MNREAD ACUITY CHARTS

Continuous-text reading-acuity charts for normal and low vision

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MNREAD ACUITY CHARTS

The ***MNREAD ACUITY CHARTS*** are continuous-text reading-acuity charts suitable for measuring the reading acuity and reading speed of normal and low-vision patients. These charts were developed at the Minnesota Laboratory for Low-Vision Research, University of Minnesota, Minneapolis, Minnesota, USA, in research funded by the National Institutes of Health.

Use the ***MNREAD ACUITY CHARTS*** to measure:

- READING ACUITY
  The smallest print that the patient can read without making significant errors (see section 2).
- CRITICAL PRINT SIZE
  The smallest print that the patient can read with maximum speed (see section 3).
- MAXIMUM READING SPEED
  The patient's reading speed when reading is not limited by print size (see section 3).

Two versions of the chart contain different test sentences. Both versions are available with either black-on-white (normal contrast) or white-on-black (reversed contrast) print. Separate score sheets are provided for each. Catalog numbers are as follows:

	contrast	chart #	score sheet #
CHART 1	normal	C400	C4001W
CHART 1	reversed	C405	C4051B
CHART 2	normal	C410	C4102W
CHART 2	reversed	C415	C4152B

1. CHART DESIGN **(see figure 1)**

1.1 Test sentences

The ***MNREAD*** sentences provide samples of reading material designed to demand the visual processing capabilities and eye-movement control required for normal text reading.

Each sentence contains 60 characters (including a space between each words and at the end of each line) printed as three lines with even left and right margins.

The vocabulary used in the sentences is selected from words appearing with high frequency in 2nd and 3rd grade reading material.

1.2 Print sizes

The ***MNREAD ACUITY CHARTS*** contain sentences with 19 different print sizes.

From the recommended viewing distance of 40 cm (16 inches) the print size ranges from 1.3 to –0.5 logMAR (Snellen equivalents 20/400 to 20/6). This range can be extended by using a shorter or longer viewing distance.

Print size is measured as the height of a lower-case 'x'. LogMAR print size is calculated as follows:

$$\log_{10}[\text{ (angle subtended by x-height) / (5 arc min) }]$$

The ***MNREAD ACUITY CHARTS*** have been carefully calibrated to give the correct logMAR sizes. The approximate M sizes and Snellen equivalents are printed beside each sentence.

Each sentence is 0.1 logMAR units smaller than the previous sentence (i.e., about 80% of the size). Logarithmic scaling allows easy calculation of reading acuity at non-standard viewing distances, as might be required for low-vision patients with logMAR acuity greater than 1.3, or for patients whose activities require correction to specific distances.

1.3 Print style

The ***MNREAD ACUITY CHARTS*** are printed with a proportionally spaced font, similar to that found in many newspapers and books. The text is printed with high contrast (approximately 85%).

2. MEASURING READING ACUITY

2.1 Chart illumination

Care should be taken to ensure that the chart is evenly illuminated so that no shadows or glare will interfere with reading. The luminance of the white background of the charts should be at least 80 cd/m^2.

2.2 Viewing distance

The print sizes and markings on the chart are designed for a testing distance of 40 cm (16 inches). However, the charts can be used to measure reading acuity at other distances. Remember to make a note of the viewing distance used.

2.3 Testing procedure

1. Patients should read the test sentences aloud, starting either from the top of the chart or from several steps above their previously recorded letter acuity.
2. Mark on the score sheet any words that are missed or read incorrectly (see figure 2).
3. Patients should continue reading the smaller sizes until they cannot read *any* words in a sentence.
4. Encourage patients to guess even when they believe the words are unreadable.

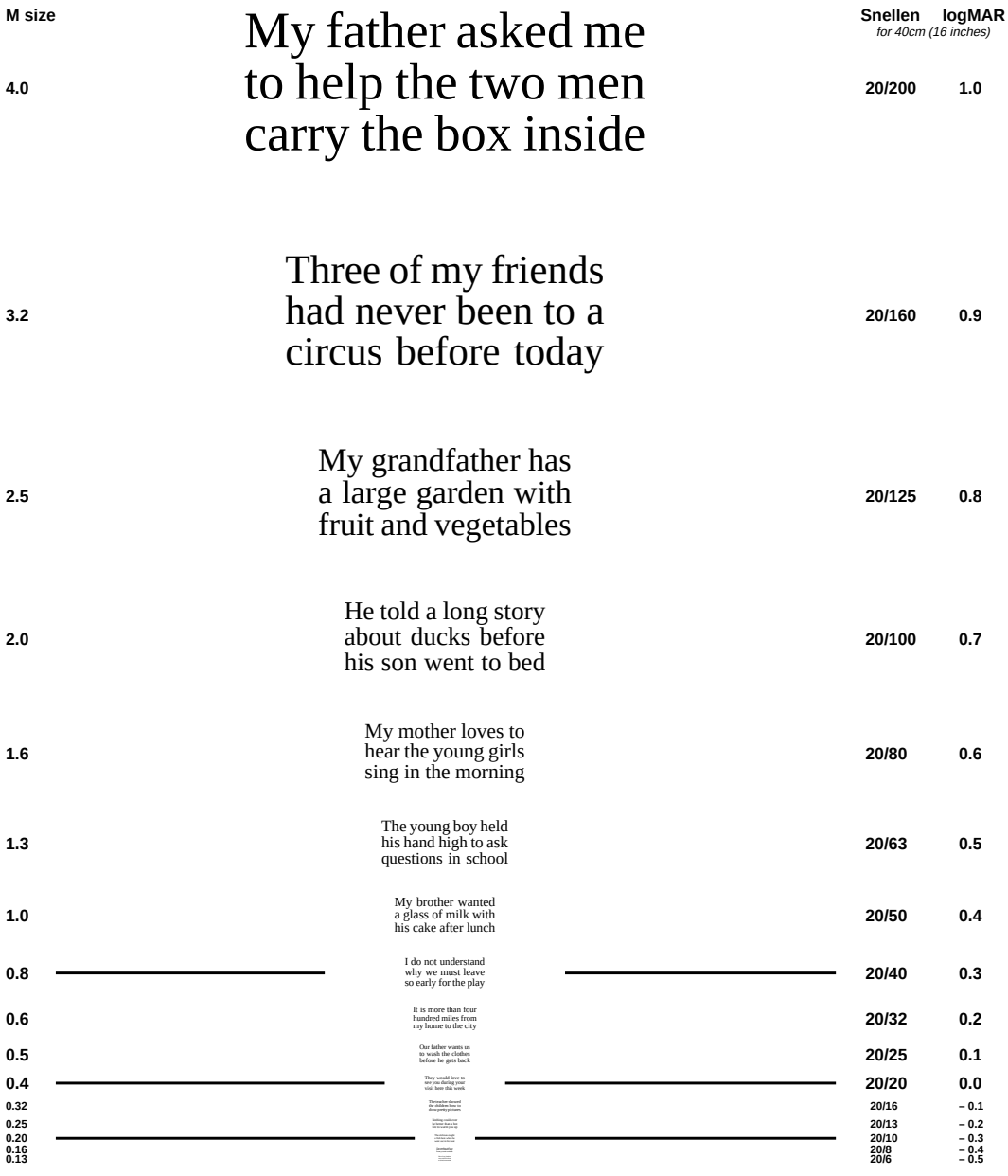

FIGURE 1: Example of the *MNREAD ACUITY CHARTS.* (Actual charts are 11 by 14 inches.)

2.4 Calculating reading acuity

An estimate of reading acuity is given by the smallest print size at which the patient can read the entire sentence without making significant errors. (Usually reading performance deteriorates rapidly as the acuity limit is approached, and it is easy to determine the level where reading becomes impossible). This method measures acuity to the nearest 0.1 logMAR.

The ***MNREAD ACUITY CHARTS*** can be used to provide a more sensitive and reliable measure of reading acuity. Each sentence has 60 characters, which corresponds to 10 standard length words, assuming a standard word length of 6 characters (including a space). Thus, each sentence can be divided into 10 smaller parts, and acuity can be measured to the closest 0.01 logMAR.

1. After the patient has read as much of the chart as possible, count the number of sentences that the patient read or attempted to read. If the patient did not start to read from the top of the chart, then include the sentences above the starting level as if they had been read.
2. Count the number of words that the patient read incorrectly.
3. Calculate reading acuity (in logMAR) using the following formula:

   Acuity = 1.4 – (sentences × 0.1) + (errors × 0.01).

   See the example of this calculation in section 4.1.

2.5 Scoring for non-standard viewing distances.

A convenient feature of the logMAR scale is that it allows simple conversion of reading acuity between different viewing distances. When the chart is used at a distance other than 40 cm, determine the patients score as outlined in the previous section, then adjust this value to account for the viewing distance used. Table A (on the back page of this booklet) lists the adjustments for a wide range of viewing distances.

2.6 Conversion to Snellen Acuity

Reading acuities in logMAR can be expressed as a Snellen fraction. Table B lists the Snellen fractions for a wide range of logMAR acuities.

3. MEASURING READING SPEED

Reading speed is an objective measure of reading performance. Research has shown that patients (with either normal or low vision) often require letters that are two or three times larger than their acuity limits before they can achieve their maximum reading speeds.

The ***MNREAD ACUITY CHARTS*** can be used to measure reading speed at different print sizes, and hence, can be used to determine the print size which supports the patient's maximum reading speed.

3.1 Testing procedure

1. Measuring reading speed can be combined with the reading-acuity measurement described previously. A blank piece of card should be used to cover the sentences below the one being read (to prevent previewing the subsequent sentences).
2. Instruct the patient to read each sentence aloud, as quickly and accurately as possible.
3. Use a stopwatch to record the time taken to read each sentence (to the nearest 0.1 sec.). Make a note of the times on the score sheet and mark any words that are missed or read incorrectly.

3.2 Calculation of reading speed

Reading speed is measured in words per minute. With the ***MNREAD ACUITY CHARTS*** the reading speed calculation is simplified because each sentence has the same length: 10 standard length words. Reading speed is given by:

reading speed = 600 / (time in seconds)

Table C lists reading speeds for a wide range of reading times.

A more precise reading speed measurement can be achieved by excluding words that were missed or read incorrectly. In this case reading speed is given by:

reading speed = 60 × (10 – errors) / (time in seconds)

If more than 10 errors were made then reading speed can be assumed to be zero.

3.3 Determining the critical print size:

The *critical print size* is the smallest print size at which patients can read with their maximum reading speed. This is an important measure as it indicates the minimum magnification required for effortless reading. The critical print size is most easily identified from a plot of the patient's reading speed at each print size.

The reverse side of the score sheet carries graph paper for plotting reading-speed data (see Figure 3). **It is not necessary to calculate reading speed for the sentences if this plotting paper is used.** The scale on the vertical axis is *reading time*. This scale has been transformed so that it corresponds to reading speed (assuming no reading errors were made). Reading speed in words-per-minute is shown on the scale at the right of the plot. The horizontal scale on the plotting paper shows *logMAR print size*.

MNREAD ACUITY CHART **CHART 1**

Name Emma N. Reid	**Date** 1st Oct '94
Eye tested OU [X] OS [ ] OD [ ]	**Test distance** 40cm [ ] other 32cm

1.3 logMAR 8.0 M 20/400 My father takes me to school every day in his big green car	**0.7 logMAR 2.0 M 20/100** He told a long story about ducks before his son went to bed **3.3**	**0.1 logMAR 0.50 M 20/25** Our father wants us to wash the clothes before he gets back **3.9**
1.2 6.3 20/320 Everyone wanted to go outside when the rain finally stopped	**0.6 1.6 20/80** My mother loves to hear the young girls sing in the morning **3.9**	**0.0 0.40 20/20** They would love to see you during your visit here this week **4.2**
1.1 5.0 20/250 They were not able to finish playing the game before dinner	**0.5 1.3 20/63** The young boy held his hand high to ask questions in school **3.7**	**–0.1 0.32 20/16** The teacher showed the children how to draw pretty pictures **4.8**
1.0 4.0 20/200 My father asked me to help the two men carry the box inside **4.0**	**0.4 1.0 20/50** My brother wanted a glass of milk with his cake after lunch **3.4**	**–0.2 0.25 20/13** Nothing could ever be better than a hot fire to warm you up **7.9**
0.9 3.2 20/160 Three of my friends had never been to a circus before today **3.4**	**0.3 0.8 20/40** I do not understand why we must leave so early for the play **3.4**	**–0.3 0.20 20/10** The old ~~man caught~~ a fish ~~here~~ when he went out in his boat **14.8**
0.8 2.5 20/125 My grandfather has a large garden with fruit and vegetables **4.4**	**0.2 0.6 20/32** It is more than four hundred miles from my home to the city **3.7**	**–0.4 0.16 20/8** Our mother tells us that we ~~should wear~~ heavy coats ~~outside~~ **24.4**
		–0.5 0.13 20/6 ~~One of my brothers went with his friend to climb a mountain~~

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FIGURE 2. Example scoresheet (see Section 4).

Typically, reading time remains fairly constant for large print sizes. But as the acuity limit is approached there comes a print size where reading starts to slow down. This is the *critical print size*. If a non-standard viewing distance was used, remember to adjust the critical print size to account for the viewing distance (see Table A).The critical print size can be converted to a Snellen fraction (using Table B).

The reading speed with print larger than the critical print size is the *maximum reading speed*. This is the reading speed that can be achieved by the patient when print size is not a limiting factor.

4. EXAMPLE

This section illustrates the calculation of reading acuity and reading speed using the ***MNREAD ACUITY CHARTS*** For demonstration purposes a viewing distance of 32cm was used, and the patient started to read from the 1.0 logMAR sentence.

The score sheet obtained is shown in figure 2. The tester has drawn a line through each word that was missed or read incorrectly, and has noted the reading time (in seconds) beside each sentence. In this case the patient was unable to read any of the last sentence on the chart (–0.5 logMAR).

4.1 Reading acuity analysis

Starting from the 1.0 logMAR level, the patient read all or part of 15 sentences. Following the procedure described in section 2.4, the three sentences above where the patient started should be counted as readable. Thus, the patient effectively read 18 sentences. From the score sheet it can be seen that the patient made 7 reading errors.

The patient's reading acuity can be calculated using the formula given in section 2.4:

$$\text{Acuity} = 1.4 - (\text{sentences} \times 0.1) + (\text{errors} \times 0.01)$$
$$= 1.4 - (18 \times 0.1) + (7 \times 0.01)$$
$$= 1.4 - 1.8 + 0.07 = -0.33 \text{ logMAR}.$$

This value now needs to be corrected for the non-standard viewing distance that was used. Table A shows that when the chart is viewed from 32 cm, the reading acuity value needs to be adjusted by +0.1 logMAR. Thus, the patient's *reading acuity* is –0.23 logMAR. This value can be converted to a Snellen fraction using Table B: –0.23 logMAR corresponds to 20/12.

4.2 Reading speed analysis

Figure 3 shows the reading speed graph for the data in figure 2. The data points show the reading time for each sentence. The scale at the right of the graph shows the corresponding reading speed in words per minute.

The graph shows that, for print sizes larger than about 0.0 or 0.1 logMAR, the patient's reading speed was approximately level, constant at 175 words per minute. This is the patient's *maximum reading speed*.

When the print size is smaller than –0.1 or 0.0 logMAR the patient's reading speed deteriorated. It can be seen that 0.0 logMAR was the smallest print size that could be read close to the maximum reading rate. Thus, 0.0 logMAR is the critical print size. This value needs to be corrected for the non-standard viewing distance that was used. Table A shows that when the chart is viewed from 32 cm, the logMAR value must be adjusted by +0.1 logMAR. Thus, the patient's *critical print size* is 0.1 logMAR. Using Table B, 0.1 logMAR corresponds to Snellen 20/25.

FIGURE 3. Reading-speed plot from the example data shown in figure 2.

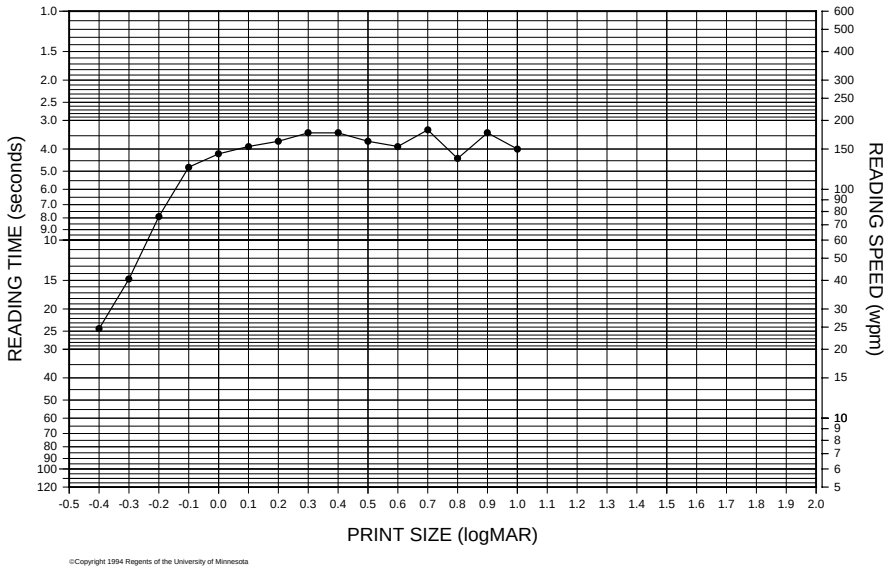

Table A
LogMAR adjustments for non-standard viewing distances

viewing distance		logMAR	viewing distance		logMAR
cm	inches	correction*	cm	inches	correction
4	1.6	+1.00	44	17.3	–0.04
8	3.1	+0.70	48	18.9	–0.08
12	4.7	+0.52	52	20.5	–0.11
16	6.3	+0.40	56	22.0	–0.15
20	7.9	+0.30	60	23.6	–0.18
24	9.4	+0.22	64	25.2	–0.20
28	11.0	+0.15	68	26.8	–0.23
32	12.6	+0.10	72	28.3	–0.26
36	14.2	+0.05	76	29.9	–0.28
40	15.7	+0.00	80	31.5	–0.30

* correction = $\log_{10}$ [40 / (viewing distance in cms)]

Table B
Conversion between logMAR and Snellen acuity

logMAR	Snellen*		logMAR	Snellen		logMAR	Snellen		logMAR	Snellen	
1.90	20/1589	6/477	1.30	20/399	6/120	0.70	20/100	6/30	0.10	20/25	6/8
1.88	20/1517	6/455	1.28	20/381	6/114	0.68	20/96	6/29	0.08	20/24	6/7
1.86	20/1449	6/435	1.26	20/364	6/109	0.66	20/91	6/27	0.06	20/23	6/7
1.84	20/1384	6/415	1.24	20/348	6/104	0.64	20/87	6/26	0.04	20/22	6/7
1.82	20/1321	6/396	1.22	20/332	6/100	0.62	20/83	6/25	0.02	20/21	6/6
1.80	20/1262	6/379	1.20	20/317	6/95	0.60	20/80	6/24	0.00	20/20	6/6
1.78	20/1205	6/362	1.18	20/303	6/91	0.58	20/76	6/23	-0.02	20/19	6/6
1.76	20/1151	6/345	1.16	20/289	6/87	0.56	20/73	6/22	-0.04	20/18	6/5
1.74	20/1099	6/330	1.14	20/276	6/83	0.54	20/69	6/21	-0.06	20/17	6/5
1.72	20/1050	6/315	1.12	20/264	6/79	0.52	20/66	6/20	-0.08	20/17	6/5
1.70	20/1002	6/301	1.10	20/252	6/76	0.50	20/63	6/19	-0.10	20/16	6/5
1.68	20/957	6/287	1.08	20/240	6/72	0.48	20/60	6/18	-0.12	20/15	6/5
1.66	20/914	6/274	1.06	20/230	6/69	0.46	20/58	6/17	-0.14	20/14	6/4
1.64	20/873	6/262	1.04	20/219	6/66	0.44	20/55	6/17	-0.16	20/14	6/4
1.62	20/834	6/250	1.02	20/209	6/63	0.42	20/53	6/16	-0.18	20/13	6/4
1.60	20/796	6/239	1.00	20/200	6/60	0.40	20/50	6/15	-0.20	20/13	6/4
1.58	20/760	6/228	0.98	20/191	6/57	0.38	20/48	6/14	-0.22	20/12	6/4
1.56	20/726	6/218	0.96	20/182	6/55	0.36	20/46	6/14	-0.24	20/12	6/3
1.54	20/693	6/208	0.94	20/174	6/52	0.34	20/44	6/13	-0.26	20/11	6/3
1.52	20/662	6/199	0.92	20/166	6/50	0.32	20/42	6/13	-0.28	20/10	6/3
1.50	20/632	6/190	0.90	20/159	6/48	0.30	20/40	6/12	-0.30	20/10	6/3
1.48	20/604	6/181	0.88	20/152	6/46	0.28	20/38	6/11	-0.32	20/10	6/3
1.46	20/577	6/173	0.86	20/145	6/43	0.26	20/36	6/11	-0.34	20/9	6/3
1.44	20/551	6/165	0.84	20/138	6/42	0.24	20/35	6/10	-0.36	20/9	6/3
1.42	20/526	6/158	0.82	20/132	6/40	0.22	20/33	6/10	-0.38	20/8	6/3
1.40	20/502	6/151	0.80	20/126	6/38	0.20	20/32	6/10	-0.40	20/8	6/2
1.38	20/480	6/144	0.78	20/121	6/36	0.18	20/30	6/9	-0.42	20/8	6/2
1.36	20/458	6/137	0.76	20/115	6/35	0.16	20/29	6/9	-0.44	20/7	6/2
1.34	20/438	6/131	0.74	20/110	6/33	0.14	20/28	6/8	-0.46	20/7	6/2
1.32	20/418	6/125	0.72	20/105	6/31	0.12	20/26	6/8	-0.48	20/7	6/2

*Snellen denominator = Snellen numerator × $10^{\text{(logMAR acuity)}}$ and has been rounded to the nearest integer.

Table C
Conversion between reading time (seconds) and reading speed (wpm) for the MNREAD sentences

time	speed*	time	speed	time	speed	time	speed	time	speed
1.0	600	3.4	176	5.8	103	8.2	73	13.5	44
1.1	545	3.5	171	5.9	102	8.3	72	14.0	43
1.2	500	3.6	167	6.0	100	8.4	71	14.5	41
1.3	462	3.7	162	6.1	98	8.5	71	15.0	40
1.4	429	3.8	158	6.2	97	8.6	70	15.5	39
1.5	400	3.9	154	6.3	95	8.7	69	16.0	38
1.6	375	4.0	150	6.4	94	8.8	68	16.5	36
1.7	353	4.1	146	6.5	92	8.9	67	17.0	35
1.8	333	4.2	143	6.6	91	9.0	67	17.5	34
1.9	316	4.3	140	6.7	90	9.1	66	18.0	33
2.0	300	4.4	136	6.8	88	9.2	65	18.5	32
2.1	286	4.5	133	6.9	87	9.3	65	19.0	32
2.2	273	4.6	130	7.0	86	9.4	64	19.5	31
2.3	261	4.7	128	7.1	85	9.5	63	20.0	30
2.4	250	4.8	125	7.2	83	9.6	63	21.0	29
2.5	240	4.9	122	7.3	82	9.7	62	22.0	27
2.6	231	5.0	120	7.4	81	9.8	61	23.0	26
2.7	222	5.1	118	7.5	80	9.9	61	24.0	25
2.8	214	5.2	115	7.6	79	10.5	57	25.0	24
2.9	207	5.3	113	7.7	78	11.0	55	26.0	23
3.0	200	5.4	111	7.8	77	11.5	52	27.0	22
3.1	194	5.5	109	7.9	76	12.0	50	28.0	21
3.2	188	5.6	107	8.0	75	12.5	48	29.0	21
3.3	182	5.7	105	8.1	74	13.0	46	30.0	20

* reading speed = 600 / (reading time in seconds)