Effectiveness of Assistive Technologies for Low Vision Rehabilitation: A Systematic Review

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Abstract: A systematic review of all types of assistive devices indicated the need for more research related to performance measurements and the effectiveness of vision rehabilitation devices.

Low vision describes any condition of diminished vision that is uncorrectable by standard eyeglasses, contact lenses, medication, or surgery that disrupts a person's ability to perform common age-appropriate visual tasks (Jutai et al., 2007). Examples of assistive technologies for vision rehabilitation include handheld magnifiers; electronic vision-enhancement systems; and mobility-related devices, such as long canes and night-vision systems. These types of devices and interventions allow individuals with low vision to lead productive lives and to maintain their independence in everyday activities. In a large survey of providers of low vision services, Elliott et al. (1997) found that for elderly patients with low vision, the primary objectives that were identified at the time of their assessments were to obtain help with reading and vision-oriented daily living activities. Common secondary objectives included being able to watch television and travel independently.

Often, success with an assistive device is determined by how well the device performs and how satisfied the user is with it (Jutai, Fuhrer, Scherer, & DeRuyter, 2005). According to Raasch, Leat, Kleinstein, Bullimore, and Cutter (1997, p. 289), effectiveness is "the degree to which a desired or planned improvement is accomplished in the subjects' usual environment." The desired outcome of low vision rehabilitation is for individuals to attain the maximum function of any remaining vision they may have; increase their level of functional ability; increase their independence; and, as a result, improve their quality of life (Agency for Healthcare Research and Quality Technology Assessment, AHRQ, 2004; Jutai et al., 2005). Outcome measures for determining the effectiveness of assistive devices and vision rehabilitation include both subjective (a person's preference) and objective (such as improved reading ability) measures of performance.

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The primary research objective of this review was to answer the following question: For adults who have low vision, what is the evidence for the effectiveness of commonly prescribed assistive technology interventions for rehabilitation? The categories of assistive technology included optical devices and electronic vision-enhancement systems, mobility-related devices (long canes and night-vision systems), prisms or field enhancement devices, lighting and filters, and adaptive computer technologies. A secondary objective was to synthesize the research evidence related to the following outcome measures with these types of assistive devices for vision rehabilitation: preference, ease of use or satisfaction, and performance.

Methods

Search process and criteria

A search of the literature was conducted to locate research related to all types of visual conditions using search terms, such as *visual impairment, low vision, rehabilitation*, and *assistive technologies* (devices, training, and strategies), on the basis of methods used in our previously published systematic reviews (Hooper, Jutai, Strong, & Russell-Minda, 2008; Strong, Jutai, Russell-Minda, & Evans, 2008a, 2008b). The population of interest was adults with visual impairment or low vision. The interventions of interest included any form of vision rehabilitation using assistive devices, training, or strategies. All types of study designs, methods, and outcomes were considered, including randomized controlled trials and nonrandomized study designs, systematic reviews, and meta-analyses.

The following databases were searched: CINAHL, EBM Reviews (including Cochrane reviews), EMBASE, MEDLINE, PsycInfo, and PubMed. Relevant journals and references were also searched by hand. All potential sources for gray literature (for instance, unpublished or published literature not found in standard journals) were investigated for pertinent data sources, including books, proceedings, and presentations. The search was limited to research published from 1980 to 2007, in English, and on adult populations aged 19 or older. Systematic reviews and meta-analyses were included in the search criteria to compare the transparency and rigor of the assessment processes that were used in this research synthesis. Each of us independently evaluated abstracts to determine their suitability for inclusion and performed quality assessments on selected studies.

Determining the quality of studies

Studies were evaluated using the Downs and Black (1998) instrument, a 27-question checklist for assessing the methodological quality of both randomized controlled trials and nonrandomized studies. The checklist is a valid and reliable instrument for assessing the quality of studies and is sensitive to the important qualities of research designs, with items distributed among key components (see Box 1).

The highest possible score is 28 for randomized controlled trials and 25 for nonrandomized studies. Studies were assigned the following levels: randomized controlled trial (I), cohort (II), case control (III), case series (IV), and expert

Instrument for assessing the quality of randomized controlled trials and nonrandomized studies (summary)

Downs and Black (1998) Checklist

A 27-item checklist used to assess the methodological quality of both randomized and nonrandomized studies of health care interventions. Answers are scored 0 or 1, except for one item in the Reporting subscale, which is scored 0 to 2. The Power item responses were collapsed from the original 0 to 5 to either 0 or 1. The total maximum score is 28.

Reporting (10 items)

Assesses whether the information provided in the paper is sufficient to allow the reader to make an unbiased assessment of the findings of the study.

External Validity (3 items)

Addresses the degree to which the findings of the study can be generalized to the population from which the participants were derived.

Internal Validity—Bias (7 items)

Addresses biases in the measurement of the intervention and the outcome.

Internal Validity—Confounding (6 items)

Addresses bias in the selection of study participants.

Power (1 item)

Addresses whether the negative findings of a study could be due to chance.

Box 1

opinion (V) (Canadian Task Force on the Periodic Health Examination, 1979). Downs and Black score ranges were given corresponding levels of quality: excellent (26–28), good (20–25), fair (15–19), and poor (14 or less). Only randomized controlled trials could be assigned a quality level of excellent because of the Downs and Black scoring process (2 questions on the checklist directly apply to the randomization of subjects). These levels of quality were then mapped to strength-of-evidence levels and used to formulate results. The following strength-of-evidence levels were adapted from methods used by Foley, Teasell, Bhogal, and Speechley (2003): Level 1a (very strong), the findings were supported by the results of 2 or more studies of at least excellent quality; Level 1b (strong), the findings were supported by at least 1 study of excellent quality; Level 2a (moderate), the findings were supported by 2 or more studies of at least good quality; Level 2b (limited), the findings were supported by at least 1 study of good quality; Level 2c (weak), the findings were supported by at least 1 study of fair or poor quality; Level 3 (consensus), in the absence of evidence, agreement by a group of experts on the appropriate course of treatment; and Level 4 (conflicting), disagreement between the findings of at least 2 randomized controlled trials (when there are more than 4 randomized controlled trials, and the results of only 1 are conflicting, the conclusion is based on the results of the majority of the studies unless the study with conflicting results is of a higher quality).

Results

We reviewed 108 studies on vision rehabilitation interventions and related subjective and objective outcome measures: 24 randomized controlled trials and 84 nonrandomized studies with various methods and designs. Nonrandomized studies were grouped into the following categories: cohort, case control, and case series designs (case reports were excluded). Because of space constraints, we discuss 10 studies (4 randomized controlled trials and 6 nonrandomized studies) from the original total, which enabled us to draw the strongest conclusions (see Table 1). Few randomized controlled trials had similar interventions, outcomes, and populations, which typically allows for rigorous comparisons to be made across studies. The majority of the studies we reviewed were largely case series designs with various interventions and outcome measures. We report primarily on the studies that scored 20 points or higher on the Downs and Black instrument (complete evidence tables and reporting on all the studies we reviewed are available from us on request). Studies that scored 20 points or higher could be used to formulate limited (2b), moderate (2a), strong (1b), or very strong (1a) levels of evidence. For categories in which there was an absence of studies scoring 20 points or higher, we discuss the studies that support the highest level of evidence in a specific category. Two Cochrane reviews, one on reading devices (Virgili & Acosta, 2006) and another on orientation and mobility (O&M) programs (Virgili & Rubin, 2006) were reviewed for study selection and methods. Two systematic reviews were reviewed to compare study selection and assessment methods (Adams, Flynn, Alligood, & Johnson, 2003; AHRQ, 2004). No meta-analyses were located.

Optical devices and electronic vision-enhancement systems

Nonelectronic optical devices, such as magnifiers, are typically used for near tasks, such as reading and spotting, and are a popular choice for many individuals with low vision because they are portable and inexpensive. If these conventional devices produce insufficient magnification or cannot provide sustained performance for particular visual tasks, electronic magnification systems and closed-circuit televisions (CCTVs) can provide high levels of magnification with a good field of view. Comparisons of participants' performances using conventional nonelectronic vision devices versus CCTV systems and other electronic vision-enhancement systems can pose challenges because the participants are not always familiar with the devices being compared (Harper, Culham, & Dickinson, 1999). Limited evidence (2b) from one good-quality case series (Goodrich & Kirby, 2001), which used a within-subjects design and a quasi-randomized device assignment, suggested that the participants' speed and duration of reading were significantly greater with CCTV systems than with prescribed optical devices. That study compared the effectiveness of nonelectronic and electronic vision devices on the basis of the reading performance and preferences for devices of 22 U.S. veterans (the inclusion criteria were legal blindness, a central scotoma with an intact peripheral field, and a desire to participate in reading rehabilitation). The participants used their own prescribed optical devices (Eschenbach or COIL stand magnifiers and microscopic lenses) and stand-mounted or

Table 1
Selected Studies.

Study details[a]	Population characteristics	Interventions and outcome measures	Results
Smith et al. (2005), I, 28	225 (total, AMD), 70 (custom prisms), 75 (standard prisms), 80 (placebo)	Randomized, placebo-controlled, double-blind study to determine the effectiveness of prism spectacles for individuals with AMD.	Prism spectacles are no more effective than conventional spectacles for people with AMD.
Greene et al. (1991), I, 20	55 (various ocular conditions)	Participants were assigned to either an Ocutech Vision Enhancing System telescope, or randomized to a control group using Walters or Designs for Vision Expanded Field telescopic systems. All devices were spectacle-mounted telescopic systems. Outcome measures included preference and performance with the device.	There was statistical significance for preference for the new system—the Ocutech Vision Enhancing System—in terms of the device's weight, appearance, adjustability, and acuity. Field of view and image brightness were preferred with the control devices.
Rossi et al. (1990), I, 20	39 (total, hemianopia or visual neglect), 18 (Fresnel prisms), 21 (controls)	Participants with hemianopia or visual neglect from a stroke rehabilitation unit were randomly assigned to either treatment with 15-D Fresnel prisms—wearing the prism for all daytime activities or to controls—or no prism treatment.	Fresnel prisms improved visual perception and mobility, but not activities of daily living.
Szlyk et al. (2005), I (cross-over), 17	10 (total, hemianopic field loss)	Participants were randomly assigned to one of two experimental groups that were statistically similar in age, gender, visual acuity, contrast sensitivity, and visual field loss. Group A received the Gottlieb Visual Field Awareness System prisms and training for three months. This was followed by assessment using the Fresnel prisms during the last three months. Group B received each prism system and training in its use in the opposite order over the same period as Group A. Pre- and postcomparisons of the effectiveness of each lens system were performed.	The lens systems were equal in their effects on performance. Lenses and training may improve driving, but public safety is still a concern.
Soong et al. (2001), IV, 21	37 (total, various ocular conditions), 19 (O&M training), 18 (no training)	Subjects were assigned to an O&M training program (group T) and matched with controls in a no-training (NT) group according to ocular disease, level of visual impairment, and age. Some subjects were prescribed mobility devices, such as long canes.	There was no improvement in mobility performance (measured by percentage of preferred walking speed and error score) for a group of visually impaired subjects immediately after O&M training compared with a control group who did not receive training.
Goodrich & Kirby (2001), IV, 21	22 (AMD, primary diagnosis)	Reading speed and duration were assessed when using the following optical devices: stand-mounted, CCTV, handheld CCTV, and a prescribed optical device.	Reading performance (speed) was significantly greater with the CCTV systems than with prescribed optical devices. No significant differences were found between the two types of CCTV systems (either stand-mounted or handheld). Patients expressed a preference for the stand-mounted system over the handheld.
Bowers et al. (2001), IV, 20	20 (AMD)	Subjects were assessed on reading performance without low vision assessments and with various print sizes at six levels of task illuminance: 50, 300, 600, 1,000, 2,000, and 5,000 lux.	Most subjects required task illumination of at least 2,000 lux to maximize reading performance. Subjective preferences should be considered.

(cont.)

Table 1
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Study details[a]	Population characteristics	Interventions and outcome measures	Results
Scott et al. (2002a), IV, 20	23 (total), 18 (AMD), 5 (controls)	Assessment of visual function parameters on the performance of computer tasks. Subjects completed 125 computer icon identification tasks.	Visual acuity, contrast sensitivity, and color vision defects are significant predictors of the performance of computer tasks. Contrast sensitivity was the most significant predictor of the accuracy of performing computer tasks.
Scott et al. (2002b), IV, 20	23 (total), 18 (AMD), 5 (controls)	Assessed the impact of graphical user interface screen features (icons and screen colors) and the performance of computer tasks.	Icon size and icon set size were significantly associated with the accuracy of performing computer tasks ($p <$ .001). Modifications of graphical user interface designs may permit the improved performance of computer tasks by persons with visual impairments that are due to AMD.
Eperjesi et al. (2004), IV, 15	12 (AMD)	Reading rates were assessed with 10 different colored light filter overlays. A clear overlay with 100% transmittance was used as a control.	Colored light filter overlays were unlikely to provide a clinically significant improvement in reading rates. Rose, purple, and blue filters had a significantly poorer overall ranking in terms of reading rates than did the other colored and clear light filters.

[a] Study details are listed according to the level of evidence and in the order of the quality assessment score (Downs and Black). Note: Study levels: I = randomized controlled trial, II = cohort, III = case control, IV = case series. Downs and Black score ranges were given corresponding quality levels: excellent (26–28) and good (20–25). Studies that scored either in the fair (15–19) or poor (≤14) ranges were excluded, except when they were the only available evidence.

handheld CCTVs. Despite the statistical significance found for improved reading speed with CCTV systems over typical, prescribed optical devices in that study, there were too few other studies of acceptable quality from which to base strong conclusions. The participants expressed a preference for the stand-mounted CCTV system over the handheld system.

Regarding the use of telescopes for spotting and distance-vision tasks, there is limited evidence (2b) from one good-quality cross-over randomized controlled trial (Greene et al., 1991) that the Ocutech Vision Enhancing System spectacle-mounted telescope has advantages over conventional spectacle-mounted Keplerian telescopes (Designs for Vision Expanded Field and Walters

2.75x and 4x), on the basis of the participants' preferences and standard clinical measures of performance. The participants preferred the newer system in terms of the device's weight and appearance and the visual acuity achieved through using the device.

Mobility devices for vision rehabilitation

Individuals with low vision often encounter potentially hazardous elements in their travel paths: undetected curbs and other drop-offs, objects on the floor or in walkways, and overhangs or protruding objects at head height. O&M programs offer instruction and training on how to use assistive devices, such as long canes and night-mobility devices. The primary research objective of our review was to evaluate the evidence of effectiveness related to assistive technology for vision rehabilitation. Although mobility-related devices were included in our criteria, the strength of evidence related to the use and effectiveness of these devices is not strong. A stronger evidence base was found in the research related to O&M training programs (with or without the use of assistive devices). Various outcome measures and research settings have been used in the area of O&M. The results from laboratory-based settings may provide rigorous surrogate outcome measures because they are expected to be closely related to performance in daily life. Alternatively, an indoor mobility course may offer a more controlled setting than the "real world" and thus may be considered more challenging (Hassan, Lovie-Kitchin, & Woods, 2002).

Limited evidence (2b) from one good-quality case series (Soong, Lovie-Kitchin, & Brown, 2001) indicated that mobility performance improves after mobility training on the basis of scores for the percentage of preferred walking speed. Soong et al. compared the mobility performance of 19 individuals who were visually impaired with 18 age-matched individuals who were visually impaired in the control group in an indoor laboratory setting with obstacles set up along the course. Sixteen participants in the training group were given long or support canes, and all the participants were tested during two visits four weeks apart. At each visit, the participant's mobility performance was assessed twice as percentage of preferred walking speed and error score were noted. This error score did not improve significantly ($p = .09$), and the percentage of preferred walking speed improved only in the control group (41% to 46% for the untrained group, 40% to 40% for the trained group; $p = .008$ for the interaction between group and visit in the analysis of variance).

Two fair-quality (2c) randomized controlled trials (Straw & Harley, 1991; Straw, Harley, & Zimmerman, 1991) evaluated the effectiveness of an O&M assessment tool and training curriculum for adults with visual impairments (50% were completely blind) on an indoor mobility course with volunteers who were trained by O&M instructors. The training period was 90 minutes per week for 10 to 12 weeks (the training period was longer than in Soong et al., 2001). Straw et al. and Straw and Harley (neither is listed in Table 1) did not incorporate the use of any type of mobility device, which makes it difficult to determine the effectiveness of mobility-related devices and the respective training program that was implemented.

Night blindness is caused primarily by retinitis pigmentosa (RP) and limits an individual's mobility, independence, and ability to travel safely in the environment. Other conditions that are affected by night blindness or impaired nighttime functioning include age-related macular degeneration (AMD), diabetes, glaucoma, cataracts, and even normal aging. The most common approach to nighttime mobility concerns is to use a long cane. Another option is to use night mobility devices or night vision devices. There is weak evidence that night vision devices for individuals with RP and other visual conditions are effective for improving nighttime mobility. More randomized controlled trials and controlled studies are required. Additional suggestions for future research on O&M training include the assessment of various types of mobility devices and their associated training programs, self-reported mobility performance, and the psychological effort required for independent mobility.

Prisms and other field-enhancement devices

Prisms and other types of field-enhancement devices are sometimes prescribed for people with visual field loss resulting from hemianopia and unilateral visual neglect. Homonymous hemianopia and unilateral visual neglect are common vision problems following stroke. Fresnel prisms (including cemented prism segments or molded prismatic lenses and mirrors) may be used to provide enhanced awareness of obstacles in the affected visual field and may be helpful in rehabilitation. There is limited (2b) evidence (Rossi, Kheyfets, & Reding, 1990) that treatment with a 15-diopter Fresnel prism is associated with an increase in visual perception scores (but not activities of daily living) in stroke patients with homonymous hemianopia and visual neglect. In Rossi et al.'s study, prisms may have enhanced the participants' visual perception and had a significant effect on the participants' mobility performance. There is limited (2b) evidence (Szlyk, Seiple, Stelmack, & McMahon, 2005) that Fresnel prisms and Gottlieb's Visual Field Awareness System are equally effective with respect to visual skills that are associated with recognition, mobility, peripheral detection, scanning, tracking, and driving.

Prismatic lenses have also been advocated for some individuals with AMD (central vision loss) when fixation is shifted to the nondiseased areas of the retina. The strongest (1b) conclusion related to prisms is based on one "excellent" randomized controlled trial (Smith, Dickinson, Cacho, Reeves, & Harper, 2005), which suggests that prism relocation spectacles are no more effective than are conventional eyeglasses for people with AMD in improving visual acuity. Smith et al. (2005) measured distance visual acuity (logMAR) as the primary outcome, and the secondary outcome measures included reading speed and critical print size, the 25-item National Eye Institute Visual Functioning Questionnaire (NEI-VFQ), the Melbourne Low-Vision ADL Index, and the Manchester Low Vision Questionnaire (MLVQ). All the participants wore their test spectacles while being assessed at the baseline and at the

NEI-VFQ assessment at the three-month follow-up, and the primary outcome measure (visual acuity) and the other measures showed no difference between the three groups. Most of the participants wore their test spectacles at least some of the time during the three-month trial period, as shown on the MLVQ and in their personal diaries.

Lighting and filters

Research has shown that the reading performance of persons with low vision is more likely to improve with the increased illumination of tasks (Bowers, Meek, & Stewart, 2001; Eldred, 1992). Proper lighting is also important for receiving the full benefits of optical devices for reading rehabilitation. There is limited evidence (2b) from one good-quality case series (Bowers et al., 2001) that the majority of participants with AMD required illumination of at least 2,000 lux to maximize their reading performance, and Bowers et al. recommended that optimal illumination should be determined on an individual basis using objective measures of performance, such as reading, and subjective assessments of visual comfort. Colored filters (lenses) have been advocated by some providers and the media for reducing glare or enhancing vision. There is weak evidence (2c) from one fair-quality case series (a within-subjects design) (Eperjesi, Fowler, & Evans, 2004) that no specific color or type of light filter enables better reading performance (for people with AMD).

Adaptive computer technologies

Individuals who are visually impaired frequently encounter vision and accessibility-related challenges when using the Internet or performing other common computing functions. Adaptive technologies, such as text magnification, screen readers, and digital image enhancements (Leat, Omoruyi, Kennedy, & Jernigan, 2005) can help both to enhance and to substitute for the visual and sensory functions that are required during computer use. Moderately strong (2a) evidence from two good-quality case series (Scott, Feuer, & Jacko, 2002a, 2002b) suggests that for participants with AMD, the accuracy and performance of computer tasks are linked with certain measures of visual function, the size of icons, and the background color of the computer screen. In one case series (Scott et al., 2002b), the impact of visual functions on the performance of computer tasks (the identification of icons) was evaluated with 18 participants with AMD and 5 sighted participants in the control group. The results indicated that visual acuity and contrast sensitivity are significantly associated with the performance of computer tasks. The other case series (Scott et al., 2002a) investigated the relationship and impact of graphical user interface screen features on the performance of computer tasks by 18 participants with AMD. These participants underwent the same visual evaluations as those in the previous study and completed 125 computer tasks with five icon sizes and sets (number of icons displayed) and five screen background colors (black, white, red, green, and blue). The sizes of icons and sets were significantly associated with the accuracy of performing computer tasks ($p < .001$), but background colors were not ($p = .63$). A larger icon size was significantly associated with a shorter time to complete tasks ($p = .001$).

Discussion

This review of research revealed both strengths and weaknesses in the research on the effectiveness of assistive technologies for people with all forms of vision loss. We found few randomized controlled trials that incorporated the randomization of participants or devices with placebo-controlled and double-blind designs. In addition, we found few observational studies that included a separate control group. The majority of observational studies had small samples and frequently used within-subjects designs with internal controls. Aside from these methodological concerns, it is clear from the research literature that reading and mobility are two of the most crucial activities of daily living for many people with various forms of vision loss, but particularly for those with age-related or acquired vision loss.

The findings of our review indicated that optical devices (electronic and nonelectronic) are effective and accessible rehabilitation options. Moderately strong evidence indicates that electronic stand-mounted or handheld CCTVs can improve reading performance and are generally preferred by persons with low vision over standard nonelectronic optical devices. Simple nonelectronic magnifiers are still preferred by individuals when portability and cost may be an issue. In addition to magnification needs, proper lighting (at least 2,000 lux) is equally vital for reading and daily activities, especially for those with age-related vision loss.

The use of prisms can have specific applications, depending on the level of visual impairment and situations. Moderately strong evidence suggests that for individuals with AMD, there is no particular benefit to wearing prism glasses, on the basis of both subjective and objective outcome measures. For individuals with hemianopia or visual neglect, there is limited evidence of the effectiveness of using Fresnel prisms, even with training. There is no indication that any particular color filter or spectacle lens will enhance vision-related tasks, such as reading, and there is limited evidence that telescopes can improve reading or face-recognition or discrimination tasks. Moderately strong evidence suggests valid links between the performance of computer tasks and visual function, icon sizes, and other features of graphical user interfaces. This finding suggests that extra attention needs to be paid to those with particular vision problems, such as deficits in color vision or contrast sensitivity, with respect to how well they can use computers. O&M training programs can help people who are visually impaired feel confident and independent while traveling, but it is difficult to arrive at strong conclusions regarding the most effective type of mobility device.

Despite the lack of strong evidence for the effectiveness of assistive technologies for vision rehabilitation, individuals who are visually impaired can do more to enhance their lives by making decisions that are based on their preferences and needs. Generally speaking, the challenges that are posed to both the clinical and research communities include a deficit of effective and standardized outcome measures for evaluating satisfaction, success, and performance with assistive technologies, strategies, and training. Yet, a "deficit" may not necessarily be a negative aspect in the literature; it may simply reflect the number of variations among devices and techniques and the diversity of low vision conditions and situations. Vision-specific instruments (both qualitative and quantitative) that are designed to measure participants' satisfaction with devices, as well as the quality of their lives, have been proved useful in providing valuable information to the low vision research community. There is a strong case for using a wide range of outcome measures to describe the effectiveness of vision rehabilitation, at least at present, until studies identify which outcomes are the most important and nonredundant (Harper, Doorduyn, Reeves, & Slater, 1999).

During the rehabilitation assessment process, it is vital for the needs of a person with low vision (such as the desire to read a newspaper or to participate in social activities) to be discussed. If devices are prescribed, training in the use of the devices is usually assumed to be an integral link that must be incorporated for any amount of success with the device. Assessments should take into consideration distinctions between "verified utility" and "presumed utility," meaning that the individual who wishes to use a device for reading a book, for example, should probably use a device for this purpose, rather than read a test card with various print samples on it (Strong, Jutai, Bevers, Hartley, & Plotkin, 2003). Another approach to consider in the selection of assistive devices is the concept of "competitive enablement" (Strong, Jutai, Plotkin, & Bevers, 2008). Competitive enablement allows consumers to make informed choices by evaluating various types of devices specific to their needs and activities, and lessens the chance that they will abandon the devices they have chosen later. There are many devices available today with similar functions, but these slight differences in functional attributes will vary in usefulness from person to person.

References

Adams, E., Flynn, K., Alligood, E., & Johnson, T. (2003, May). *Optical devices for adults with low vision: A systematic review of published studies of effectiveness*. Boston: VA Technology Program, Office of Patient Care Services. Retrieved from http://www.va.gov/vatap/pubs/lowvision.pdf

Agency for Healthcare Research and Quality Technology Assessment. (2004). *Vision rehabilitation for elderly individuals with low vision and blindness.* Rockville, MD: Author. Retrieved from http://www.cms.hhs.gov/InfoExchange/downloads/RTCvisionrehab.pdf

Bowers, A. R., Meek, C., & Stewart, N. (2001). Illumination and reading performance in age-related macular degeneration. *Clinical & Experimental Optometry, 84,* 139–147.

Canadian Task Force on the Periodic Health Examination. (1979). The periodic health examination. *Canadian Medical Association Journal*, *121*, 1193–1254.

Downs, S., & Black, N. (1998). The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *Journal of Epidemiology & Community Health, 52,* 377–384.

Eldred, K. B. (1992). Optimal illumination for reading in patients with age-related maculopathy. *Optometry & Vision Science, 69,* 46–50.

Elliott, D. B., Trukolo-Ilic, M., Strong, J. G., Pace, R., Plotkin, A., & Bevers, P. (1997). Demographic characteristics of the vision-disabled elderly. *Investigative Ophthalmology & Vision Science, 38,* 2566–2575.

Eperjesi, F., Fowler, C. W., & Evans, B. J. W. (2004). The effects of coloured light filter overlays on reading rates in age-related macular degeneration. *Acta Ophthalmologica Scandinavica*, *82,* 695–700.

Foley, N. C., Teasell, R. W., Bhogal, S. K., & Speechley, M. R. (2003). Stroke rehabilitation evidence-based review: Methodology. *Topics in Stroke Rehabilitation*, *10*, 1–7.

Goodrich, G. L., & Kirby, J. (2001). A comparison of patient reading performance and preference: Optical devices, handheld CCTV (Innoventions Magni-Cam), or stand-mounted CCTV (Optelec Clearview or TSI Genie). *Optometry, 72,* 519–528.

Greene, H. A., Pekar, J., Brilliant, R., Freeman, P. B., Lewis, H. T., Siwoff, R., Paton, C., Madden, D. J., & Westlund, R. (1991). The Ocutech Vision Enhancing System (VES): Utilization and preference study. *Journal of the American Optometric Association, 62,* 19–26.

Harper, R., Culham, L., & Dickinson, C. (1999). Head-mounted video magnification devices for low vision rehabilitation: A comparison with existing technology. *British Journal of Ophthalmology*, *83,* 495–500.

Harper, R., Doorduyn, K., Reeves, B., & Slater, L. (1999). Evaluating the outcomes of low vision rehabilitation. *Ophthalmic and Physiological Optics*, *19,* 3–11.

Hassan, S., Lovie-Kitchin, J., & Woods, R. (2002). Vision and mobility performance of subjects with age-related macular degeneration. *Optometry & Vision Science, 79,* 697–707.

Hooper, P. L., Jutai, J. W., Strong, J. G., & Russell-Minda, E. (2008) Age-related macular degeneration and low vision rehabilitation: A systematic review. *Canadian Journal of Ophthalmology*, *43*(2), 180-187.

Jutai, J. W., Fuhrer, M. J., Scherer, M. J., & DeRuyter, F. (2005). Toward a taxonomy of assistive technology device outcomes. *American Journal of Physical Medicine & Rehabilitation, 84,* 294–302.

Jutai, J. W., Hooper, P., Strong, G., Russell-Minda, E., Cooper, L., Hutnik, C., et al. (2007). *Vision Rehabilitation Evidence-Based Review: Module 1: Terminology, Demography, and Epidemiology of Low Vision.* London, Ontario, Canada: University of Western Ontario and Canadian National Institute for the Blind.

Leat, S. J., Omoruyi, G., Kennedy, A., & Jernigan, E. (2005). Generic and customized digital image enhancement filters for the visually impaired. *Vision Research*, *45*, 1991–2007.

Raasch, T. W., Leat, S. J., Kleinstein, R. N., Bullimore, M., & Cutter, G. (1997). Evaluating the value of low vision services. *Journal of the American Optometric Association*, *68,* 287–295.

Rossi, P. W., Kheyfets, S., & Reding, M. J. (1990). Fresnel prisms improve visual perception in stroke patients with homonymous hemianopia or unilateral visual neglect. *Neurology, 40,* 1597–1599.

Scott, I. U., Feuer, W. J., & Jacko, J. A. (2002a). Impact of graphical user interface screen features on computer task accuracy and speed in a cohort of patients with age-related macular degeneration. *American Journal of Ophthalmology*, *134,* 857–862.

Scott, I. U., Feuer, W. J., & Jacko, J. A. (2002b). Impact of visual function on computer task accuracy and reaction time in a cohort of patients with age-related macular degeneration. *American Journal of Ophthalmology, 133,* 350–357.

Smith, H. J., Dickinson, C. M., Cacho, I., Reeves, B. C., & Harper, R. A. (2005). A randomized controlled trial to determine the effectiveness of prism spectacles for patients with age-related macular degeneration. *Archives of Ophthalmology, 123,* 1042–1050.

Soong, G. P., Lovie-Kitchin, J. E., & Brown, B. (2001). Does mobility performance of visually impaired adults improve immediately after orientation and mobility training? *Optometry & Vision Science*, *78,* 657–666.

Straw, L. B., & Harley, R. K. (1991). Assessment and training in orientation and mobility for older persons: Program development and testing. *Journal of Visual Impairment & Blindness*, *85,* 291–296.

Straw, L. B., Harley, R. K., & Zimmerman,

G. J. (1991). A program in orientation and mobility for visually impaired persons over age 60. *Journal of Visual Impairment & Blindness*, *85*(3), 108–112.

Strong, G., Jutai, J. W., Bevers, P., Hartley, M., & Plotkin, A. (2003) The psychosocial impact of closed-circuit television low vision aids. *Visual Impairment Research*, *5,* 179–190.

Strong, G., Jutai, J., Plotkin, A., & Bevers, P. (2008). Competitive enablement: A consumer-oriented approach to device selection in device-assisted vision rehabilitation. In W. C. Mann (Ed.), *Aging, disability, and independence: Selected papers from the 4th International Conference on Aging, Disability and Independence* (pp. 179–195). Amsterdam: IOS Press.

Strong, J. G., Jutai, J. W., Russell-Minda, E., & Evans, M. (2008a). Driving and low vision: An evidence-based review of rehabilitation. *Journal of Visual Impairment & Blindness*, *102,* 410–419.

Strong, J. G., Jutai, J. W., Russell-Minda, E., & Evans, M. (2008b). Driving and low vision: Validity of assessments for predicting driver performance. *Journal of Visual Impairment & Blindness*, *102,* 340–351.

Szlyk, J. P., Seiple, W., Stelmack, J., & McMahon, T. (2005). Use of prisms for navigation and driving in hemianopic patients. *Ophthalmic and Physiological Optics*, *25,* 128–135.

Virgili, G., & Acosta, R. (2006). Reading aids for adults with low vision. *Cochrane Database of Systematic Reviews*, *Issue 4,* Art. No.: CD003303.

Virgili, G., & Rubin, G. (2006). Orientation and mobility training for adults with low vision. *Cochrane Database of Systematic Reviews*, *Issue 3,* Art. No.: CD003925.

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