Research Reports

A Comparison of Subjects' Reading and Writing Performance and Preference While Using Various Portable Electronic Magnifiers

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The ability to read print to help maintain independence and quality of life is a primary concern of people with visual impairments (Krieger, 1967; Lamoureux et al., 2007; Leat, Legge, & Bullimore, 1999; Nguyen, Weismann, & Trauzettel-Klosinski, 2009; Stelmack et al., 2008). One option for reading is a CCTV (closed-circuit television) or, using a more specific term, electronic magnifier. An electronic magnifier uses a camera to enlarge images onto a screen. It emerged as assistive technology in the early 1970s. Uslan, Shen, and Shragai (1996) provide a historical overview of the evolution and availability of electronic magnifiers. They report electronic magnifier systems "designed and built specifically for visually impaired people" from the 1950s to the early 1970s with Apollo Lasers and Visualtek bringing these products to the market in the early 1970s (Uslan, Shen, & Sharagai, 1996, p. 466).

Electronic magnifiers have the advantages of adjustable magnification, contrast enhancement, binocular viewing, and large screen size (Wolffsohn & Peterson, 2003). They have been shown to be an effective tool in improving reading performance (Jutai, Strong, & Russell-Minda, 2009), to be an important learning device for students (Peck, 1995), to increase reading rates (Lagrow, 1981), to extend reading duration (Goodrich, Kirby, Wagstaff, Oros, & McDevitt, 2004), and to provide lasting significant positive psychosocial impact (Huber, Jutai, Strong, & Plotkin, 2008). In the past, electronic magnifiers were only available as nonportable desktop electronic magnifiers. Portable electronic magnifiers are now readily available.

The aim of this study was to gain an understanding of preferences, and reading and writing performance of subjects with visual impairments using different portable electronic magnifiers. Performance was measured by assessing reading rates, writing speeds, and equivalent power used. Preferences were determined by having subjects rank ease of writing tasks with portable electronic magnifiers. This study assesses trends and provides information that practitioners may find useful as they demonstrate and prescribe portable electronic magnifiers.

Methods

Subjects

Fourteen subjects were tested. The subjects' ages, ocular diagnosis, vision impairment, years of desktop electronic magnifier use, and education level are listed in Table 1. Subjects had no previous portable electronic magnifier experience, but they frequently used a desktop electronic magnifier for reading and writing. All subjects were employed at one of three agencies that serve people who are visually impaired (that is, those who are blind or have low vision). Subjects volunteered to participate, and all testing was done in their place of employment.

Portable electronic magnifiers

Eight portable electronic magnifiers were classified into large and small categories, based on screen size. Table 2 shows screen size and magnification range. Large portable electronic magnifiers had diagonal screen measurements of 14.61 to 17.78 centimeters and smaller ones had a measurement of 10.16 centimeters. Large portable electronic magnifiers were: Miniviewer and Olympia by Telesensory, Traveller by Optelec, and Assist Vision Slider by New Times. Small portable electronic magnifiers were: Compact by Optelec, Pico by

Table 1
Characteristics of subjects.

Subject	Age	Highest education level	Ocular diagnosis	Visual acuity in better seeing eye	Years of desktop electronic magnifier use
1	44	Some college	Retinitis pigmentosa	10/120	10
2	38	Some college	Congenital glaucoma	10/300	18
3	47	High school	Oculocutaneous albinism	10/80	6
4	41	Some college	Leber's congenital amaurosis	10/200	>20
5	36	Master's degree	Cone-rod dystrophy	10/700	>20
6	40	Some college	Oculocutaneous albinism	10/50	>20
7	54	Master's degree	Retinitis pigmentosa	10/80	5
8	53	Bachelor's degree	Retinopathy of prematurity	10/200	9
9	35	Master's degree	Cone-rod dystrophy	10/40	3
10	36	Some college	Proliferative diabetic retinopathy	10/60	2
11	39	Master's degree	Congenital nystagmus	10/120	15
12	49	Associates degree	Congenital nystagmus	10/400	>20
13	39	Some college	Retinitis pigmentosa	10/225	10
14	43	Some college	Congenital cataract	10/140	19

Telesensory, Quicklook by Ash Technology, and PocketViewer by HumanWare.

Study design

Subjects read text and performed three different writing tasks with all eight portable electronic magnifiers and the desktop electronic magnifier they used daily. Testing was done over two sessions; each lasted 60 to 90 minutes. All features of each portable electronic magnifier were explained and demonstrated. The subjects were given an unlimited amount of time to practice. They used the level of magnification that was most comfortable for them, and it was not changed during testing.

This study was approved by the Institution Review Board of the Illinois College of Optometry. Written informed consent was obtained from all participants. The results were tabulated and statistical analysis performed using SPSS Base 12.0 (SPSS Inc., Chicago, Illinois).

Table 2
Summary of reading rates, writing rates, and range of electronic magnification.

Device	PEM size/ diagonal display measurement (cm)	Electronic magnification range	Mean "standard-length words" read/minute (*SD*)	Mean letters written/minute (*SD*)
Desktop electronic magnifier	N/A/48.18–55.88	Continuous	61.8 (26.1)	85.5 (22.5)
New Times Assist Vision Slider	Large/16.26	Continuous	46.5 (20.2)	50.1 (14.5)
Optelec Traveller	Large/16.26	Continuous	41.9 (22.9)	63.7 (20.8)
Telesensory Miniviewer	Large/14.61	Continuous	48.2 (27.2)	60.5 (19.4)
Telesensory Olympia	Large/17.78	Continuous	48.4 (20.7)	69.8 (23.6)
Ash Technology Quicklook	Small/10.16	6×	46.5 (20.2)	64.3 (23.9)
HumanWare PocketViewer	Small/10.16	8×	35.0 (20.1)	52.6 (20.8)
Optelec Compact	Small/10.16	4× or 8×	35.5 (16.1)	60.3 (25.1)
Telesensory Pico	Small/10.16	5× or 13×	35.6 (19.8)	60.7 (21.8)

Note: PEM = portable electronic magnifier.

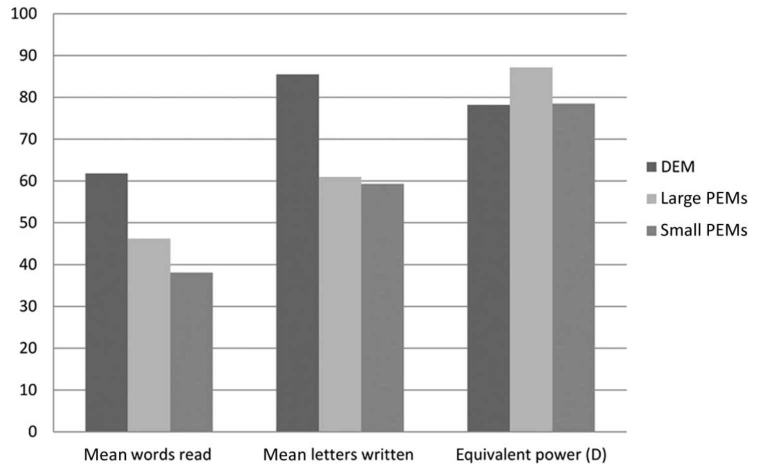

Figure 1. Mean words read, letters written, and equivalent power. *Note:* DEM = desktop electronic magnifier; PEM = portable electronic magnifier.

Reading assessment

Reading speed was measured using articles from a standard print–size *Time* magazine. Subjects were asked to read aloud for three minutes, and they were informed they would be timed. Subjects were encouraged to use the same spectacles, or removal of spectacles, that they typically do with their desktop electronic magnifier.

The number of "standard-length words" was used to calculate the reading rates. *Standard-length words* is defined as the number of characters and spaces divided by six. It has been shown that if the reader's grade level exceeds the grade level of the text, then reading rate is independent of the text difficulty (Carver, 1990). The average grade level of the material was calculated by Microsoft Word using the Flesch-Kincaid Grade Level, which determined a score of 9.0. This level was below all subjects' education level; therefore, the text difficulty would not affect reading rate. Relative distance magnification (eye-to-screen distance), image size, and object size were all measured in centimeters with a tape measure. The eye-to-screen distance was measured from the subject's eyes to the screen of the electronic magnifier. *Transverse magnification* is the amount of enlargement created by an electronic magnifier, a measure of how much print is enlarged onto the screen, which was calculated by dividing the image size by the object size. *Equivalent power* is defined as the total amount of magnification needed by a subject to perform a visual task, including both relative distance magnification and transverse magnification. The product of these two types of magnification determined the equivalent power that was used.

Writing assessment

Subjects were asked to sign their name, fill out a check, and print a paragraph. The subjects were informed that the task of printing the paragraph would be timed. The paragraphs used were taken from Sloan Reading Cards for adults (Good-Lite, Elgin, Illinois).

Subjects were asked to rate the writing tasks on the Likert 1–5 scale, with 1 being difficult and 5 being easy. For analysis purposes, the Likert scale ratings were dichotomized. Task median values rated between 4.0 and 5.0 were classified as easy. Task median values rated 2.5 through 3.5 were rated as neutral. Task median value rated between 1.0 and 2.0 were classified as difficult.

Results

Table 2 and Figure 1 summarize reading and writing rates. For mean reading rates, desktop

Table 3
Likert scale rating of writing tasks, 1 being difficult and 5 easy. For analysis purposes, the Likert scale ratings were dichotomized. Task median values rated 4 through 5 were classified as easy. Task median values rated 2.5 through 3.5 were classified as neutral. Task median values rated as 1 through 2 were classified as difficult.

Device	Size of PEM	Sign name median	Fill out check median	Write paragraph median
Desktop electronic magnifier	N/A	5 (easy)	5 (easy)	5 (easy)
New Times Assist Vision Slider	Large	2 (difficult)	2 (difficult)	1 (difficult)
Optelec Traveller	Large	4 (easy)	3.5 (neutral)	3.5 (neutral)
Telesensory Miniviewer	Large	3 (neutral)	2.5 (neutral)	2 (difficult)
Telesensory Olympia	Large	4.5 (easy)	4 (easy)	3.5 (neutral)
Ash Technology Quicklook	Small	3 (neutral)	3 (neutral)	2.5 (neutral)
HumanWare PocketViewer	Small	2 (difficult)	1 (difficult)	1 (difficult)
Optelec Compact	Small	2 (difficult)	2 (difficult)	1.5 (difficult)
Telesensory Pico	Small	2.5 (neutral)	2 (difficult)	2 (difficult)

Note: PEM = portable electronic magnifier.

electronic magnifiers were the fastest at 61.8 words per minute. Three of the large portable electronic magnifiers had faster rates than all but one of the small portable electronic magnifiers. The average of the mean reading rates of the large portable electronic magnifiers was 46.2 words per minute versus 38.1 for the small ones. The averages of the mean writing rates were similar between the two portable groups, with larger portable electronic magnifiers at 61.0 and smaller portable electronic magnifiers at 59.3. Writing rates of desktop electronic magnifiers were the fastest at 85.5.

Subjects' median Likert scale (1–5) responses and assessments based on these median values for writing tasks are summarized in Table 3. For desktop electronic magnifiers, all tasks were rated as easy. For portable electronic magnifiers, the range of the median values and assessments indicated that the larger ones were easier to write with than smaller ones for all tasks. Figure 2 illustrates the percentage of subjects who rated writing tasks easy. Two of the larger portable electronic magnifiers were rated easy to perform tasks by the largest percentage. Two small portable electronic magnifiers had the lowest percentage of subjects rating them as easy.

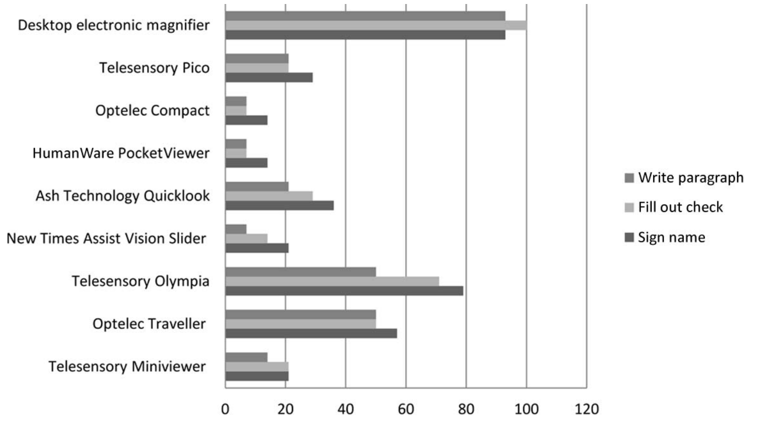

Figure 2. Percentage who rated tasks as easy.

Table 4
Summary of equivalent power, distance of eye to screen, relative distance magnification and transverse magnification.

Device	Size of PEM	Mean equivalent power in diopters (*SD*; range)	Mean distance eye to screen in cm (*SD*)	Mean relative distance magnification in diopters (*SD*)	Mean transverse magnification
Desktop electronic magnifier	N/A	78.2 (81.2;12.2–275)	30.8 (13.2)	+3.2 (7.6)	24.4×
New Times Assist Vision Slider	Large	83.8 (68.6; 28–280)	19.7 (11.0)	+5.1 (9.1)	16.4×
Optelec Traveller	Large	90.6 (100.3; 16.5–375)	18.2 (11.0)	+5.5 (9.1)	16.5×
Telesensory Miniviewer	Large	87.5 (90.5; 15–350)	14.0 (7.4)	+7.2 (13.5)	12.1×
Telesensory Olympia	Large	80.9 (95.9; 10.5–384.1)	17.3 (9.2)	+5.8 (10.9)	13.9×
Ash Technology Quicklook	Small	55.4 (43.1; 15.3–171.4)	16.5 (10.3)	+6.1 (9.7)	9.1×
HumanWare PocketViewer	Small	82.9 (69.6; 15.3–266.4)	14.4 (7.9)	+6.9 (12.7)	12.0×
Optelec Compact	Small	67.2 (48.4; 22.9–200)	17.0 (9.1)	+5.9 (11.0)	11.4×
Telesensory Pico	Small	86.3 (86.4; 20.8–325)	17.3 (10.9)	+5.8 (9.2)	14.9×

Note: PEM = portable electronic magnifier.

Table 4 and Figure 1 show the equivalent power (*SD*, range). The average of the mean equivalent power for desktop electronic magnifiers was +78.2 diopters (D), for large portable electronic magnifiers +85.7 D, and for small +72.9 D. The average of the transverse magnification used was 24.4× for desktop electronic magnifiers, 14.7× for large portable electronic magnifiers, and 11.8× for small portable electronic magnifiers. Mean eye-to-screen distance for all portable electronic magnifiers was 16.8 cm (large ones = 17.3 cm and small ones = 16.3 cm), with the resultant mean relative distance magnification greater than +6 diopters. Mean eye-to-screen distance for desktop electronic magnifiers was the longest at 30.8 cm with the relative distance magnification of +3.2 D. The differences between large and small portable electronic magnifiers for mean equivalent power, average transverse magnification, and mean eye-to-screen distance were not statistically significant.

The subjects who participated in this study had an average of 14 years of desktop electronic magnifier use. Their comments were collected and summarized. No comments about reading and writing were unique to any particular level of vision, except the comment on the need for more magnification. This need was specific to subjects who had more severe vision impairments, which often require more magnification. Comments in regard to reading included: 14 subjects reported that it was easiest to read when the portable electronic magnifier rested on the paper; 11 stated it was easy to lose their place while reading, especially going from one line to the next; 7 wanted more magnification; and 4 said that the easier it was to move the portable electronic magnifier, the easier it was to read. Comments for writing included: 5 subjects said the tilted screen made writing easier; 5 noted that to improve writing, the portable electronic magnifier should be more sturdy when set up for writing; 5 said that it was awkward to write under; and 4 said the pen did not fit well under the portable electronic magnifier. General positive comments were made about portability and use for short reading and writing tasks. Negative comments included need for more magnification, lighter weight, and a lower price.

Discussion

Reading and writing rates as well as ease of writing tasks were superior in desktop electronic magnifiers when compared to all portable electronic magnifiers. The mean reading rate of the desktop electronic magnifier was 15.6 words per minute (WPM) faster than large portable electronic magnifiers and 23.7 faster than small portable electronic magnifiers. Reading rates of the larger portable electronic magnifiers were faster by 8.1 WPM as compared to smaller ones. This finding is likely because the desktop electronic magnifier and larger portable electronic magnifiers have a combination of larger screen size, less page navigation, and higher available magnification. Larger field of view (screen size) has been shown to allow for increased reading rates (Fine, Kirschen, & Peli, 1996; Lovie-Kitchin & Woo, 1988; Lowe & Drasdo, 1990; Whittaker & Lovie-Kitchin, 1993).

With writing tasks, in general, there was more difficulty with small portable electronic magnifiers than with larger ones. The desktop electronic magnifiers were rated 5 (easy) in all categories. The larger portable electronic magnifiers were probably rated as easier because there was more space below the camera under which to put a pen and to use the pen at a greater angle to the paper (more upright). With practice and improved design, it is likely that both reading and writing tasks would become easier with smaller portable electronic magnifiers. Improved design could include: higher resolution, continuous range of magnification versus set levels, increased screen size, decreased weight, and improved ergonomics for writing.

There was no significant difference between large and small portable electronic magnifiers in terms of equivalent power used. With all of them, however, relative to desktop electronic magnifiers, subjects had to hold the device more than twice as close to their eyes. The mean eye-to-screen distance was 30.8 cm for the desktop electronic magnifier, and the average of the mean for portable electronic magnifiers was 16.8 cm. This increased the relative distance magnification by more than twice. One of the main reasons for this increase is that there was less transverse magnification with portable electronic magnifiers and the difference had to be compensated for by increasing the relative distance magnification.

Since this higher level of relative distance magnification with portable electronic magnifiers was somewhat unexpected, this aspect was not corrected for in the study. Our subjects may have been able to contribute accommodation for this increased demand. It is possible that this increase may have had an effect on reading rates. In order to provide a clearly focused retinal image and allow optimal portable electronic magnifier use, this eye-to-screen distance should be corrected. Practitioners should make sure there is adequate accommodation or an appropriate prescription of plus lenses (Keating, 2002).

In this study, eight subjects had central scotoma. Of these, there were no trends in preference or performance with the portable electronic magnifiers. Future research could investigate their use with different types of vision loss.

Desktop electronic magnifiers allow faster reading rates and more comfortable writing than portable electronic magnifiers do, and these devices should be considered first when prescribing assistive technology, especially in the education of children. Portable electronic magnifiers do have the advantage of portability and lower cost; therefore, they can be viable assistive technology tools. They are not, however, a replacement for desktop electronic magnifiers, but they could be considered as supplementary magnification devices. When selecting which device to demonstrate to a person, a practitioner may want to choose a larger screen size for a person who has a higher demand for reading. Also, if writing is an important goal, portable electronic magnifiers that have more room to put a pen under the camera would be better devices to demonstrate.

Limitations

The results of this study do have limitations, given the small heterogeneous group of subjects that evaluated portable electronic magnifiers and the short amount of training time that they were given. Another limitation was not fully correcting for the shortened eye-to-screen distance that occurred. Due to these factors, results cannot be over-generalized; however, they can give general guidelines that may assist practitioners when recommending portable electronic magnifiers.

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