of 0.70 logMar ($p=0.013$) with the Eye-01. Improvement in print size ranged up to 7 lines. All subjects performed better on tasks with the device compared to without ($p=0.004$) and especially with the edge enhancement (Britext™) feature ($p<0.001$). In a subset of subjects (N=10), a combination of features (Magnification, Portal™ and Britext™) was explored for task performance compared to Magnification alone and Magnification and Britext™ together. With glasses alone, only 2 of the 10 could do any of the three tasks. With combination of all features, 8 of the 10 could do at least two of the tasks and the mean time to complete tasks for all 10 subjects using a combination of all three features were better together than the mean time for each feature separately ($p=0.02$). For the full 20 subjects with spectacles alone, only 5 (of 20)

subjects could complete bill pay compared to 12 with Eye-01. For identification of cans, only 3 subjects with spectacles could do so, compared to 16 with the device. Finally, for grocery store signs, 2 people could correctly identify all the words with spectacles, whereas 11 could do so with the Eye-01 (Figure 3). If the Eye-01 had not been fixed at 3X with the magnification, it is likely even more subjects could do all tasks.

The mean time to complete TIADL tasks of utility bill search, can label identification, and reading grocery store aisle signs was approximately faster by 2 times (308s reduced to 191s and 163s) with the Eye-01 and Britext™ respectively, see Table I. With spectacles alone, 13 of the subjects were unable to perform any of the tasks resulting in maximum time score of 360 sec. With the Eye-01, all subjects completed at least one if not all three tasks, see Figure 3. Mean distance visual acuity improved from a mean of 20/125 (0.81 logMar) to a mean of 20/60 (0.47 logMar) with the Eye-01.

For the secondary objectives exploring the relationship of impairment and age on endpoint performance, there appeared to be a trend with older subjects having worse reading scale scores on the VFQ, but the relationship was not significant (r=-0.24). For task performance with spectacles alone or with the Eye-01, there was no relationship of age or performance on the VFQ and the performance ability, but a relationship may not be obvious due to small sample size. There were also no baseline predictors of identifying patients who improve in overall task function to a greater degree than others, however scotoma pattern could be qualitatively linked to reading performance. Patients with bilateral AMD with visual acuity loss in the range of the study subjects often experience a ring pattern scotoma (non-seeing area) where fixation is preserved but surrounded by a missing ring-shaped pattern. An alternative pattern is with a scotoma pushed to a more peripheral area with an alternative area used to fixate, or preferred retinal locus (PRL). Using the clock dial method described earlier, 6 subjects had ring scotomas, 9 had scotomas to the right or up and to the right (diagonal), and 2 had had scotomas to the left or down and to the left. Location of the scotoma or conversely the PRL was uncertain in three subjects and may have included a partial ring pattern. The four subjects with ring scotomas required extra fixation and reading training on the second visit and demonstrated more difficulty with reading with or without the device. The 9 subjects with right sided scotomas performed well on outcomes overall.

For the final research question related to participant feedback on training and features of the Eye-01, the mean time to train on the first visit took 41 minutes (n=20). The steps used in the training process included creating a steady head posture to stabilize viewing (Figure 4), spotting with the device for distance and intermediate targets, and finally, reading continuous text short paragraphs. After reading training, subjects were exposed briefly to features such as Britext™ and Portal™. The steps did seem to appropriately train the subjects on the use of the device without significant fatigue. During the second visit when each step was briefly re-introduced, all subjects demonstrated efficient recall of training steps. The study visits including the training was conducted by an optometrist who was unfamiliar with low vision or the Eyedaptic device but who was trained on the details of the study.

Regarding feedback on the features of the Eye-01, Britext™ was well received for task performance more than for reading. Subjects stated that they thought they could see to read better with the feature, but their reading speed or critical print size were no better than without it. However, the setting of Britext™ was fit to a specific size estimated to compliment the fixed 3X magnification, however, a thinner or thicker Britext™ edge may be better for individual users and could easily be adjusted outside of the study parameters. Subjects did comment that Britext™ was helpful for identifying cans on a shelf and identifying words on a grocery store sign and the corresponding time to complete tasks was significantly better with the Britext™ feature than magnification alone.

The Portal™ feature is a window that can vary in diameter within the full screen of the video display and the size was fixed for the study. Subjects did not prefer the feature for the reading test, but this fixed diameter may also have limited the acceptance. The concept of the Portal™ is to provide context within the magnified view of reading text or any environment view that needs enhancement. For reading, the Portal™ provides a view of the end of the line and possibly the beginning of the next line within a paragraph context. However, subjects did not notice this feature helping with these purposes when initially introduced but they may have not had enough time to understand its use and they may have just desired initial simplicity as they learned the basic training steps of maintaining a steady head position. In the ten subjects with prior exposure to the device, comments were more accepting of the feature and one subject stated that she toggles the Portal™ feature on for a word she can't quite see and then once identified, she returns to the flat straight magnification screen for wider view. In the subgroup of subjects who tested a combination of Portal™ and Britext™ vs just either feature alone or straight magnification during task performance, task completion was faster with the combination than with the other features alone but with such a small subgroup ($p<0.05$) the concept is worth exploring in future studies.

The Warp™ feature was not used with endpoint measures of reading or task performance but it was introduced for reactions and comments from subjects at the end of the study visit. The Warp™ feature shifts visual information from an area of scotoma or blind spot and shifts it to a more peripheral area of vision but to do so, the information is pushed or warped to edge of the scotoma. The size and the shape of the shifted area can be customized for the user and so has potential to help a user with context when information is missing but it does require training and its usefulness may depend on location of eccentric viewing. Subjects were asked to report on their impression of the Warp™ feature at the end of the second visit and most comments revealed initial confusion and lack of understanding how to use the newly gained information shifted from the non-seeing area or scotoma. Subjects were also tired by the end of the visit and this may have impacted their initial responses. In addition, the examiner was not a trained low vision physician or therapist and was uncertain how to best train the feature. Customizing the Warp™ setting would require the trainer to not only know where the patients' preferred retinal location was located but also how to advise the patient on information that might be re-gained depending on Warp™ placement. Training the use of the feature in the context of each subject's scotoma pattern is a complicated process and would best

be done in a comprehensive low vision rehabilitation setting.

Discussion:

The purpose of the study was to examine the performance of persons with AMD on reading and sample tasks of daily life at varying distances. Overall, the Eye-01 did improve all outcomes or measures of performance as expected but various features enhanced tasks differently. Britext™ is an edge enhancement feature that is preferred by subjects but positively impacts task performance more than reading. A combination of features may improve task performance even further than just magnification alone. Culham, Chabra, and Rubin [14] explored early models of head mounted devices and found that optical magnifiers may have been best for individual tasks, but they did not explore the value of one device to replace multiple devices. In a recent review of reading aids for low vision participants ranging from optical aids to stand mounted electronic devices to head mounted electronic devices, there was not enough evidence to conclude a certain type of device was better for reading [15]. As patients in a low vision rehabilitation setting have many options for magnification ranging from optical to video or digital modes but they are usually task specific. Devices that can do more for patients in rehabilitation through the ability to perform multiple tasks at different distances and situations through customizable or variable platforms offer great promise and may justify the expense of such technology.
This study is the first of its kind to explore a feature while fixing certain settings so that each feature can be compared step by step. Although the study design does limit the wider range of magnification that the device is capable of, the comparison of features provides valuable information to the design team prior to market release. The training program that was also created and evaluated in the study can serve as a basis for the device to transition into the comprehensive rehabilitation models across the US and outside the US. The fact that an optometrist study examiner efficiently learned and performed the training process indicates a transferrable process for low vision therapists and other professionals in the rehabilitation setting to easily adopt.

As an augmented reality device, the Eye-01 did improve the ability to access small print and to perform timed daily living tasks at all viewing distances when compared to standard near correction alone in a group of subjects with moderate visual impairment from AMD. Although mobility was not studied nor were tasks performed in a natural shopping or home situation, the various features may help patients with AMD in different settings whether reading or performing a task such as bill paying or identifying items in a grocery store. In this study, very few subjects could perform any of the tasks with spectacles alone but with the Eye-01, all subjects could perform at least one of the tasks. A future study will incorporate a take-home aspect that allows users more time with the device and exploration in different settings. Feedback for each of the features with patients of varying ages and impairment levels was helpful for the developers as they continue to improve the device for commercial use. Although the study was completed with a fixed magnification setting and fixed feature widths/diameters, the benefits across all subjects was still remarkable with most subjects unable to complete tasks at three viewing distances without the device and able to complete one or all tasks with use. The Eye-01 does have the capability to customize magnification with a highly responsive autofocus feature so patients of all impairment levels with AMD should benefit. Continuous text reading for patients with ring scotomas or acuity worse than 20/200 is likely a challenging task no matter the low vision device used but there is still benefit in spot reading and performing tasks daily with an augmented device such as the Eye-01. AMD patients with a ring scotoma have difficulty with reading due to the ring shaped non-seeing area removing letters or words on both the right and the left while reading but they do typically have better visual acuity or discrimination within that ring. A useful study for patients with ring scotoma may be to magnify just slightly using the Eye-01 and then combine this with Britext™ (edge enhancement) to help with loss of contrast sensitivity therefore proving to be a useful tool. In addition, Britext™ with the Eye-01 seems to enhance task performance over magnification alone in most patients with AMD based on study findings. In addition, Britext™ and the Portal™ feature may prove to be an even better combination for daily task performance at varying distances for some patients. The feedback from participants throughout the study regarding training processes, ease of use, and special features such as Warp™ also provided input to the development team as they continued to improve the design and the accompanying training program for market release.

Acknowledgements:

Each of the authors are affiliated with the development of the Eye-01 in some capacity as a consultant (RLK, TT), or have equity in Eyedaptic (BTK, DW, MCM, BDK). Funding for the study was provided by Eyedaptic.

References:

1. Congdon N et al. Causes and prevalence of visual impairment among adults in the United States. Archives of Ophthalmology 2004; 122:477-85
2. McAllister B, Kammer R. Low vision rehabilitation. In: Davey P, ed Ophthalmology - Current Clinical and Research Updates. IntechOpen, 2014
3. Faye E. Clinical Low Vision. Boston, MA, Little Brown & Co, 1984
4. Ehrlich JR, Ojeda LV, Wicker D, et al. Head-mounted display technology for low-vision rehabilitation and vision enhancement. Am J Ophthalmol 2017; 176:26-32
5. Deemer AD, et al. Low vision enhancement with head-mounted video display systems. Optometry and Vision Science 2018; 95;694–703
6. Mansfield J, et al., A new reading-acuity chart for normal and low vision. In: Ophthalmic & Visual Optics/ Noninvasive Assessment of the Visual System. Technical Digest. Washington, DC, 1993;3:232–235.
7. Owsley C, et al. Timed instrumental activities of daily living tasks: relationship to cognitive function and everyday performance assessments in older adults. Gerontology 2002;48: 254–265
8. Gills VL, et al. A new timed instrumental activities of daily living (tiadl) measure for evaluation of rehabilitation outcomes. Invest Ophthalmol Vis Sci ARVO Abstract. 2007; 48:3558
9. Busse A, et al. Adaptation of dementia screening for vision-impaired older persons. Journal of Clinical Epidemiology 2002; 55:909–915

10. Age-Related Eye Disease Study Research Group. Cognitive impairment in the age-related eye disease study. Archives of Ophthalmology 2006;124: 537
11. Sunness JS, et al. Fixation patterns and reading rates in eyes with central scotomas from advanced atrophic age-related macular degeneration and Stargardt disease. Ophthalmology 1996; 103:1458–1466
12. Kollbaum PS, et al. Validation of an ipad test of letter contrast sensitivity. Optometry and Vision Science 2014;291-6
13. Stelmack JA, et al. Psychometric properties of the veteran's affairs low-vision visual functioning questionnaire. Invest Ophthal & Vis Sci 2004; 45:3919-28
14. Culham L, et al. Clinical performance of electronic, head-mounted, low-vision devices. Ophthalmic Physiol Opt 2004; 24:281–90
15. Virgili G, Acosta R, Bentley SA, Giacomelli G, Allcock C., et al. Reading aids for adults with low vision. Cochrane Database of Systematic Reviews 2018; 4:4