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Psychophysics of Reading—XIII. Predictors of Magnifier-aided Reading Speed in Low Vision

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A key clinical problem in low-vision assessment is finding simple measures that are predictive of real-world performance. Our purpose was to determine whether a set of clinical variables could predict how well low-vision subjects read with their magnifiers. The variables were Snellen acuity, presence/absence of central scotomas, clear/cloudy ocular media, age, magnifier type, and score on a standardized test of reading speed (Minnesota Low-vision Reading Test). Forty low-vision subjects identified the magnifier they most "preferred" to use, based on the frequency and length of time used, ease of use, or any other factor considered important by each subject. All subjects were highly experienced with their magnifier (3 months to 21 yr of use). We classified the magnifiers into five categories: (1) standard correction only; (2) hand-held magnifier; (3) spectacle-mounted magnifier; (4) closed-circuit TV; and (5) stand magnifier. Subjects used their preferred magnifiers to read aloud printed paragraphs of about 150 words from which their reading speeds were calculated. By far the best predictor of the magnifier-aided reading speed was the score on the standardized reading test which accounted for 79.7% of the variance. 43.7% of the variance was accounted for by age, and 42.3% by magnifier type. Snellen acuity, central visual field status, and ocular media status were not significantly correlated with magnifier-aided reading speed. We conclude that a standardized clinical reading test can give a valid prediction of the reading speed a low-vision patient is likely to achieve with a magnifier.

Low vision Reading Reading speed Magnifier Acuity Clinical predictor

INTRODUCTION

A recent survey reported that there are about three million visually impaired Americans (Tielsch, Sommer, Will, Katz, & Royall, 1990). A common and serious effect of visual impairment is reading difficulty. In fact, low vision has sometimes been defined as the inability to read the newspaper with best optical correction at a normal reading distance.

Most people with low vision use a magnifier to read. Even after appropriate magnifier prescription, there is an enormous range in reading performance across low-vision patients. Our primary goal was to determine how well clinical measures can predict low-vision reading performance with magnifiers. A good clinical predictor would be useful to clinicians in recommending suitable rehabilitation strategies. For example, rehabilitation recommendations would be very different for two patients, one predicted to read 150 words/min with a magnifier and the other 15 words/min. The first patient might rely on magnifier-aided print reading for most tasks. The second patient might be prescribed a magnifier for short texts such as food labels, medicine instructions, or short letters. Longer texts might be handled on cassette or in Braille. Evaluation of reading potential may also be important in determining whether a prescribed magnifier optimizes a patient's reading performance. If a reliable clinical predictor indicated that the patient should be able to achieve 150 words/min, but the measured magnifier-aided speed is only 50 words/min, the clinician would be alerted to the need for further training of the patient or for alternative prescription.

Legge, Rubin, Pelli and Schleske (1985) showed that status of central visual fields and ocular media play an important role in determining reading speed. However, Legge, Ross, Isenberg and LaMay (1992) showed that these clinical measures, along with Snellen acuity, are poor predictors of standardized reading speed in a large clinical sample. Age, a non-visual measure, was shown to be a better predictor of reading performance than acuity. Legge *et al.* (1992) suggested that a standardized clinical measure of reading speed might be necessary to achieve good prediction of real-world reading function.

Our study was conducted in large part to test this conjecture. The question we posed is the following: can a standardized test of reading performance do a better job of predicting reading performance with magnifiers than conventional clinical measures?

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The standardized reading test we used was the Minnesota Low-vision Reading Test (also called MNREAD) (Legge, Ross, Luebker, & LaMay, 1989). MNREAD is a computer-based test of reading speed that uses very large letters (6 deg, 20/1440 Snellen). *A priori*, we cannot be sure that the MNREAD score is a valid predictor of magnifier-aided reading performance. Magnifier reading speed may be affected by factors not present in the MNREAD test such as the physical characteristics of the magnifier, the reader's ability to scan the text with the magnifier, and line-finding ability.

The type of magnifier used by a person with low vision is determined by several factors including cost, physical characteristics of the magnifier (e.g. size), optical characteristics (e.g. power and field size), nature of the reading task, nature of vision loss, and availability. It is natural to ask whether there is a link between the type of magnifier used and reading performance. Two studies by Cohen and Waiss (1991a, b) indicate that the type of magnifier can affect reading speed. They tested reading speeds of normally sighted subjects who read with magnifiers of different equivalent powers. When field size was not controlled, reading speed varied as a function of magnifier type. When variations in field size were equated for, reading speeds with spectacles, hand magnifiers, and stand magnifiers showed no significant statistical differences.

In addition to our interest in prediction of reading speed, we also studied the relationship between reading speed and the type of preferred magnifier. We did this by classifying the preferred methods of magnification of our 40 subjects into five categories. We asked whether there were differences in reading speed across categories?

METHODS

Subjects

We studied 40 subjects with low vision. (Two additional subjects were excluded from that data analysis because of insufficient documentation of their eye condition.) The age range was 23–84 yr with a mean of 45 yr. There were 23 women (mean age of 50 yr) and 17 men (mean age of 41 yr). Subjects were either referred to us from the Minneapolis Society for the Blind or selected from the low-vision subject roster maintained in our laboratory. The following criteria were used in selecting subjects: (1) native English speakers with reading fluency; (2) no known cognitive deficit; (3) at least 3 months of experience with the method of preferred magnification; (4) distribution across magnifier type; and (5) distribution across age, sex, acuity, field and media status. Characteristics of subjects are listed in Table 1.

Acuity was measured with the Lighthouse Distance Visual Acuity Chart (2nd edn). The entries for LogMAR in Table 1 pertain to the higher acuity eye. Diagnosis, central visual field, and ocular media designations were derived from a clinical summary obtained from each subject's ophthalmologist or optometrist. A binary classification was used in describing the status of central fields (loss or intact) and media (cloudy or clear). The visual field was designated as having "loss" if an absolute scotoma covered all or part of the central 5 deg (diameter) and as "Intact" otherwise. Ocular media were designated as "Cloudy" if corneal scarring, cataracts, vitreous debris or other obstructions occurred within the ocular media and designated as "Clear" in the absence of such obstructions.

Magnifier use

As part of the intake interview, we asked our subjects to describe their magnifier use at home or at work. Seven of our subjects used no magnifier, preferring to read with the naked eye or with standard refractive corrections only. We refer to these subjects as the "Standard Correction Only" group (SCO). The remaining 33 subjects used at least one magnifier.

We asked our subjects to choose the magnifier they most "preferred" to use (based on the length of time used, ease of use, convenience, or any other factor considered important by each subject). We classified these magnifiers into four categories: (1) Hand-held, $N = 10$; (2) Stand, $N = 5$; (3) Spectacle-mounted, $N = 8$; and (4) Closed-circuit TV (CCTV), $N = 10$.

We classified as Hand-held any convex (positive) lens held by the subject at some chosen distance between the page and eye. A stand magnifier was any lens, supported at a fixed distance from the page by a mount (i.e. stand) resting on the page. The Hand-held and Stand magnifiers used by our subjects were of different sizes and power and consisted of both the illuminated and non-illuminated types. The Spectacle-mounted magnifiers were any magnifier worn in a spectacle frame. These included magnifying lenses worn binocularly as well as telescopes or microscopes worn monocularly. CCTV allows the user to view magnified images on a TV monitor. The user can control magnification and brightness. The user can also reverse the contrast so that a page of black print on a white background appears as white print on a black background.

A more detailed description of different types of magnifiers is provided by Sloan and Brown (1961) and Sloan (1977), along with explanations of advantages and disadvantages of each magnifier type.

Subjects were highly experienced with their magnifiers, with period of use ranging from 3 months to 21 yr of use. Some subjects reported using a number of different magnifiers while others reported using only one magnifier. The frequency and length of magnifier use varied greatly between our subjects. Some subjects reported using a magnifier for a minute or two at a time, a couple of times a day. Other subjects reported using a magnifier up to an hour or more at a time, several times a day. The tasks for which magnifiers were used also varied widely between subjects, from reading price tags, instrument dials, and bills to reading continuous text in books and newspapers.

All subjects, except those in the CCTV and SCO groups, brought their preferred magnifier to the test session. Subjects in the CCTV group used a CCTV

(VTEK Voyager XL, black and white) in our laboratory instead of bringing their own. These subjects were given a chance to become familiar with the laboratory CCTV. Subjects in the SCO group read the test material either with the naked eye or with refractive correction only.

Note that two subjects in our Stand group (subjects J and U in Table 1) indicated using both a stand and a hand-held magnifier. For the purpose of data analysis, we included these subjects only in the Stand group.

Procedure

After the procedures were described to the subjects, they consented to participate. Following an intake interview and acuity testing, reading speed was measured with the MNREAD test.

The MNREAD test has been described in detail by Legge *et al.* (1989) and is briefly described here. For this test, subjects used only refractive correction, when necessary, and did not use their preferred magnifiers. [Subjects in the SCO group viewed both the MNREAD screen and the test paragraphs (see below) with the naked eye or the same standard refractive correction.] The test uses simple sentences presented at high magnification on a computer screen. The subject is asked to read the sentence aloud as rapidly as possible. Each sentence, rendered as black letters on a white background, consists of four lines of 13 character spaces. The luminance of the white background was approx. 100 cd/m^2. At a viewing distance of 19 cm, each fixed-width character subtends 6 deg (center-to center character spacing). This large character size (equivalent to Snellen 20/1440 or logMAR 1.86) lies within the acuity limit of almost all low-vision subjects, thereby enabling these subjects to read near their peak rate. Each sentence is selected at random without replacement from a pool of 28 sentences and is presented for timed exposures. If the subject can read the entire sentence, the exposure time is reduced for the next sentence. This procedure continues until the exposure

TABLE 1. Characteristics of low-vision subjects are presented, together with the MNREAD score and magnifier-aided reading rate

Subject	Age (yr)	LogMAR	Media	Central loss	Diagnosis	Magnifier type	Reading Rate (words/min) MNREAD	Magnifier
A	36	0.30	Cloudy	No	RP	CCTV	36	41
B	36	1.00	Cloudy	No	Congenital cataract	SCO	155	95
C	40	1.00	Cloudy	No	Congenital cataract	Spectacle-mounted	124	139
D	30	0.30	Cloudy	No	Diabetic retinopathy	Hand-held	201	117
E	41	1.70	Cloudy	No	Corneal opacification	CCTV	49	66
F	41	0.70	Cloudy	No	Congenital cataract, RP	CCTV	55	53
G	61	1.20	Cloudy	No	Congenital cataract	Hand-held	25	24
H	25	1.00	Cloudy	No	RLF, congenital aphakia	Hand-held	145	99
I	84	0.60	Cloudy	No	Macular degeneration	Stand	11	14
J	42	0.30	Cloudy	No	Diabetic retinopathy	Stand	221	102
K	30	0.70	Clear	No	Aphakia, glaucoma	Hand-held	191	148
L	36	*	Clear	No	Albinism	CCTV	127	72
M	23	0.00	Clear	No	Optic atrophy	SCO	165	125
N	39	0.70	Clear	No	Optic neuritis	Hand-held	138	115
O	31	1.00	Clear	No	Aphakia	SCO	115	77
P	43	0.30	Clear	No	Diabetic retinopathy	Spectacle-mounted	144	178
Q	31	0.48	Clear	No	Myopic retinal degeneration	SCO	186	147
R	36	1.00	Clear	No	Macular pucker	SCO	218	145
S	28	0.40	Clear	No	RP, macular edema	CCTV	91	54
T	39	0.90	Clear	No	Optic nerve hypoplasia	SCO	298	195
U	28	1.20	Clear	No	Cataracts, Aphakia	Stand	104	77
V	28	1.17	Cloudy	Yes	Myopic retinal degeneration	SCO	133	139
W	83	0.60	Cloudy	Yes	Macular degeneration	Hand-held	56	41
X	42	0.70	Cloudy	Yes	Diabetic retinopathy	Spectacle-mounted	223	143
Y	55	1.20	Cloudy	Yes	Diabetic retinopathy	Hand-held	71	65
Z	82	0.90	Cloudy	Yes	Macular degeneration	Stand	52	31
AA	42	1.17	Clear	Yes	Optic atrophy	CCTV	63	50
BB	82	*	Clear	Yes	Macular degeneration	Hand-held	16	36
CC	46	1.00	Clear	Yes	Macular degeneration	Hand-held	60	41
DD	44	1.08	Clear	Yes	Retinal lesion	Spectacle-mounted	86	81
EE	34	1.38	Clear	Yes	Stargardts disease	Hand-held	57	56
FF	71	1.30	Clear	Yes	Macular degeneration	Hand-held	72	68
GG	62	1.20	Clear	Yes	RP, cataracts, aphakia	Spectacle-mounted	82	79
HH	39	0.80	Clear	Yes	Stargardts disease	Spectacle-mounted	259	140
II	33	1.20	Clear	Yes	RLF	Spectacle-mounted	72	107
JJ	67	0.51	Clear	Yes	Optic atrophy	CCTV	146	78
KK	45	1.20	Clear	Yes	Leber's disease	Spectacle-mounted	80	85
LL	41	0.60	Clear	Yes	Juvenile macular degeneration	CCTV	43	39
MM	31	1.30	Clear	Yes	Macular degeneration	CCTV	117	150
NN	82	1.40	Clear	Yes	Macular degeneration	Stand	17	23

*Acuity was not included due to insufficient documentation.

A nobleman and a merchant once met in a tavern. For their lunch they both ordered soup. When it was brought, the nobleman took a spoonful, but the soup was so hot that he burned his mouth and tears came to his eyes. The merchant asked him why he was weeping. The nobleman was ashamed to admit that he had burned his mouth and answered, "Sir, I once had a brother who committed a great crime, for which he was hanged. I was thinking of his death, and that made me weep." The merchant believed this story and began to eat his soup. He, too burned his mouth, so that he had tears in his eyes. The nobleman noticed it and asked the merchant, "Sir, why do you weep?" The merchant, who now saw that the nobleman had deceived him, answered, "My Lord, I am weeping because you were not hanged together with your brother."

FIGURE 1. A sample passage read by subjects with their preferred magnifier.

time is short enough so that the subject can't complete the sentence. In the present study, three to five sentences were presented at this exposure time. For each, reading rate was computed in words/min as the number of words read correctly (i.e. verbatim) divided by the exposure time. The mean reading rate obtained across these trials is shown in Table 1 under the heading "MNREAD".

Subjects used their preferred magnifiers to read aloud printed passages that resembled ordinary reading material. There were seven passages, each about 150 words long, printed as black letters on 8 × 11 in. matt white paper glued to stiff cardboard. Each passage was printed in a fixed-width font (Courier, 12 pt) and was displayed in a double spaced, left justified format with about 1 in. left and right margins and about 1.5 in. top and bottom margins. These passages were taken from the *Standard test lessons in reading* prepared by McCall and Crabbs (1925–26). Figure 1 shows one of the seven passages as it appeared on a card.

Subjects were encouraged to hold the card in any way that felt most comfortable for viewing and reading. Some subjects placed the card on the table while others held it with their hand. Subjects were also free to move their head or hand to scan the card while reading. Lighting in the testing room was adjusted according to the subject's preference. Some subjects preferred to have a bright incandescent lamp close to the text while others preferred florescent overhead room light.

Subjects in the CCTV group were allowed to use all the options typically provided on a CCTV—adjustments of the zoom magnification, brightness, and contrast polarity. Four chose black text on a white background and six chose white text on a black background.

Subjects were instructed to read a complete passage aloud as rapidly as possible. The experimenter measured the time taken by the subject to finish reading the passage and kept track of errors. We defined "error" as words omitted or read incorrectly (e.g. reading "mountain" as "fountain" or "apples" as "apple"). The reading rate was then computed in words/min as the number of words read correctly divided by the time measured. Reading rates were obtained for each subject on either two or three passages. We refer to the mean reading rate across these trials as the "magnifier-aided reading rate", shown for each subject in Table 1.

The data were analyzed with the Systat statistical package (v. 5.1). Descriptive statistics, regression analyses, and analyses of variance were conducted. The criterion for statistical significance was $p < 0.05$. For reading rates and acuity, log values were used in statistical analyses. Using log values enabled us to better deal with the wide range of values represented in our data and to work with more homogeneous variances. Age was used directly. The non-numeric variables (i.e. ocular media, central field, magnifier type, and sex) were coded as numerical indicator variables for regression analyses.

RESULTS AND DISCUSSION

The question we posed earlier was whether or not a set of clinical measures could predict how well low-vision patients read with their preferred magnifiers (i.e. magnifier-aided reading rate). Our predictor variables included age, Snellen acuity, status of central visual field and ocular media, and MNREAD score. Our results show MNREAD score, magnifier type and age do predict magnifier-aided reading rate while acuity and status of central field and media do not.

By far the strongest single predictor of magnifier-aided reading rate was the MNREAD score. In simple regression analysis for the subject sample as a whole, MNREAD score accounted for 79.7% of the variance in magnifier-aided reading rate ($p < 0.0001$). Figure 2 shows a scatter plot of the magnifier-aided reading rate and the MNREAD score, together with the regression line. A separate analysis was performed that analyzed the results for 33 subjects after having statistically removed the seven subjects who read without a magnifier (the SCO group). This analysis confirms that the

MNREAD score still accounted for more than 75% of the variance in the magnifier-aided reading rate ($p < 0.001$).

The MNREAD score was also a strong predictor of magnifier-aided reading speed within the four subgroups defined by clear ($r^2 = 0.780$) and cloudy ($r^2 = 0.813$) ocular media and intact ($r^2 = 0.859$) and loss ($r^2 = 0.696$) central fields.

How accurately does the MNREAD score predict the magnifier-aided reading rate? If there were a perfect match between MNREAD score and magnifier-aided reading rate, data would lie along the equality line in Fig. 2. Our results show that as MNREAD scores increase, the magnifier-aided reading rates lag behind and fall below the equality line. Our data indicate that MNREAD score was a better predictor of magnifier-aided reading rate for slower readers than for faster readers. We divided our 40 low-vision subjects into subgroups of "slow" readers—the 21 subjects with MNREAD rates below the group mean of 113 words/min; and "fast" readers—the 19 subjects with MNREAD rates above the mean. Simple regression of MNREAD score accounted for 74.3% of variance in the magnifier-aided reading rate for the "slow" readers, while it accounted for only 15.2% of the variance for the "fast" readers.

Why is a weaker correlation found between MNREAD scores and magnifier-aided reading rate for the faster readers? One possibility is that scanning requirements of magnifiers may impose a ceiling on reading speed. The faster the reader, the greater is the impact on reading speed of the extra time taken to scan the magnifier, especially the return sweeps from the end of one line to the beginning of the next. In a recent study, Beckmann, Legge, and Rentschler (1993) have measured directly the time taken in the return sweeps in CCTV reading, and found that they sometimes had a substantial effect on reading speed. The MNREAD test does not involve manual scanning, though it does require return sweeps of the eyes from the end of one line to the beginning of the next. The design of the MNREAD test minimizes page-navigation demands in reading, and this may explain why some fast readers score substantially higher on MNREAD than they do with a magnifier.

In simple regression analysis performed for the subject sample as a whole, acuity did not significantly correlate with magnifier-aided reading rate ($r = 0.109$). Figure 3 shows a scatter plot of the magnifier-aided reading rate as a function of acuity. Acuity accounted for only 1.2% of the variance in the reading rate, as shown in Fig. 3 by the nearly flat regression line. Acuity also failed to predict magnifier-aided reading rate within four subgroups of subjects, based on cloudy/clear ocular media and intact/loss central field.

There was no significant effect of field status or media status on magnifier-aided reading rate in our analysis of variance (field status and media status by magnifier-aided reading). These results indicate that our binary classifications of field and media status of patients are not helpful in predicting reading performance with magnifiers.

We found a statistically significant correlation of 0.661 between age and magnifier-aided reading rate ($p < 0.0001$). This relationship accounted for 43.7% of

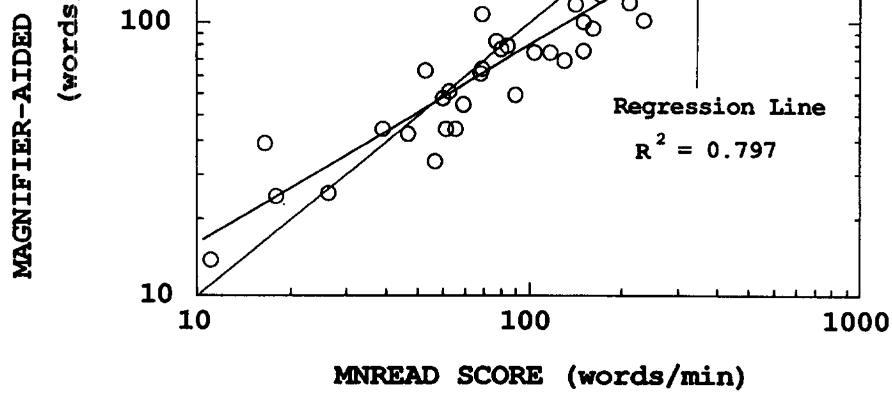

FIGURE 2. Magnifier-aided reading rate is plotted as a function of MNREAD score for all subjects. MNREAD score was by far the strongest predictor of the reading rate obtained with the magnifier. The two lines shown are the regression line and the equality line. Regression equation is $\log R = 0.496 + 0.709 \log M$, where R is magnifier-aided reading rate and M is the MNREAD reading rate. The equality line shows that the match between MNREAD score and magnifier-aided reading rate is better at the lower range of reading rate than at the higher range. At the higher range MNREAD score tends to overestimate the magnifier-aided reading rate.

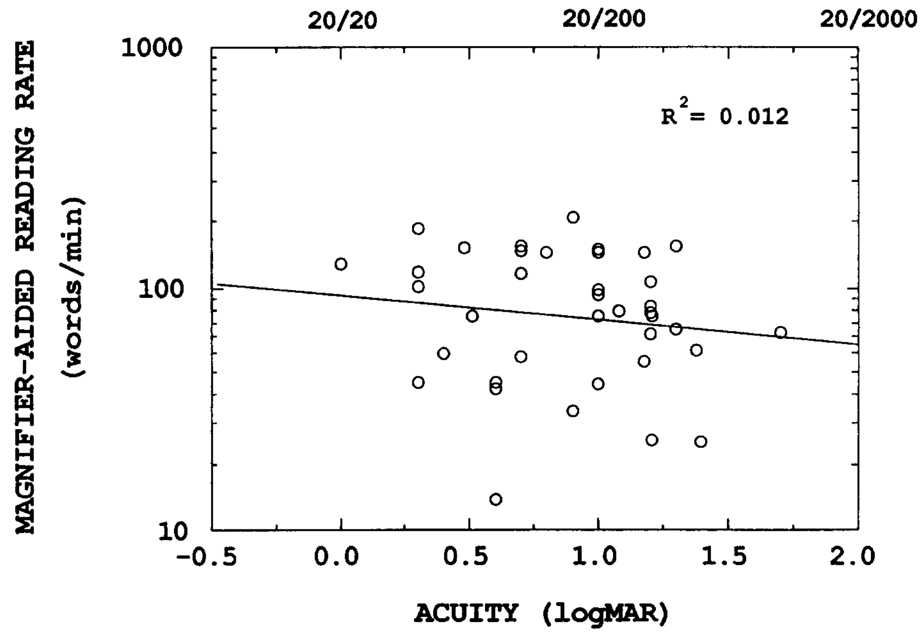

FIGURE 3. Magnifier-aided reading rate is plotted as a function of acuity (Snellen and logMAR) for all subjects. Regression equation is $\log R = 1.944 - 0.076A$, where R is magnifier-aided reading rate and A is acuity in logMAR. Acuity was a poor predictor of magnifier-aided reading rate.

the variance in the magnifier-aided reading rate, as shown in Fig. 4. The moderate relationship between age and reading speed is consistent with findings of Legge *et al.* (1992) that showed that age was a better predictor of low-vision reading rate than acuity.

Magnifier type was also a significant predictor of magnifier-aided reading rate ($p < 0.001$). This variable accounted for 42.3% of the variance in reading rate. The link between magnifier type and magnifier-aided reading rate is shown in a bar graph in Fig. 5. Not surprisingly, subjects in the SCO group showed the highest reading speed (mean = 132 words/min), followed by Spectacle-mounted magnifier (mean = 119 words/min), Hand-held magnifier (mean = 74 words/min), and CCTV (mean = 67 words/min). The Stand group had the lowest mean reading speed (mean = 49 words/min).

Mancil and Nowakowski (1986) showed that the type of low-vision aid used has a significant effect on reading

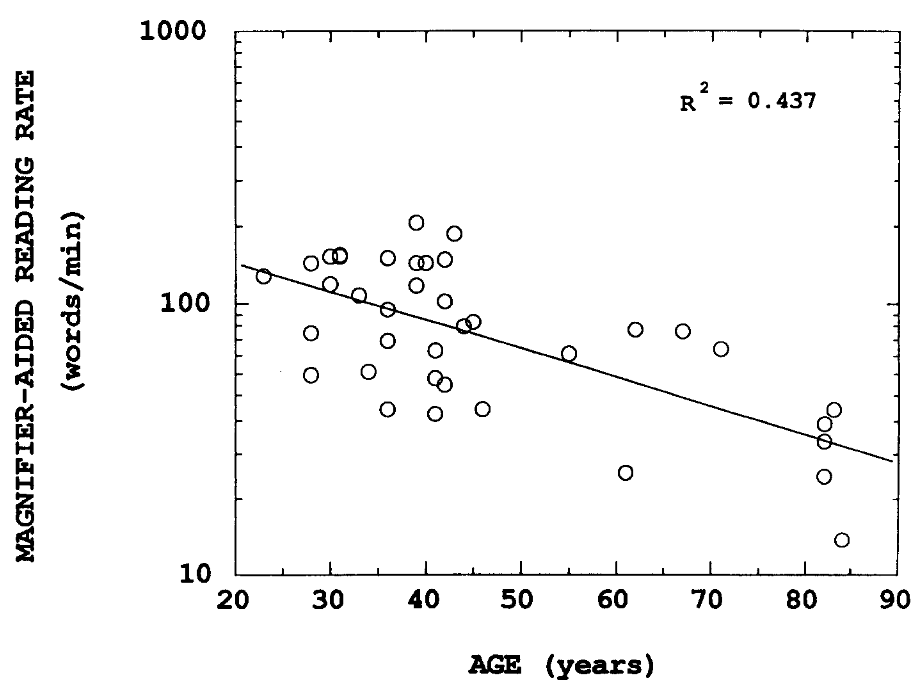

FIGURE 4. Magnifier-aided reading rate is plotted as a function of age. Regression equation is $\log R = 2.329 - 0.010G$, where R is magnifier-aided reading rate and G is age in years. Data are shown for all subjects. Age was a much better predictor of reading rate than acuity.

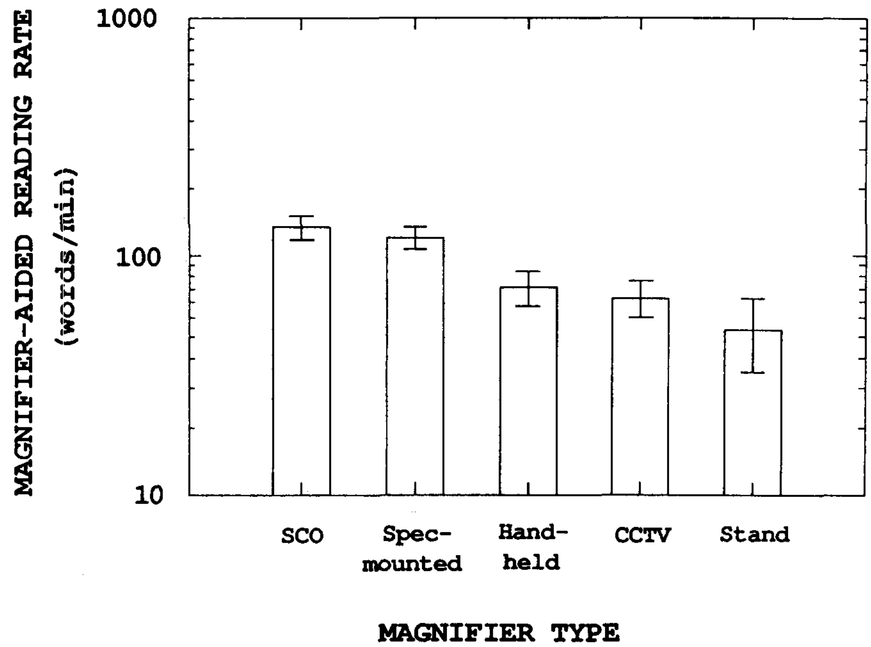

FIGURE 5. The bar graph shows the mean magnifier-aided reading rates for the SCO group and four magnifier groups: Spectacle-mounted, Hand-held, CCTV, and Stand. Data are shown for all subjects. The error bars represent the SEM.

speed for normally-sighted subjects (optometry students): a stand magnifier yielded the lowest reading speed, followed in order by a spectacle-mounted telescope, hand-held magnifier, and spectacle-mounted microscope. These results are similar to ours in showing that reading performance was slowest with the stand magnifier. We cannot make a finer-grained analysis of our spectacle-mounted magnifier data because our design does not permit a useful subdivision of subjects according to telescope and microscopes. Our results are consistent with findings by Cohen and Waiss (1991a) who compared reading speeds of normally-sighted subjects obtained with four types of low-vision aids and found fastest reading speed with the spectacles, followed by telemicroscope, hand magnifier, and stand magnifier. Their findings with normal subjects are in qualitative agreement with our low-vision data which showed that reading performance was slowest for the stand magnifier and intermediate (between the spectacle-mounted and stand magnifiers) for the hand-held magnifier.

Why is reading performance with the stand magnifier slow compared with other magnifiers? We found that subjects in our Stand magnifier group had difficulty repositioning their magnifier at the start of each new line. After manually scanning to the end of a line, subjects would often back track inaccurately, placing their Stand on a line that they had already read or skipping a line. Another possibility is that narrow field of view is responsible for the slow reading speed. In their study of several magnifier types, Cohen and Waiss (1991a) reported that the stand magnifier had the narrowest field and lowest reading speeds.

We asked how well MNREAD score and age together predict magnifier-aided reading rate. We found that MNREAD score and age together accounted for 81.4% of the variance in the reading rate. However, once MNREAD score was taken into account, age was no longer a significant predictor of magnifier-aided reading rate. We found that age and MNREAD score together do not provide a significantly better prediction of the magnifier-aided reading rate than MNREAD score alone.

We found a link between age and magnifier type, which an analysis of variance showed to be statistically significant ($p < 0.05$). The bar graph in Fig. 6 shows mean age of subjects in each magnifier group, together with error bars. The SCO group was the youngest group (mean age = 32 yr). The oldest was the Stand magnifier group (mean age = 64 yr), followed by the Hand-held magnifier group (mean age = 53 yr), the Spectacle-mounted magnifier group (mean age = 44 yr), and the CCTV group (mean age = 40 yr). Our results are consistent with the findings of Sloan and Brown (1961) that the preference for a stand magnifier tends to increase with the age of the patient. They reported that of those with severe visual impairment (reading vision of 10M or poorer), 84% of their older subjects (>60 yr) and only 27% of their younger subjects (<30 yr) preferred a stand magnifier.

We asked if the status of visual fields and ocular media affect the type of magnifier preferred. An analysis of variance on our entire subject sample showed no significant field or media effects on magnifier type. We note that six of the seven subjects in our SCO group did have intact central field (Table 1). We also note the six out of eight subjects in our Spectacle-mounted magnifier group had central-field loss. Sloan and Brown (1961) reported that Stand magnifiers are often used by older patients with marked loss of central vision. We may have failed to find a similar result in our study due to smaller sample

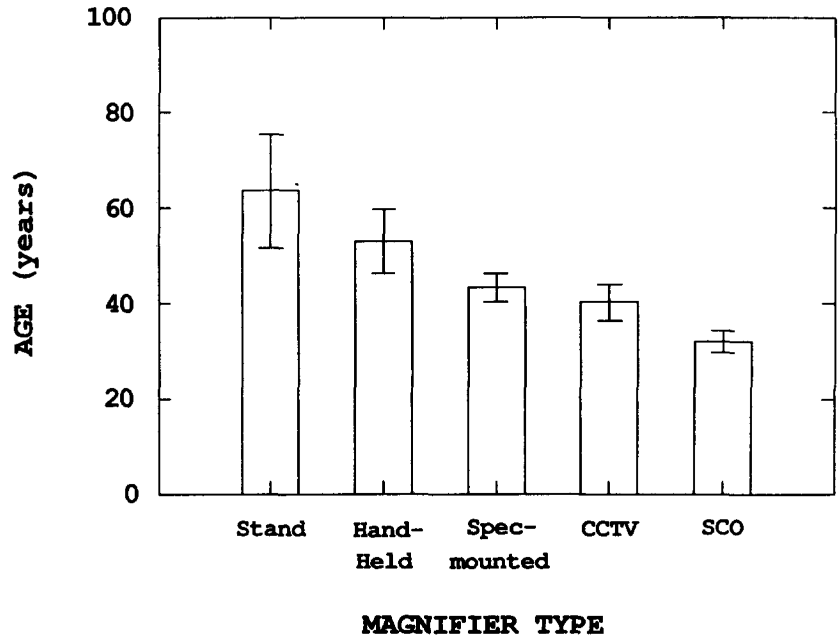

FIGURE 6. Each bar represents the mean age of subjects in the SCO group and four magnifier groups: Spectacle-mounted, Hand-held, CCTV and Stand. Data are shown for all subjects. The error bars represent the SEM.

size. In addition, the advent of CCTV as a magnifier following the work of Sloan and Brown may play a role.

Finally, we asked if contrast sensitivity was a useful predictor of magnifier-aided reading speed. Contrast sensitivities, measured with the Pelli–Robson chart, were available for 23 of our 40 subjects. In simple regression, we found that contrast sensitivity accounted for only 9.5% of the variance in magnifier-aided reading rate. The correlation was not statistically significant.

CONCLUSIONS

We found that a standardized measure of reading, MNREAD test, was by far the strongest predictor of magnifier-aided reading rate. The prediction was best for low-vision patients with reading rates below about 110 words/min. Our results indicate that acuity, status of the central visual field, and status of ocular media are poor predictors of the reading speed a low-vision patient is likely to achieve, and of the type of magnifier they are likely to prefer.

Our results support the growing consensus that clinical evaluation of the effects of eye disease on real-word tasks requires new performance-based tests. We have shown here that MNREAD provides a fairly accurate prediction of magnifier-aided reading speed. Our results indicate that clinicians can use a standardized test of reading to estimate a patient's potential for reading with a magnifier.

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