Article • Preferences and Reading Performance of People with Low Vision using a Portable Electronic Magnifier versus a Smartphone Magnification App

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ABSTRACT

Purpose: People with low vision have difficulty reading. There is a scarcity of reports on whether the use of a portable electronic magnifier (PEM) versus a smartphone magnification app is more efficacious for reading tasks. The purpose of this study was to evaluate reading rates for both a PEM and a smartphone app, as well as to have subjects comment on their preferences between the two devices.

Methods: Adults attending a low vision clinic were recruited to participate. The study included a pre-study survey, device training, and a reading assessment and concluded with a post-study survey. The reading assessment was a three-minute reading task done with a PEM and a smartphone magnification app.

Results: Fourteen subjects completed the study. Reading rates were found to be higher with the portable electronic magnifier as compared to the magnification app, with a P value of 0.04. Seventy-nine percent of subjects preferred reading with the PEM overall, but 57% of subjects favored the magnification app for short reading tasks. Subjects were found to use their smartphones frequently for a variety of different tasks.

Conclusion: Reading rates were faster with a PEM, which was preferred by most subjects. Reading with a magnification app on a smartphone is a good alternative for short reading tasks. The majority of subjects responded that their smartphones were helpful to accomplish their activities of daily living, and they were reliant on their smartphones.

Keywords: app, assistive technology, electronic magnifier, magnification, smartphone

Introduction

The National Eye Institute defines visual impairment as low vision when the best-corrected visual acuity is less than 20/40 in the better-seeing eye.[1] The National Eye Institute projects the rate of low vision to continue to increase, affecting 5 million Americans by 2030.[1] Having low vision can negatively impact a person's independence, well-being, and quality of life.[2] A major area of impact is a person's ability to read, which is a goal prioritized by many with low vision.[3] It has been found that the ability and rate at which a person can read is decreased when there is low vision present.[4] Assisting patients in achieving this goal helps them to be more independent and satisfied with their quality of life.[5,6]

In the evolution of low vision rehabilitation, portable electronic magnifiers (PEMs) are now commonly prescribed to enable the reading of printed material. PEMs are helpful because they allow access to a range of magnification and enhance contrast, which has been shown to increase reading rates.[7] A barrier to obtaining PEMs is cost. Patients may not be able to afford these devices that are not typically covered

Table 1. List of Subjects' Age, VA, and Diagnosis

AGE	VA	Diagnosis
47	20/80	Albinism
51	20/100	Degeneration of macula, hereditary retinal dystrophy
61	20/100	POAG, Progressive high degenerative myopia
55	20/80	Degenerative myopia
23	20/70	Albinism
39	20/150	Degenerative myopia
13	20/160	Achromatopsia
58	20/80	ION, Glaucoma
59	20/300	Optic Atrophy
48	20/200	Retinitis pigmentosa
60	20/100	Glaucoma
31	20/200	Optic Atrophy
46	20/80	Optic Atrophy
54	20/80	Albinism, Optic Atrophy
65	20/100	Optic Atrophy

by vision or medical insurances. A low or no-cost alternative to a PEM is a smartphone app that provides magnification and contrast enhancement.

The use of smartphones by people with low vision is becoming increasingly popular.[8] Magnification apps may be an ideal option because they can increase text size and contrast, similar to a PEM, while the voice commands or GPS navigation capabilities are added benefits.[9] Additionally, a smartphone is something people typically carry with them at all times, so no additional device is needed.

The efficacy of using a smartphone magnification app versus a PEM to assist people with low vision for reading is currently not well studied. The aim of this research was to gain an understanding of preference and reading performance of people with low vision using a PEM versus a magnification app. Performance was measured by assessing reading rate. Preferences were gathered by administering a pre- and post-study survey. This study gathered also information on how smartphones are used by this group of subjects.

Methods

Subjects

Fifteen subjects were tested. The subjects' age, visual acuity, and diagnoses are listed in Table 1. The subjects were established patients in a low vision clinic and volunteered to participate. To be included, subjects had to own and be comfortable using a smartphone. Subjects were between the ages of 13 and 65 years old, with visual acuity ranging from 20/70 to 20/300.

Table 2. Listing of Survey Questions Asked Prior to Reading Activity

Pre-Reading Activity Questions:	
1.	What is your comfort level using a smartphone?
2.	How often do you use your smartphone as a magnifier?
3.	What activities do you use your smartphone to help with beyond making phone calls?
4.	How helpful is your smartphone in accomplishing daily living tasks?
5.	How often do you rely on your smartphone?

Devices

Each subject participant used the same PEM, the Pebble HD by Enhanced Vision. The subjects also used a smartphone that they were accustomed to using, either an iPhone or an Android-based phone. The magnification app used by all subjects was Brighter and Bigger version 2.05. The screen sizes used in this study were as follows: Pebble HD: 4.3"; Android phone: 5.1"; and iPhone: 4.7". The app and the PEM are demonstrated in this video: http://bit.ly/2U02Beb

Procedure

The sequence of the study included a pre-study survey, device training, a reading assessment, and a post-study survey. Subjects were given the option to complete both surveys either with an online survey tool or on a large-print paper copy. The pre-study survey questions can be seen in Table 2.

Pre-study survey questions asked subjects how they use their smartphone, how often they rely on it, and how useful is it with their daily living activities. Device training included presenting both the PEM and the magnifier app, demonstrating all features, and allowing

Table 3. Listing of Survey Questions Asked After Reading Activity

Pre-Reading Activity Questions:	
1.	Which device did you prefer?
2.	Which device was easier to use?
3.	What benefits did you find in one device over the other?
4.	For short reading tasks (less than 5 min), I preferred:
5.	For longer reading tasks (greater than 5 min), I preferred:

unlimited time for practice. The reading assessment took place after the subject was comfortable with both devices. All subjects were experienced users of smartphones and electronic magnification. On average, subjects took 10 minutes total to learn and to use both forms of magnification comfortably. The post-study survey was done after the reading assessment; the questions can be seen in Table 3. Post-study survey questions asked subjects about which device they preferred, which device was easier to use, and in what way they felt that one device was more beneficial versus the other.

The reading assessment was the measurement of reading rate and collection of subjects' comments about the devices. Reading speed was measured using two articles from a standard-print-size Time magazine. The same two articles were read by all subjects. One article was used for the PEM, and a different article was used for the magnification app. This was done to eliminate any increased reading speed with the second device tested due to familiarity with article content. The order of device presentation was randomized. Prior to the timed reading, subjects were asked to find the level of magnification and viewing mode (white-on-black or black-on-white) that was most comfortable for them. Once the reading assessment began, no settings were changed. During the testing, each individual subject's viewing mode and total magnification were equivalent, whether using the PEM or the magnification app. The same amount of magnification was generated from the PEM and the magnification app for each subject. Also, the same working distance (eye-to-screen) or relative distance magnification was also constant between the PEM and the magnification app for each subject. Each subject also used the same spectacle correction and working distance with both devices. Subjects were asked to read aloud to monitor accuracy. Subjects self-corrected reading errors during their timed reading. Reading rates were calculated by using the number of standard-length words, which is defined as six-letter spaces with the inclusion of spacing and punctuation.[10] The number of standard words read was divided by the three-minute time interval to calculate the words-per-minute reading rate. Reading accuracy was monitored, but understanding of content was not tested.

Statistical Analysis

Data was analyzed as a whole. All data was first analyzed for normalcy. An appropriate paired t-test was run to compare reading rates obtained using the PEM and the magnification app. Results were deemed as significant for a P value less than 0.05.

Results

The reading rates obtained with both devices were compared and are shown in Figure 1. Reading rates were faster with the PEM over the magnification app for 13 of the 14 subjects. The mean words-per-minute reading rate with the PEM was 73.65 and with the magnification app was 59.99. The range was 18 to 149.56 words per minute with the PEM and 3.83 to 89.83 for the magnification app. It was decided to exclude one subject's data from the analysis. This subject (60 yo with 20/100 vision from glaucoma) demonstrated a poor effort during the testing and had to restart several times using both devices. Data was collected for both methods of magnification yet was excluded from both sets of data due to the subject's psychological state. It was determined

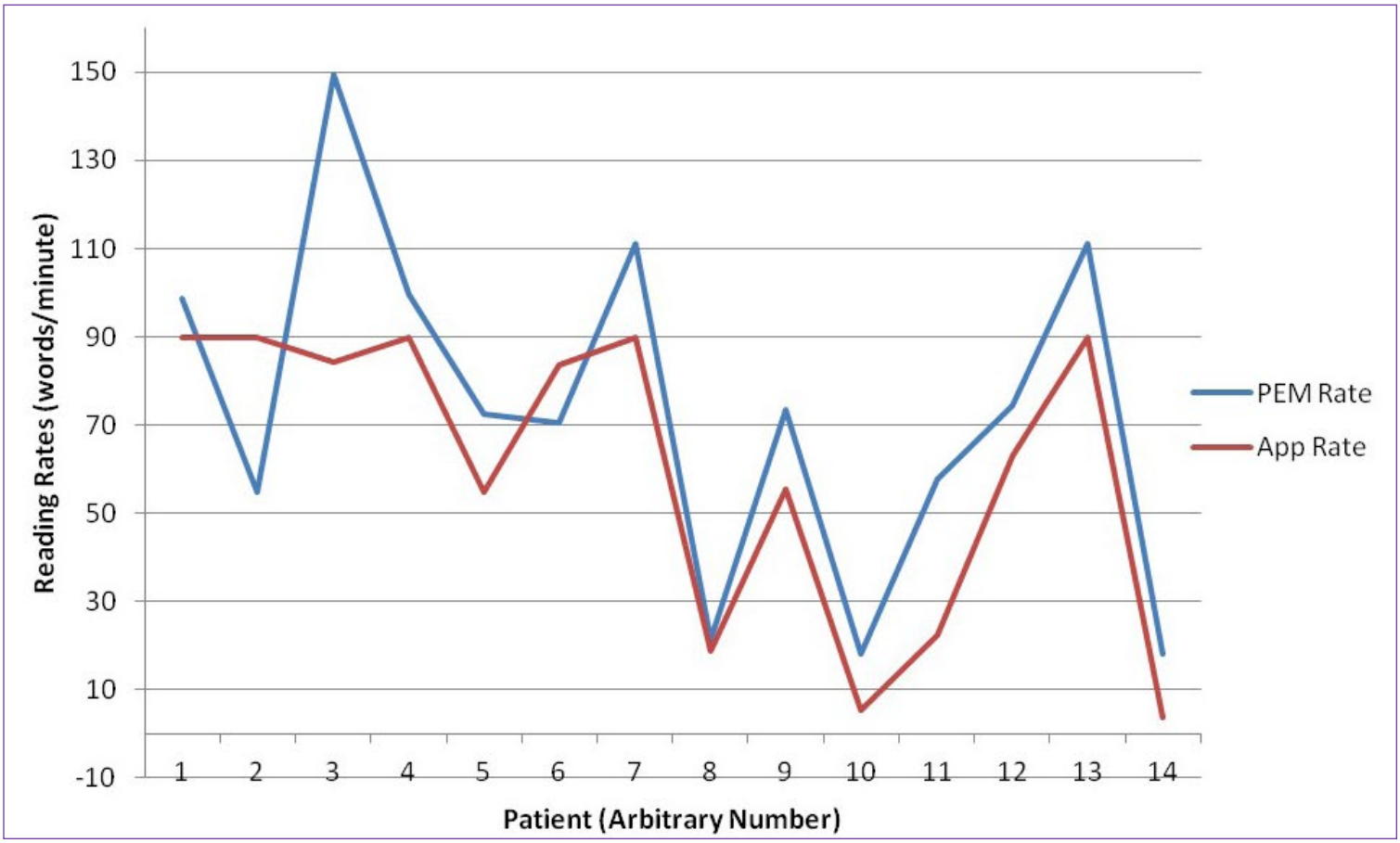

Figure 1. A comparison of reading rates using a PEM vs. smart phone application.

from looking at the subject's medical record that there was longstanding psychological distress due to the vision loss. The subject's clinical data demonstrated fluctuations, and numerous referrals to psychological counseling were documented.

Statistical significance (P=0.04) between the reading rates using PEM and magnification apps was demonstrated; subjects to read faster.

To determine whether there was a correlation between performance with the devices and visual acuity, data was separated and compared based on the following VA ranges: 20/70 to 20/100, >20/100 to <20/200, and 20/200 to 20/300. Afterwards, statistical analysis P values were calculated and can be seen in Table 4.

There was no significant difference in the reading rates obtained while using either device when comparing subjects grouped by visual acuity categories.

The pre-study survey results found that all subjects were between somewhat comfortable (40%) to very comfortable (60%) using their smartphone. All subjects reported using magnification on their smartphones; 42% used magnification daily, and 58% used magnification weekly. Subjects reported using their phones for text messaging (100% of subjects), audio and visual reading (80% of subjects), social media (53% of subjects), camera (87% of subjects), and navigation via GPS (40% of subjects). In using their smartphone in helping with activities of daily living, 33% of subjects found them somewhat helpful, and 53% found them very helpful. Twenty percent of subjects reported that they could not live without their smartphone, 53% said they always rely on their smartphone, and 27% of subjects only rely on their smartphone occasionally.

The post-study survey found that 79% percent of the subjects preferred the PEM over the magnifier app for reading tasks due to its ease of use, stability, and focus. Eighty-six percent of subjects stated that the PEM was both physically and visually easier to use. When

Table 4. Calculated P Values for All Comparison Groups

Group	P Value
All Subjects	P=0.040
Subjects w/ VA of 20/70-20/100	P=0.098
Subjects w/ VA of >20/100-<20/200	P=0.904
Subjects w/ VA of 20/200-20/300	P=0.187

asked about which device they would use for short reading tasks (less than five minutes), 57% of subjects favored the magnification app. Eighty percent of subjects preferred the PEM for long reading tasks (longer than five minutes). When asked about benefits of one device over the other, the comments were split. Favorable comments for the PEM included the following: easy to keep place while reading, clear focus, and stable image. Favorable comments for the magnification app included the following: (lower) cost, and it is a device that they carry with them. Unfavorable comments for the PEM included the following: (higher) cost, weight, and an extra device to carry. Unfavorable comments for the magnification app included the following: unsteady image, easy to lose place, autofocus not fast enough, and toolbar got in the way. When subjects were asked which device they would prefer if cost was not an issue, 86% chose the PEM, and 14% chose the magnification app.

Discussion

This study sought to determine whether a PEM or a magnification app would provide faster reading rates for people with low vision. This study showed that when analyzing the 14 subjects as a group, statistically significant (P value of 0.04) faster reading rates were found while using the PEM. Faster reading rates are more likely to help people with low vision meet their reading goals. However, when subject data was separated into groups based on visual acuity, there was no significant difference in reading rate. This may indicate that visual acuity was not a factor in performance between the two devices.

The survey results indicated that 79% of subjects preferred the PEM for all reading tasks, but 57% favored the magnification app for shorter reading tasks. The main dissatisfaction with the magnification app was the difficulty of use, the lack of image stability, and the loss of place while reading. If apps and smartphones can technologically advance to increase stability and focusing, then their use as portable magnifiers may increase. One study found that an iPhone magnifier app with a stabilization function increased reading performance in people with low vision at distance.[11] It is possible that this technology may be applied to increase reading rates at near and impact the lack of stability experienced by the subjects in this study.

Some limitations of this study include a small heterogeneous group of subjects and the magnification app itself. Even though a faster reading rate was found with the PEM, a larger sample size may provide a different result. The Brighter and Bigger magnification app was chosen due to the large range of magnification, different viewing modes available, and availability on both the iOS and Android OS systems. As apps advance, different features may be developed that affect reading rates.

The screen sizes were also different between the PEM and the smartphones. The PEM was the smallest at 4.3", while both phones had larger screen sizes (5.1" and 4.7"). Research has shown that a larger field of view (screen size) allows for increased reading rates.[12-14] In one study comparing reading rates with different-sized PEMs, a larger screen size (5.8-7") allowed reading rates of 8.1 words per minute faster than smaller screen size (4").[15] In our study, the PEM had a faster reading rate with a smaller screen size than both smartphones. If the screen sizes had been equal, it is possible that reading rates with the PEM would have been even faster.

Finally, psychological benefits of using a smartphone magnification app over a PEM

were not explored in this study. Other studies acknowledge that using a magnification device can be embarrassing to some people.[16] Thus, future studies may question people about whether or not societal acceptance would impact their preference for one device over another. The results may help in subject selection for the use of smartphone applications as a magnification device.

Conclusion

This study found that individuals with low vision rely on and use their smartphones for many different tasks. The majority of subjects responded that their smartphones were helpful to accomplish their activities of daily living, and they were reliant on their smartphones. Smartphones are becoming an important tool for people with visual impairment to help maintain independence. This study underscores the importance of including discussion and demonstration of smartphones, accessibility features, and magnification apps in the delivery of low vision rehabilitation care to people with low vision and blindness.

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