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Television, computer and portable display device use by people with central vision impairment

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Abstract

Purpose: To survey the viewing experience (e.g. hours watched, difficulty) and viewing metrics (e.g. distance viewed, display size) for television (TV), computers and portable visual display devices for normally-sighted (NS) and visually impaired participants. This information may guide visual rehabilitation.
Methods: Survey was administered either in person or in a telephone interview on 223 participants of whom 104 had low vision (LV, worse than 6/18, age 22–90 years, 54 males), and 94 were NS (visual acuity 6/9 or better, age 20–86 years, 50 males). Depending on their situation, NS participants answered up to 38 questions and LV participants answered up to a further 10 questions.
Results: Many LV participants reported at least 'some' difficulty watching TV (71/103), reported at least 'often' having difficulty with computer displays (40/76) and extreme difficulty watching videos on handheld devices (11/16). The average daily TV viewing was slightly, but not significantly, higher for the LV participants (3.6 h) than the NS (3.0 h). Only 18% of LV participants used visual aids (all optical) to watch TV. Most LV participants obtained effective magnification from a reduced viewing distance for both TV and computer display. Younger LV participants also used a larger display when compared to older LV participants to obtain increased magnification. About half of the TV viewing time occurred in the absence of a companion for both the LV and the NS participants. The mean number of TVs at home reported by LV participants (2.2) was slightly but not significantly ($p = 0.09$) higher than NS participants (2.0). LV participants were equally likely to have a computer but were significantly ($p = 0.004$) less likely to access the internet (73/104) compared to NS participants (82/94). Most LV participants expressed an interest in image enhancing technology for TV viewing (67/104) and for computer use (50/74), if they used a computer.
Conclusions: In this study, both NS and LV participants had comparable video viewing habits. Most LV participants in our sample reported difficulty watching TV, and indicated an interest in assistive technology, such as image enhancement. As our participants reported that at least half their video viewing hours are spent alone and that there is usually more than one TV per household, this suggests that there are opportunities to use image enhancement on the TVs of LV viewers without interfering with the viewing experience of NS viewers.

Introduction

Television (TV) watching is a common activity of daily living. While TV is primarily a visual experience, people with vision impairments (from mild to profound) report watching TV for durations that are comparable to[1–3] or more than[4] those reported by normally-sighted people. Some older studies have found that people with vision

impairments reported TV watching as an important family time activity.[1,5,6] TV watching is also commonly included as one of the items in visual function and quality of life questionnaires.[7] In the last two decades there have been large changes in the content, methods of delivery and viewing patterns of videos. The internet has become a major source of information, and often includes moving images, including TV programs, movies, videos (e.g. YouTube) and various forms of animation (e.g. Flash). Moving image presentations are becoming common on other devices, particularly portable devices such as iPad, iPod and mobile (cell) phones.

Older people (e.g. over 65 years of age) tend to spend more time watching TV than others.[8] The current demographic trend in most western countries is for an increase in the proportion of older people and the associated higher incidence of vision impairment with increasing age from conditions such as age-related macular degeneration (AMD),[9–11] suggests that more people with vision impairment will be spending more time watching TV.

Often, people with vision impairment due to reduced central vision report difficulty with TV, with complaints such as difficulty in getting useful visual information, distinguishing characters from their faces and following a storyline.[3,12] A small number of aids have been devised to improve TV usage, some have been demonstrated to provide benefit to people with vision impairment, but none have been widely adopted. The three main approaches have been non-visual methods (sensory substitution), image magnification and contrast enhancement. Additional information about TV can be provided by sensory substitution techniques such as audio description provided by Descriptive Video Service[6,13] or by other people (e.g. a relative watching at the same time). While potentially useful, these are limited and may interfere with the TV experience and the benefit has yet to be demonstrated.[13]

To provide (effective) magnification, a common solution is sitting closer or using larger sized TV screens. Sitting closer (e.g. 1 m)[14,15] is often rejected by people with vision impairment due to difficulty with room ergonomic needs and can disrupt the viewing experience of others. A Fresnel lens placed over the screen can provide magnification, but with reduced clarity and contrast. Others use head- and spectacle-mounted telescopes. However, the field limitation of telescopes may result in context being lost, as the peripheral parts of the image are no longer visible. Of people with spectacle-mounted telescopes about 80–50% report using them for watching TV.[16,17]

Image processing for vision rehabilitation, first proposed in the 1980s,[18,19] has been evaluated for contrast enhancement,[15,18,20–26] image binarisation,[19,20,24,27] and edge enhancement.[3,14,28] In general, image enhancement has been shown to improve the perceived image quality,[3,14,23,25,26,29] was often selected (adjusted) over original images[14,15,25,30] and improved performance[20,25] for people with vision impairment. However, the benefits found with these image enhancements have been modest. Thus far, no image enhancement technique has been used in a commercial vision rehabilitation device. While people with vision impairment have been reported to show a preference for image enhancement, normally-sighted individuals may not prefer image enhancement.[15,26]

Most image enhancement approaches to rehabilitation of viewing TV would have an impact on other people watching at the same time. While family time was reported as an important aspect of TV watching in surveys completed 2–4 decades ago,[1,5] viewing with others may no longer be as important or as common. Watching alone is more common with increasing age[2] and there are an average of 2.86 TV sets per household in the USA,[31] usually in different rooms, suggesting that many people with vision impairment could find considerable opportunities to make use of vision rehabilitation such as image enhancement. With the rapidly changing entertainment technology, the proliferation of portable visual display devices such as the Kindle and iPad, and with the extensive use of computers and internet to obtain and watch videos, TV viewing habits can be expected to have changed since the available studies. Also, while internet and computer use has expanded dramatically in the last decade, people with vision impairment have been reported to use these technologies less than normally-sighted people[32,33] and the same may be true for portable video devices.

The purpose of our study was to survey the video viewing habits for TV, movies, computers and portable visual display devices of people with vision impairment (particularly, reduced central vision) and with normal sight. The information obtained through this survey will help us understand their current video viewing habits. Such knowledge can guide vision rehabilitation efforts for video watching by people with vision impairment for TV, computer viewing and portable visual display devices.

Methods

The study was approved by the Institutional Review Board (IRB) of Schepens Eye Research institute and adhered to the tenets of declaration of Helsinki. The survey was administered either in person or as a telephone interview. Verbal consent from each participant was obtained for the telephone-administered survey after the study was explained and the consent form was read out. Written consent was obtained from participants who took the survey in person.

Survey administration

A pilot survey of 19 participants with vision impairment was conducted in June 2008 (aged 40–86 years; binocular visual acuity 6/15–6/120). A more detailed survey (items are reported in the Appendix) of 223 participants (aged 20–90 years; binocular visual acuity 6/4.5–6/300) was administered from July 2009 to September 2010. The detailed survey was repeated on 14 of the 19 pilot subjects who were reachable and agreed to participate. As the average time interval between the administration of the pilot survey and the detailed survey was about 2 years (range 1.8–2.2 years) for these 14 participants differences between the two administrations reflected both repeatability of the items and the change of responses with time, which could have happened due to change in lifestyle or circumstances of these participants. Three examiners administered the detailed survey either over the telephone or in person and one examiner administered the survey only in person. For both the telephone ($n = 147$) and in person ($n = 76$) administration of the survey, the questions were verbally asked and all the choices were read out before the participant could choose an answer. There were a total of 48 questions and the survey took about 10–15 min to complete. All participants were asked up to 38 questions (depending on the number of TVs in the household and usage of computers) to determine their video viewing habits on TV, computer and portable devices. Participants with vision impairment also answered up to 10 additional questions to determine the difficulty level of viewing videos (the Appendix lists all questions and the available responses). Most participants seemed able to give the distances and screen dimensions of the video devices without difficulty. When interviewed by telephone, the participant was able to measure or estimate the distances from their TV at home (if they so desired). For in-person administration of the questionnaire, participants, if they had difficulty, were able to look at the different TV/computer monitors in our lab and drawings of sample outlines on a board to estimate the distances and sizes. Data collection was administered by the examiner using a custom FileMaker Pro5.5 (FileMaker Inc., http://www.filemaker.com/) interface with a layout like a paper-based form. The verbal responses were recorded in the electronic file by the examiner.

Study participants

Participants who visited our vision rehabilitation laboratory to participate in other studies were approached to participate in the survey. Some of the normally-sighted participants were employees of our institute or were escorting the participants with vision impairment for studies. We used a database that contains information about individuals who have participated in studies or indicated an interest in participating in studies to identify other potential participants. Telephone calls to these individuals were made to request their participation in the survey over the telephone.

Since our interest was the impact of reduced central vision, people with extensive peripheral visual field loss (e.g. hemianopia and retinitis pigmentosa), that could impose other or additional problems for viewing TV and other video images, were not included. Participants with a binocular habitual visual acuity of 6/9 or better were considered as having normal sight (NS). Participants with a binocular visual acuity worse than 6/18 were considered as having low vision (LV). By those criteria, there were 94 participants with NS (aged 20–86 years; 50 males) and 104 participants with LV (aged 22–90 years; 54 males). The remaining 25 participants (aged 20–88 years, 11 males) had visual acuity 6/12–6/18 and were considered as having reduced vision. Five of the NS participants had early AMD in one or both eyes. This classification of the groups based on visual acuity is similar to that proposed by Colenbrander.[34] Results for the participants with reduced vision are not reported here, but analyses that included some or all of these 25 individuals were not substantively different from the result reported here for the remaining 198 participants.

Visual acuity measurements were made for participants who took the survey in person. When the survey was administered over the telephone, if the participant reported that their vision had not changed since their last visit to our laboratory, the visual acuity that was recorded in our database from the participant's earlier visit was used. When the survey was administered over the telephone, if the participant knew a more recent visual acuity measurement, the new, participant-reported values were used ($n = 5$ participants). When the survey was administered over the telephone, if the participant did not know their present visual acuity but reported their vision to be reduced when compared to the most recent visit to our laboratory, then a visual acuity one line worse than the earlier value was used ($n = 8$ participants). There was no significant correlation between visual acuity and age for the LV participants (Spearman, $\rho_{103} = -0.05$, $p = 0.64$), but there was a significant correlation ($\rho_{93} = 0.33$, $p = 0.001$) for the NS participants, as has been noted previously.[35]

As shown in *Figure 1*, there were more participants aged <30 years with NS ($n = 12$) than with LV ($n = 6$), and there were more participants aged over 80 years with LV ($n = 26$) than with NS ($n = 19$), but overall, there was no significant difference between the age distributions of the two groups (Kolmogorov–Smirnoff two sample,

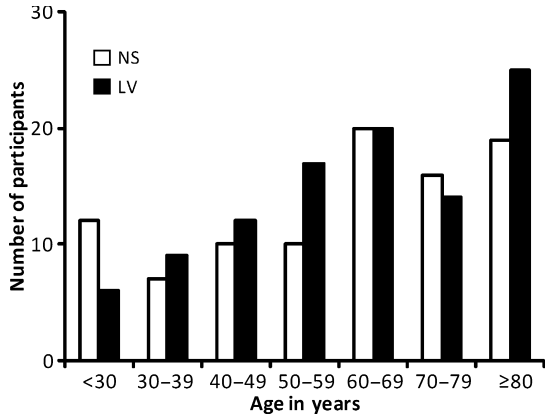

Figure 1. The age distribution of the 104 low vision (LV) and 94 normally-sighted (NS) survey participants.

$z_{197} = 0.81$, $p = 0.53$). Neither was there a significant difference in gender between the two groups (Pearson chi-square, $\chi^2_1 = 0.03$, $p = 0.86$). There was a significant difference in race between the two groups ($\chi^2_1 = 10.4$, $p = 0.006$), with more Asian (7 vs 0), more Black (10 vs 5) and fewer White (70 vs 87) participants in the NS than the LV group. This difference may reflect limitations in our recruitment methods for this convenience sample, or it may reflect real differences in the prevalence of LV.[10,36] Participants with LV reported a wide range of ocular diseases, of which age-related macular degeneration was the most common (*Table 1*). Sixteen participants reported more than one ocular disease condition.

Data analysis

Data from the FileMaker Pro5.5 database was exported into the SPSS statistical package v. 19.0.0 (IBM, http://www.spss.com/) for data analysis. Since we performed many statistical analyses, $p \leq 0.01$ was considered statistically significant. As our sample size was not large ($n = 198$), effects that approached significance ($0.01 < p \leq 0.10$) are also noted.

Table 1. Frequency of ocular diseases reported by the survey participants. Some ($n = 16$) participants reported more than one condition

Ocular disease	Number of cases
Age-related macular degeneration (AMD)	59
Stargardt's/Juvenile macular degeneration (JMD)	20
Optic neuropathy	13
Albinism	8
Glaucoma	7
Myopic degeneration	6
Retinopathy of pre-maturity	6
Nystagmus	5
Cone/Rod dystrophy	4
Diabetic retinopathy	3
Cataract	3
Others	14

Results

Television

All but three participants (one LV, age 34 years and two NS, aged 26 and 31 years) had a TV at home. Of these three, the two NS participants watched TV elsewhere (at a friend or relative's residence) and answered the survey questions based on that viewing experience. The one LV participant did not watch TV elsewhere and did not answer questions related to TV viewing. Most (176/198) had cable or satellite TV access, while 19 participants relied on broadcast TV service, with no difference between the LV and NS groups.

The number of TVs at home reported by LV participants (average 2.2) was slightly, but not significantly, higher than the number reported by normally-sighted participants (average 2.0) (*Table 2*). The number of TVs at home increased with increasing age for the NS group but not for the LV group, and not with visual acuity for either group (*Table 3*). Many participants (77/196) had a wide screen (high definition: HDTV) for their first TV, with the proportion of wide screen TVs becoming lower for the second (23/103) and third (6/30) TVs. LV participants were slightly more likely to have a first and second TV that was widescreen than NS participants.

The number of hours of TV watched per day was slightly, but not significantly ($p = 0.07$), higher for the LV group (average 3.6 h) than the NS group (average 3.0 h). The number of hours of TV watching was correlated with age but not with visual acuity. The number of hours of TV watched increased with increasing number of TVs at home for both groups ($\rho \geq 0.45$, $p < 0.001$). When watching TV, people reported that about half of their viewing occurred when there was usually not another viewer ('sometimes', 'rarely' and 'never') (*Figure 2*). This viewing pattern was the same for the two groups (Kolmogorov–Smirnov two sample, $z_{195} = 0.71$, $p = 0.69$).

Of the 103 LV participants, 71 reported at least 'some' difficulty for overall TV viewing (*Figure 3a*), with 77 reporting having difficulty at least 'often' with details and 67 reporting missing important information at least 'often' (*Figure 3b*). As the three questions about difficulty with TV (overall difficulty, missing details and missing important information) were significantly correlated ($\rho_{102} = 0.48$–0.56, $p < 0.001$), by averaging the responses to those questions, we produced a composite variable that was used to investigate predictors of difficulty with watching TV. Difficulty with watching TV increased

Table 2. Summary of video viewing habits compared between the low vision (LV) group and normally-sighted (NS) group

(Survey questionnaire number), survey question	LV group median (range)/ proportion	NS group median (range)/ proportion	Statistical test of difference
(6) Number of TVs at home	2 (0–6)	2 (0–5)	$z_{196} = 1.65$, $p = 0.10$
(7) Service provided by cable or satellite	95/104	81/94	$\chi^2_1 = 2.02$, $p = 0.16$
(8 + 14 + 20) Duration for viewing TV (h)	3.5 (0–10.5)	3.0 (0–9.5)	$z_{197} = 1.79$, $p = 0.07$
(10) Viewing distance for the first TV (feet)	5 (<2 to >10)	7 (∼3 to >10)	$z_{195} = 8.5$, $p <$ **0.001**
(11) Size of the first TV (inches)	35 (∼17 to ∼60)	25 (∼12 to ∼60)	$z_{195} = 3.5$, $p <$ **0.001**
Visual angle of first TV (from questions 10 and 11, degrees)	38 (∼12 to ∼127)	18 (∼6.4 to ∼44)	$z_{195} = 9.1$, $p <$ **0.001**
(12) First TV is HDTV	47/103	30/93	$\chi^2_1 = 3.66$, $p = 0.06$
(18) Second TV is HDTV	18/61	5/42	$\chi^2_1 = 4.44$, $p = 0.03$
(26) Computer at home	87/104	78/94	$\chi^2_1 = 0.02$, $p = 0.90$
(27) Viewing DVDs on computer	22/84	25/78	$\chi^2_1 = 0.68$, $p = 0.41$
(28) HD-DVD or blu-ray on computer or TV	12/104	10/94	$\chi^2_1 = 0.04$, $p = 0.84$
(29) Internet access at home	77/87	77/78	$\chi^2_1 = 6.02$, $p = 0.014$
(30) Internet access elsewhere	38/104	63/94	$\chi^2_1 = 18.4$, $p <$ **0.001**
Internet access elsewhere if no computer at home	2/17	5/16	$\chi^2_1 = 1.87$, $p = 0.17$
(32) Internet access	73/104	82/94	$\chi^2_1 = 8.43$, $p =$ **0.004**
(33) Watching videos on internet	40/73	54/82	$\chi^2_1 = 1.98$, $p = 0.16$
(36) Viewing distance from computer (feet)	0.75 (0.25–2.5)	1.5 (0.25–2.5)	$z_{152} = 4.1$, $p <$ **0.001**
(37) Size of computer screen (inches)	18 (10.5–25)	16 (10.5–30)	$z_{103} = 3.4$, $p <$ **0.001**
Visual angle of computer screen (from questions 36 and 37, degrees)	76 (33–153)	53 (26–143)	$z_{102} = 5.0$, $p <$ **0.001**
(44) Have video-capable handheld device	24/102	29/91	$\chi^2_1 = 1.68$, $p = 0.20$
(45) Used handheld device to watch videos	16/104	20/94	$\chi^2_1 = 1.15$, $p = 0.28$
(47) Use personal DVD player	19/104	22/94	$\chi^2_1 = 0.79$, $p = 0.37$
(48) Watch movies in theatre	77/104	82/94	$\chi^2_1 = 5.44$, $p = 0.02$

Number of hours watch TV per week is the sum of the hours reported for up to three TVs (questions 8, 14 and 20). Visual angles were computed from the reported size and viewing distances. Significant ($p \leq 0.01$) differences are indicated by bold font and differences that approached significance ($0.01 < p \leq 0.10$) are underlined. The Mann–Whitney test was used to compare frequencies and other distributions of responses. The Pearson Chi-square (χ^2) test was used to compare binary responses (e.g. Q26). For simplicity of presentation in this table, responses to some questions about frequency (e.g. Q27) were binarised (i.e. either 'never' or 'yes'). Comparisons of those frequencies are presented in the text.

slightly, but not significantly, with age (Spearman, $\rho_{102} = 0.17$, $p = 0.08$) and was not correlated with visual acuity ($p = 0.33$).

The TVs reported by LV participants were larger ($p < 0.001$) than those reported by the NS participants (*Table 2* and *Figure 4*). There was a non-significant trend ($p = 0.09$) for NS participants with 'worse' visual acuity (visual acuity of NS participants ranged from 6/4.5 to 6/9) to have a larger TV, but, surprisingly, this was not the case for LV participants (*Table 3*). TV size was not significantly correlated with difficulty with watching TV among the LV participants ($\rho_{101} = -0.16$, $p = 0.11$). TV size decreased with increasing age among LV participants but not among NS participants (*Table 3*). A multiple regression analysis found that younger LV participants had larger TVs than younger NS participants, whereas older LV and NS participants had TVs of about the same size. This suggests that, in general, older LV participants did not have access to larger TVs to compensate for poor vision or perceived difficulty with their viewing experience.

The viewing distances reported by LV participants (average 4.3 feet) were smaller ($p < 0.001$) than those reported by the NS participants (average 7.6 feet). LV participants with worse visual acuity had shorter TV viewing distances (*Table 3*).

Effective magnification, obtained by increasing TV size or decreasing viewing distance, was directly assessed through the visual angle of the TV, estimated from the reported size and viewing distance. Among the NS participants, visual angle was more highly correlated with TV size ($\rho_{92} = 0.64$, $p < 0.001$) than with viewing distance ($\rho_{92} = -0.40$, $p < 0.001$), suggesting that changes in visual angle were obtained more from changes in TV size than changes in viewing distance. Conversely, for the LV participants, visual angle was more highly correlated with viewing distance ($\rho_{102} = -0.81$, $p < 0.001$) than with TV size ($\rho_{102} = 0.41$, $p < 0.001$), suggesting that, for LV participants, changes in visual angle were obtained more from changes in viewing distance than changes in TV size.

Table 3. Spearman correlations (ρ) between selected variables related to television use and cinema attendance for the NS (above diagonal) and LV (below diagonal) groups. Number of hours watch TV per week is the sum of the hours reported for up to three TVs (questions 8, 14 and 20). Difficulties watching TV is a composite of questions 1, 2 and 3. Significant ($p \leq 0.01$) correlations are indicated by bold font and correlations that approached significance ($0.01 < p \leq 0.10$) are underlined. Results that differed between the NS and LV groups are highlighted with shading

NS group / LV Group	Age	Visual acuity	(11) Size of First TV
(6) Number of TVs at home	**ρ_{93}=+0.26 p=0.01** / ρ_{102}=-0.12 p=0.23	ρ_{93}=-0.01 p=0.94 / ρ_{102}=+0.07 p=0.51	$\underline{\rho_{92}}$=+0.19 $\underline{p=0.07}$ / **ρ_{102}=+0.24 p=0.01**
Number of hours watch TV per week	**ρ_{93}=+0.29 p=0.004** / $\underline{\rho_{103}}$=+0.18 $\underline{p=0.07}$	ρ_{93}=-0.03 p=0.74 / ρ_{103}=-0.06 p=0.57	$\underline{\rho_{92}}$=+0.20 $\underline{p=0.05}$ / $\underline{\rho_{102}}$=+0.18 $\underline{p=0.08}$
(11) Size of first TV	ρ_{92}=+0.01 p=0.94 / **ρ_{102}=-0.31 p=0.002**	$\underline{\rho_{92}}$=+0.18 $\underline{p=0.09}$ / ρ_{102}=-0.05 p=0.64	-------- / --------
(10) Viewing Distance (first TV)	ρ_{92}=+0.16 p=0.14 / ρ_{102}=+0.14 p=0.16	ρ_{92}=+0.02 p=0.82 / $\underline{\rho_{102}}$=-0.21 $\underline{p=0.03}$	**ρ_{92}=+0.34 p=0.001** / ρ_{102}=+0.14 p=0.17
Visual angle (first TV)	ρ_{92}=-0.10 p=0.36 / **ρ_{102}=-0.29 p=0.003**	$\underline{\rho_{92}}$=+0.18 $\underline{p=0.09}$ / $\underline{\rho_{102}}$=+0.17 $\underline{p=0.09}$	**$\underline{\rho_{92}}$=+0.64 $\underline{p<0.001}$** / **$\underline{\rho_{102}}$=+0.41 $\underline{p<0.001}$**
(5) Non-broadcast movies on TV	**ρ_{93}=-0.44 p<0.001** / **ρ_{103}=-0.40 p<0.001**	ρ_{93}=-0.01 p=0.94 / ρ_{103}=-0.14 p=0.15	ρ_{93}=-0.01 p=0.94 / $\underline{\rho_{102}}$=+0.23 $\underline{p=0.02}$
(48) Movies in theatre	$\underline{\rho_{93}}$=-0.22 $\underline{p=0.04}$ / **ρ_{103}=-0.28 p=0.005**	ρ_{93}=+0.11 p=0.31 / ρ_{103}=-0.14 p=0.15	ρ_{92}=+0.11 p=0.30 / ρ_{102}=+0.02 p=0.83
Difficulties watching TV	-------- / $\underline{\rho_{103}}$=+0.17 $\underline{p=0.08}$	-------- / ρ_{103}=+0.10 p=0.33	-------- / ρ_{102}=-0.16 p=0.11

The visual angle of the TV reported by LV participants (average 49 degrees diagonal) were larger than those reported by the NS participants (average 19 degrees diagonal). A larger TV viewing angle was associated weakly with worse visual acuity (*Table 3*) and not with increased difficulty with watching TV ($\rho_{102} = 0.08$, $p = 0.43$), though some LV participants with greater difficulty watching TV had a larger visual angle (*Figure 5*) and those LV participants tended to be younger. As age increased, visual angle decreased among the LV participants but not among NS participants (*Table 3*). Overall, this suggests that some, younger, LV participants were making use of this simple mode of obtaining magnification, though it had not resolved their viewing difficulties (*Figure 5*).

Most of the LV participants did not use any visual aid for viewing TV (84/103), while nine reported using their spectacles, five used a telescope, three used binoculars, and two used a Fresnel sheet. This indicates that there was little use of vision rehabilitation devices in this sample of LV participants. Of the 104 LV participants, 67 indicated an interest in assistive technology for TV viewing, with only seven indicating no interest.

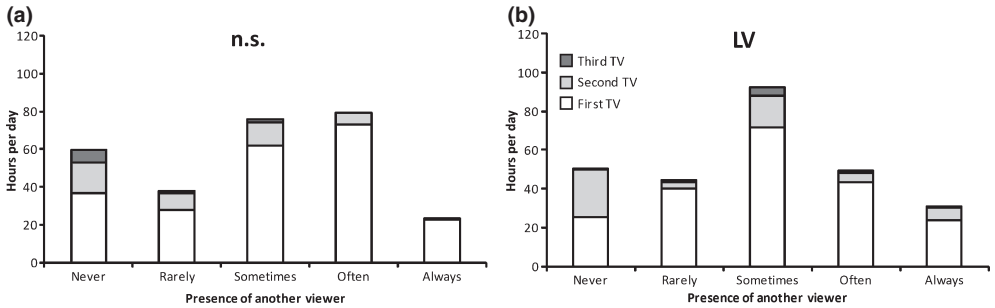

Figure 2. Cumulative hours per day watched on the first, second and third most frequently viewed TV, categorized by frequency of the presence of another viewer for (a) normally-sighted (NS) and (b) low vision (LV) participants. The distributions for the two groups were not statistically significantly different.

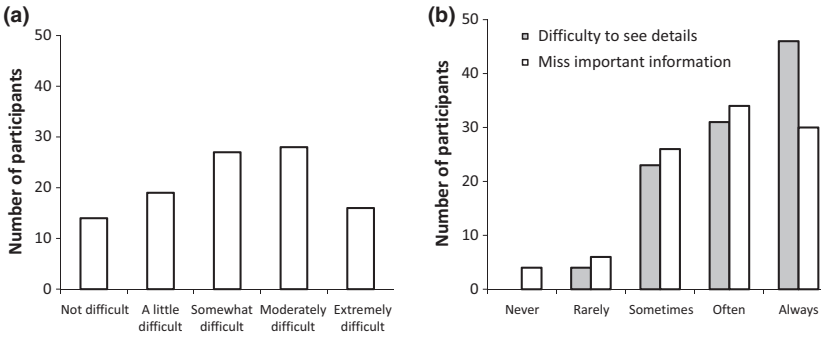

Figure 3. For the 103 LV participants: (a) The reported overall difficulty with watching TV; and (b) The reported frequencies of difficulty seeing details and of missing important information while viewing TV.

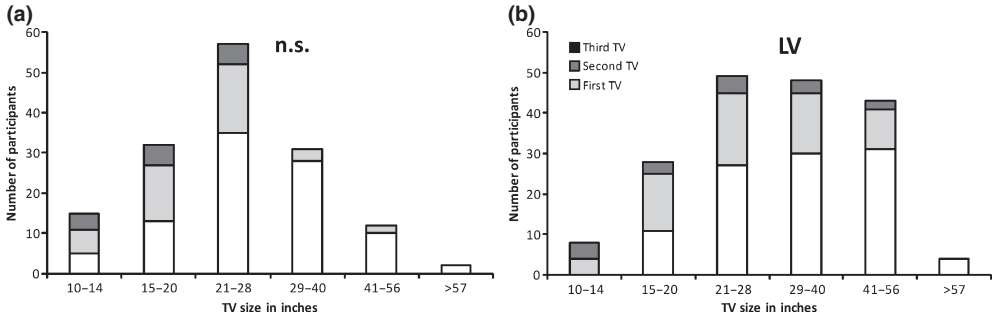

Figure 4. TV sizes (in inches measured diagonally) reported by the (a) normally-sighted (NS) and (b) low vision (LV) participants. LV participants tended to have larger TV screen sizes.

Almost 3/4 participants reported watching movies on a TV at home that were not broadcast (e.g. DVD player), with a wide variety of viewing frequencies (*Figure 6a*). LV participants (35/104) were slightly, but not significantly (Mann–Whitney, $z_{197} = 1.25$, $p = 0.21$), less likely to watch such movies than NS participants (24/94). Of those that watched such movies, the LV group watched them slightly, but not significantly, less frequently than the NS group (Mann–Whitney, $z_{138} = 1.60$, $p = 0.11$) (*Figure 6a*). The frequency of watching such movies at home decreased with increasing age for both groups (*Table 3*). NS participants that viewed such movies on TV more frequently had larger TV sizes ($\rho_{92} = 0.21$, $p = 0.05$) and sat closer ($\rho_{92} = -0.20$, $p = 0.05$), while LV participants that viewed such movies on TV more frequently also had larger TV sizes ($\rho_{102} = 0.32$, $p = 0.02$), but tended, not significantly, to sit further from the TV ($\rho_{102} = 0.11$, $p = 0.29$).

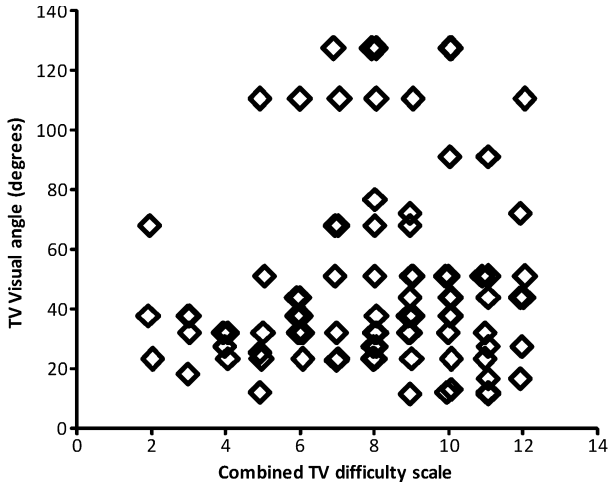

Figure 5. There was a non-significant trend for the visual angle of the primary TV to be larger for some LV participants with greater reported difficulty with TV. This use of effective magnification was mainly by younger LV participants. Of interest for vision rehabilitation is the group of participants in the lower right corner of the plot, as these participants reported high difficulty but were not making use of effective magnification. To improve legibility, some overlapping data points were randomly offset along the *x*-axis.

Theatre

About 4/5 people reported watching movies in a theatre (cinema), with most watching such movies a 'few times a year' (*Figure 6b*). Frequency of attendance decreased with age (*Table 3*). LV participants were slightly less likely to watch such movies than NS participants (*Table 2*). Of those people with LV who went to the movie theatre, their frequency of attendance was similar to that of NS subjects (Mann–Whitney, $z_{158} = 1.30$, $p = 0.19$).

Computer

About 4/5 participants reported having a computer at home, with no difference in availability between the two groups (*Table 2*). Younger (≤60 years) participants were more likely (86/90) to have a computer at home ($\chi^2_1 = 16.9$, $p < 0.001$) than older participants (99/133). Of the 185 participants reporting a computer at home, most participants did not view movies (e.g. DVD) on the computer (131/163) or high-definition movies (e.g. HD-DVD or blu-ray) on computer or TV (176/198), and there was no difference in frequency of such viewing between the two groups (*Table 2*). Frequency of viewing movies on a computer decreased with increasing age but was not related to visual acuity (*Table 4*). LV participants were slightly less likely to have internet access at home and much less likely to have internet access elsewhere (other than home) than NS participants (*Table 2*). As the most common other internet access site was work, these differences in internet access may reflect frequency of employment possibly being lower among LV participants (employment status was not asked in the survey). Most (133/155) of the participants with internet access reported using the internet at least once per day. Internet use was more frequent among the normally-sighted than the LV group (Mann–Whitney, $z_{197} = 3.30$, $p = 0.001$) and decreased with age for both groups (*Table 4*). Many participants with internet access reported watching internet video content (e.g. music videos, YouTube), with normally-sighted participants watching such videos slightly more frequently than LV participants (Mann–Whitney, $z_{154} = 1.84$, $p = 0.07$) and frequency of watching internet video content declined with increasing age in both groups (*Table 4*). Among those people watching internet video material, it was uncommon for there to be another viewer present, with only 20/122 reporting another viewer often or always present.

The computer monitors used by LV participants tended to be larger, the viewing distances were shorter and the angular sizes were greater (*Table 2*) than those reported by NS participants, indicating that many LV participants were making use of this simple mode of obtaining magnification. However, while NS participants with 'worse' visual acuity had larger computer monitors, surprisingly, this was not the case for LV participants (*Table 4*). As

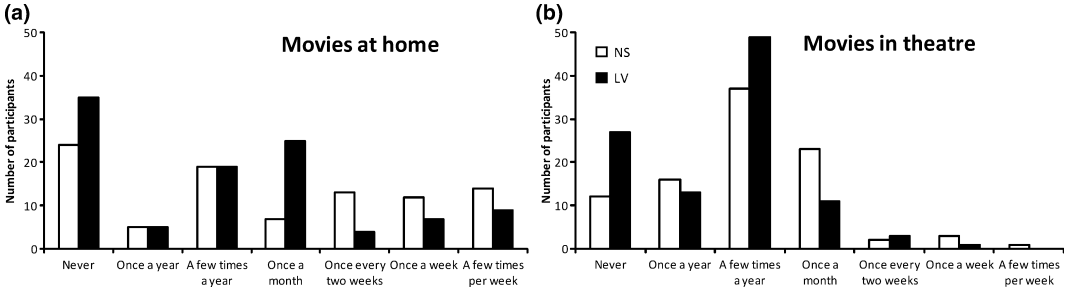

Figure 6. The number of participants reporting watching movies (a) at home; and (b) in the theatre (cinema) is shown for normally-sighted (NS) and low vision (LV) participants. LV participants were slightly less likely to watch movies in a theatre than NS participants.

Table 4. Spearman correlations (ρ) between selected variables related to computer and handheld device use for the NS (above diagonal) and LV (below diagonal) groups. Significant ($p \leq 0.01$) correlations are indicated by bold font and correlations that approached significance ($0.01 < p \leq 0.10$) are underlined. Results that differed between the NS and LV groups are highlighted with shading. Difficulties with computer viewing is a compilation of questions 38, 40 and 41

LV Group \ NS group	Age	Visual acuity	(33) Frequency internet videos
(27) DVD on computer	**ρ_{93}=-0.38 p=0.001** / **ρ_{100}=-0.32 p=0.001**	ρ_{93}=-0.19 p=0.06 / ρ_{100}=+0.13 p=0.20	**ρ_{93}=+0.48 p<0.001** / **ρ_{100}=+0.40 p<0.001**
(28) HD DVD or Blu-ray	ρ_{93}=-0.25 p=0.02 / ρ_{103}=-0.15 p=0.13	ρ_{93}=-0.01 p=0.96 / ρ_{103}=+0.02 p=0.84	ρ_{93}=+0.12 p=0.24 / ρ_{103}=+0.21 p=0.03
(32) Frequency internet access	**ρ_{93}=-0.51 p<0.001** / **ρ_{103}=-0.47 p<0.001**	ρ_{93}=-0.15 p=0.16 / ρ_{103}=+0.11 p=0.29	**ρ_{93}=+0.54 p<0.001** / **ρ_{103}=+0.62 p<0.001**
(33) Frequency internet videos	**ρ_{93}=-0.63 p<0.001** / **ρ_{103}=-0.48 p<0.001**	ρ_{93}=-0.14 p=0.18 / ρ_{103}=-0.10 p=0.33	-------- / --------
(36) Viewing distance of computer	ρ_{58}=-0.01 p=0.93 / ρ_{44}=+0.16 p=0.28	ρ_{58}=+0.22 p=0.10 / ρ_{44}=-0.28 p=0.06	ρ_{58}=-0.11 p=0.39 / ρ_{44}=-0.09 p=0.55
(37) Size of computer screen	ρ_{77}=-0.05 p=0.70 / ρ_{74}=-0.10 p=0.40	**ρ_{77}=+0.29 p=0.01** / ρ_{74}=-0.12 p=0.30	ρ_{77}=-0.02 p=0.98 / ρ_{74}=+0.05 p=0.70
(45) video on handheld device	**ρ_{88}=-0.46 p<0.001** / **ρ_{94}=-0.46 p<0.001**	ρ_{88}=-0.20 p=0.06 / ρ_{94}=-0.06 p=0.60	**ρ_{88}=+0.38 p<0.001** / **ρ_{94}=+0.45 p<0.001**
Difficulties with computer viewing	---- / **ρ_{77}=+0.37 p=0.001**	---- / ρ_{77}=+0.01 p=0.92	---- / **ρ_{77}=-0.31 p=0.005**

visual acuity became worse, LV participants sat slightly closer to the monitor, while NS participants tended to sit slightly further (*Table 4*). Among LV participants, woman (average 17 inches) sat closer to the monitor (Mann–Whitney, $z_{44} = 3.0$, $p = 0.002$) than men (average 28 inches). This difference was not found among NS participants.

Over half (44/75) of the LV participants who used a computer reported 'always' using assistive technologies (e.g. ZoomText) while using the computer, while about a quarter (19/75) reported never using assistive technologies. Those LV participants who used assistive technologies accessed the internet more frequently ($\rho_{67} = 0.28$, $p = 0.02$) and had larger computer monitors ($\rho_{72} = 0.38$, $p = 0.001$). Of the LV participants that used a computer, most (64/76) reported at least 'sometimes' having difficulty with details on a computer screen, most (39/48) reported at least 'sometimes' missing important information in video content and most (28/44) reported at least 'some' difficulty watching videos on the computer (*Figure 7*). As the three questions about difficulty with computers and computer video viewing (overall difficulty,

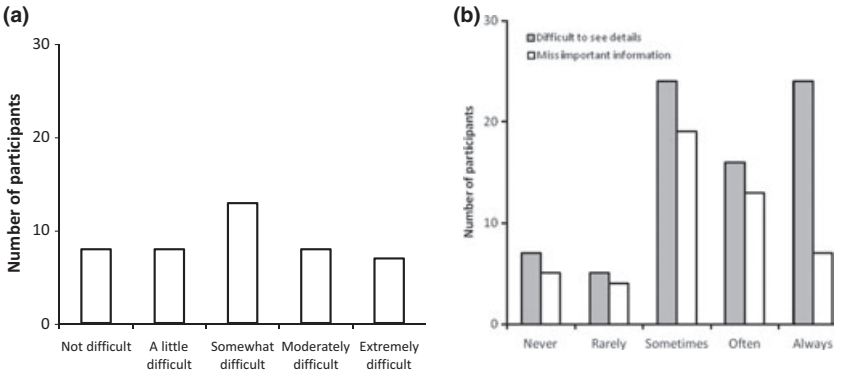

Figure 7. For the LV participants that reported use of a computer: (a) the reported difficulty watching videos on the computer; and (b) the reported frequencies of difficulty seeing details and of missing important information while using or watching videos on computer.

missing details and missing important information) were significantly correlated ($\rho = 0.38$–0.66, $p \leq 0.006$), we produced a composite variable that was used to investigate predictors of difficulty with computer use. Difficulty with computers did not increase as visual acuity worsened, but did increase with age (*Table 4*). Lower frequency of watching internet videos was also associated with greater difficulty with computers (*Table 4*). Most (50/74) of the LV participants that used a computer indicated an interest in assistive technology for computer use, with only five expressing no interest in such technology.

Portable devices

About a quarter (53/193) of participants reported owning a handheld device with video capabilities such as an iPod or other mp3 player, mobile (cell) phone, or personal video game system (such as a PlayStation Portable), and there was no significant difference in the frequency between the two groups (*Table 2*). Most (162/198) participants had not watched videos on handheld devices (owned by them or on a friend or relative's device), while 22 participants watched rarely and 14 participants watched sometimes or more often. Of the participants who watched video on handheld devices, most (11/16) of the LV participants reported extreme difficulty, while 7/22 NS participants reported at least 'some' difficulty, and difficulty was greater among the LV group than the NS group (Mann–Whitney, $z_{37} = 3.00$, $p = 0.003$). Most (157/198) participants reported never using a portable DVD player to watch videos, with no difference between the two groups (*Table 2*). While there were no significant differences related to these portable devices between the two groups, age was a factor. Participants aged over 60 years were less likely (12/110) to own a video-capable handheld device ($\chi^2_1 = 35.2$, $p < 0.001$), were less likely (7/115) to have watched video on a handheld device ($\chi^2_1 = 27.0$, $p < 0.001$), and were less likely (17/115) to have used a portable DVD player ($\chi^2_1 = 5.86$, $p = 0.015$) than younger participants (41/83; 29/83; 24/83, respectively).

Discussion

Video viewing habits for participants with a wide range of visual acuities were surveyed, and normally-sighted (NS) and low vision (LV) participants compared. In our sample, compared to NS participants, LV participants tended to have slightly more TVs at home ($p = 0.10$), were slightly more likely to have a widescreen (HD) TV ($p = 0.06$), were less likely to have internet access at home ($p = 0.02$) or elsewhere ($p < 0.001$) and used the internet less frequently ($p = 0.004$). Many LV participants reported having moderate or extreme difficulty with TV (42/103) (*Figure 3a*), with computer display use (15/44) (*Figure 7a*), and with watching videos on handheld devices (12/16). Difficulty in watching videos on handheld devices was asked to both the NS and LV participants, and the LV participants reported greater difficulty. A similar pattern of difficulty can be assumed for difficulty in watching TV and videos on computers, the questions for which were not asked of the NS participants. The rate of difficulty with TV viewing was similar to that found in a recent Dutch survey,[12] which also found that most of their participants (80%) reported difficulty with subtitles, a question not included in our survey.

Most (50/75) of the LV participants used assistive technologies for the computer at least 'often', but few LV participants (19/103) used any visual aid to watch TV, with most of those (9/19) using only spectacles specifically as an aid to watch TV. The worst visual acuity of our participants was 6/300, and 17 had a visual acuity worse than 6/60. All these individuals reported watching TV. We did not ask about the usage of radios in our survey. Four par-

ticipants reported using the TV mainly to hear the programs, rather than to view. Overall, this confirmed our suspicions that people with LV have difficulty with viewing video, that there is a need for further development of rehabilitation approaches and, as discussed below, there are opportunities for improved assistance even within currently available rehabilitation approaches.

Effective magnification (larger visual angles) rather than rehabilitation devices has been used by our LV participants to improve their viewing experience with TV, but as illustrated in *Figure 5*, many individuals who report high levels of difficulty with watching TV do not use a TV with a large visual angle. LV Participants with greater difficulty watching TV did not have larger TVs ($p = 0.11$), shorter viewing distances ($p = 0.20$) or larger visual angles of the TV screens ($p = 0.43$). The lack of significant relationships between these components of effective magnification and difficulty with TV may reflect the use of effective magnification by, at least some of the LV participants. *Figure 5* indicates that a substantial number of the LV participants in our sample could benefit from using effective magnification.

Overall, LV participants had larger TVs than the NS participants ($p < 0.001$), but this difference was only found among younger participants, with older LV participants having TVs of the same size as older NS participants. This interaction between vision status, age and TV size could reflect, in part, the buying habits of younger adults to purchase the current technological gadgets (e.g. HDTV), and it may reflect the financial status of the participant, in that people with LV often have lower disposable incomes.[4,37,38] However, the younger LV participants did tend to have larger TVs, and many of our older participants were retired, a time at which the disposable income difference might be less. It seems that, though low vision practitioners often advise their patients with reduced central vision to get a bigger TV, at least among our sample, many did not heed this advice, particularly those who were older. Thus, increasing the strength of the advice given to older LV patients about using a larger TV, if financially affordable, may improve rehabilitation and it can be adopted easily.

Few of our LV participants (10/103) reported using a visual aid other than spectacles for TV viewing, all of which used optical means to provide magnification (telescopes, binoculars and Fresnel sheet). This rate is much lower than the 64% (38/59) rate reported in a recent Dutch survey.[12] In that study, participants were reported as being prescribed telescopes because of the difficulty reading the subtitles (nearly all foreign language TV programs, which accounts for about 30% of the programs, are subtitled). For participants in our study, the low rate of use of optical magnification for TV viewing may reflect much less need to read subtitles, the prescribing habits of local practitioners, and be related to whether the costs of such devices are subsidised. Even so, assuming that optical magnification is of benefit, increasing the emphasis on this rehabilitation strategy seems an easy way that practitioners might assist LV patients with TV viewing. Over half (44/75) of the LV participants reported always using assistive technologies for computer viewing. Most of these technologies involve modification (electronic magnification) of the display on the computer monitor.

Most of LV participants expressed interest in assistive technology such as image enhancement for TV (67/104) and for computer viewing of videos (50/74). This high rate of interest may be a reflection of recruitment bias, as our LV participants tended to be motivated to seek available rehabilitation options, as many attended the institute for vision rehabilitation research study participation. Typically, image enhancement involves modification of the image that is displayed, and an image that is acceptable to LV viewers may not be acceptable to normally-sighted viewers.[26] If much TV and video watching by LV viewers occurred in the presence of normally-sighted viewers, and could hinder the joint enjoyment, image enhancement might not be a useful rehabilitation strategy. In our survey, we observed that half of the TV viewing time by LV participants (*Figure 2b*) was without another viewer (similar to that of NS participants, *Figure 2a*). For computer video viewing, it was much less common to view in the presence of another viewer (about 20%). Also, on average there were more than two TVs per household in our survey and the national average is almost three [31] We did not ask the number of people at home, so it is possible that even when only one TV is reported, it could be a personal TV used only by the participant. The results of this survey suggest that most people with LV have access to a TV that they could watch without interfering with the viewing experience of NS viewers. Obtaining effective magnification through a short viewing distance will interfere with the viewing experience of others watching the same screen. Further, while telescopes and binoculars can serve as visual aids for the intermediate viewing distances of TV and computer viewing, the need to maintain a fairly steady head position due to the limited field of view can make them difficult to use (if the head is not kept steady, the screen may no longer be visible). Since image enhancement of the video image can be viewed with more natural head and eye movements, it may be more widely used. Therefore, the development of image enhancement for vision rehabilitation to improve the video viewing experience of LV patient is a valuable endeavour.

Currently, it is often suggested in the media that computers and other video display devices, which frequently draw content from the internet, are being used instead of

the TV, particularly by younger people. Within our sample, only three participants (one LV and two NS) reported not having a TV at home and using the computer as their primary source to watch videos, including material that might otherwise have been viewed on TV. Older participants were less likely to have a computer at home, less likely to view video on the computer, accessed the internet less frequently, less likely to own a handheld device with video capabilities and less likely to use a portable DVD player. There was no difference between LV and NS groups for computer access, video viewing, handheld device ownership and portable DVD player use. The greater frequency of internet access by the NS group was probably related to access at work. Great difficulty viewing videos on the smaller portable device screens was commonly reported by LV participants both young and old.

Study limitations

The questionnaire was not developed in a systematic manner, such as that used for quality of life instruments. Some of the questions (Appendix) may be considered technical or difficult (e.g. asking the size and distance of displays). It is possible that such difficult questions might produce variable responses, and the resultant low reliability could make it more difficult to find affects. Since the questionnaire was always administered by an interviewer, the interviewer was able to facilitate the response process, for example, by providing an explanation or alternative phrasing of the question, and by assisting the participant in assessing the size and distance of displays. The questionnaire could be improved and an assessment of its reliability would be appropriate. Visual acuity of participants was often not assessed at the time of the survey administration, introducing a potential source of error. Even so, we were surprised at how similar the visual acuities reported by participants were to those that we had measured at previous visits (confidence limits for visual acuity measures in such populations are about 2–3 lines).[39,40]

Most of the participants in this survey study had attended the institute in relation to our low vision research. Those people might be more active (e.g. prepared to leave their home) than the general population. These people may also be more prepared to try new things, such as computers and other electronic devices than the general population. Most of our study participants (202/223) were recruited from the geographical location of New England, USA (Massachusetts, New Hampshire, Vermont, Rhode Island, Connecticut and Maine) area, majority of whom were from Massachusetts (189/202). In the greater Boston (Massachusetts) region, within which most participants lived, there is better public transportation than in most parts of the USA, and this may allow people with reduced vision to more easily participate in activities outside the home. As a further indication of this possibility, in our sample, the participants reported slightly fewer (average 2.1) TVs per household than the national average of 2.9.[31] Also, our survey did not include questions about the socio-economic status or the educational level of the participants. Hence some caution needs to be applied when using this data to compare it with patient population elsewhere.

Nevertheless, the few results obtained in this survey that can be compared to the previous available literature provided similar outcomes. The amount of time reported watching TV was similar for the NS and LV participants, in agreement with previous literature,[1–3] with a trend ($p = 0.07$) for the LV participants to watch more TV, as has been previously noted.[4] Like previous studies,[8] TV viewing duration was higher amongst older adults in our study population. This suggests that our convenience sample was similar to previous larger studies, but it could have suffered from a recruitment bias.

Conclusion

In general, we found that our LV participants had similar TV, theatre, computer and portable-device video viewing habits to those of our NS participants. There was a substantial effect of age on such video viewing. Difficulty viewing video in all three formats was reported by most of our LV participants. Older LV participants are those who have most difficulty and they make less use of video. Most of the LV participants showed interest in image enhancing technology to assist with viewing video. There is a clear need for visual rehabilitation technology for video viewing. With the increase in computer and portable-video device usage and an aging population, rehabilitation technology should address both the TV viewing and computer video viewing needs. Portable devices that accommodate the needs of people with reduced vision should also be developed. For the low vision practitioner, there seems to be two currently available strategies that could immediately improve the experience of people with reduced vision, the first being to place greater emphasis on increasing TV and computer monitor size among older patients, and secondly to increase the use of optical magnification devices for TV by patients.

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Appendix

List of questions asked in the survey
(Questions in bold were asked only to participants with vision impairment)

(1) Do you find it difficult to see details on the TV?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always

(2) Do you feel that while watching TV you miss important information that is available to people without vision impairments?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always

(3) How difficult, if at all, do you find it to watch TV?
(a) Not difficult
(b) A little difficult
(c) Somewhat difficult
(d) Moderately difficult
(e) Extremely difficult
(f) Not applicable

(4) Would you be interested in technology to enhance the TV image to help you see it?
(a) No
(b) Maybe
(c) Yes
(d) Don't know

(5) How often do you watch movies at home on your TV that are not broadcast on television?
(a) Never
(b) Once a year
(c) Few times a year
(d) Once a month
(e) Once every 2 weeks
(f) Once a week
(g) Few times per week

(6) How many TV's do you have in your home?
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

(7) Which service provider do you watch?
(a) Broadcast
(b) Broadcast & cable
(c) Cable

For the TV at home you use most frequently …

(8) How many hours do you watch this TV per day?
(a) 0–1
(b) 1–2
(c) 2–3
(d) 3–4
(e) 4–5
(f) >5

(9) Do you watch this TV with other people?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always

(10) When watching this TV, how close are you to it (feet)?
(a) <2
(b) 2–4
(c) 4–6
(d) 6–8
(e) 8–10
(f) >10

(11) How big is this TV (inches diagonal)?
(a) 10–14
(b) 15–20
(c) 21–28
(d) 29–40
(e) 41–56
(f) >57
(12) What type of TV is this?
(a) Wide Screen (HDTV)
(b) Old TV (SDTV)
(c) HDTV (non-wide screen)
(13) Do you use a visual aid to watch this TV?
(a) No
(b) Glasses
(c) Telescope
(d) Binocular
(e) Fresnel
(f) Other

For the TV you use second most frequently (skip if not applicable) …
(14) How many hours do you watch this TV per day?
(a) 0–1
(b) 1–2
(c) 2–3
(d) 3–4
(e) 4–5
(f) >5
(15) Do you watch this TV with other people?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always
(16) When watching this TV, how close are you to it (feet)?
(a) <2
(b) 2–4
(c) 4–6
(d) 6–8
(e) 8–10
(f) >10
(17) How big is this TV (inches diagonal)?
(a) 10–14
(b) 15–20
(c) 21–28
(d) 29–40
(e) 41–56
(f) >57
(18) What type of TV is this?
(a) Wide Screen (HDTV)
(b) Old TV (SDTV)
(c) HDTV (non-wide screen)
(19) Do you use a visual aid to watch this TV?
(a) No
(b) Glasses
(c) Telescope
(d) Binocular
(e) Fresnel
(f) Other

For the TV you use third most frequently (skip if not applicable) …
(20) How many hours do you watch this TV per day?
(a) 0–1
(b) 1–2
(c) 2–3
(d) 3–4
(e) 4–5
(f) >5
(21) Do you watch this TV with other people?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always
(22) When watching this TV, how close are you to it (feet)?
(a) <2
(b) 2–4
(c) 4–6
(d) 6–8
(e) 8–10
(f) >10
(23) How big is this TV (inches diagonal)?
(a) 10–14
(b) 15–20
(c) 21–28
(d) 29–40
(e) 41–56
(f) >57
(24) What type of TV is this?
(a) Wide Screen (HDTV)
(b) Old TV (SDTV)
(c) HDTV (non-wide screen)
(25) Do you use a visual aid to watch this TV?
(a) No
(b) Glasses
(c) Telescope
(d) Binocular
(e) Fresnel
(f) Other
(26) Do you have a computer in your home?
(a) Yes
(b) No

(27) Do you ever watch DVDs on your computer?
(a) Never
(b) Once a year
(c) Few times a year
(d) Once a month
(e) Once every 2 weeks
(f) Once a week
(g) Few times per week
(28) Do you ever watch Blu-ray or HD DVD on your computer or TV?
(a) Never
(b) Once a year
(c) Few times a year
(d) Once a month
(e) Once every 2 weeks
(f) Once a week
(g) Few times per week
(29) Do you have internet access at home and is it 'dial-up'?
(a) No
(b) Yes
(c) I have dial-up
(30) Do you access the internet in places other than your home?
(a) Yes
(b) No
(31) If yes, where do you access the internet? (Check all that apply)
(a) Library
(b) Work
(c) School
(d) Friend or Relatives' House
(e) Internet Cafe
(f) Other
(32) How frequently do you use the internet at home or elsewhere?
(a) Never
(b) Once a year
(c) Few times a year
(d) Once a month
(e) Once every 2 weeks
(f) Once a week
(g) Few times per week
(h) Once a day
(i) More than once a day
(33) Do you ever watch videos on the internet?
(a) Never
(b) Once a year
(c) Few times a year
(d) Once a month
(e) Once every 2 weeks
(f) Once a week
(g) Few times per week
(h) Once a day
(i) More than once a day
(34) What types of 'videos' do you watch over the internet? (check all that apply)
(a) You Tube
(b) TV shows
(c) Downloaded movies
(d) Music videos
(e) Movie trailers
(f) Short video clips
(g) Other
(35) When watching any video or DVD on a computer do you watch with other people?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always
(36) When watching videos or DVDs on a computer, how close to the screen are you?
(a) <0.5′
(b) 0.5′–1′
(c) 1–2
(d) 2–3
(e) >3′
(37) How big is the computer screen (inches diagonal)?
(a) 0–8
(b) 9–12
(c) 13–15
(d) 16–20
(e) 21–30
(f) >30
(38) Do you use any assistive technologies on your computer such as ZoomText, or any other enhancement or magnification software?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always
(39) Do you find it difficult to see details on the computer screen?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always
(40) Do you feel that while watching videos on your computer you miss important information that is available to people without vision impairments?
(a) Never
(b) Rarely
(c) Sometimes

(d) Often
(e) Always

(41) How difficult, if at all, do you find it to watch videos on the computer?
(a) Not difficult
(b) A little difficult
(c) Somewhat difficult
(d) Moderately difficult
(e) Extremely difficult
(f) Not applicable

(42) Would you be interested in technology to enhance the computer image to help you see it?
(a) No
(b) Maybe
(c) Yes
(d) Don't know

(43) Do you video stream from computer?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always

(44) Do you have a handheld device with video capabilities such as an iPod or other mp3 player, cell phone, or personal video game system?
(a) Yes
(b) No

(45) Have you ever used any handheld device to watch a video?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always

(46) How difficult, if at all, did you find it to watch the video on the handheld device?
(a) Not difficult
(b) A little difficult
(c) Somewhat difficult
(d) Moderately difficult
(e) Extremely difficult
(f) Not applicable

(47) Do you ever use a personal DVD player?
(a) Never
(b) Rarely
(c) Sometimes
(d) Often
(e) Always

(48) How often do you watch movies in the theater?
(a) Never
(b) Once a year
(c) Few times a year
(d) Once a month
(e) Once every 2 weeks
(f) Once a week
(g) Few times per week