



MNREAD App

**Continuous-text reading-acuity test
for normal and low vision**

User Guide

Version 0.9

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1. Symbols & Terminology

This user guide uses the terms:

- **Experimenter** or **User** to refer to the person operating the iPad® device;
- **Patient** or **Subject** to refer to the person undergoing the test.

This manual uses the following symbols to indicate special information:



Tips that help you better use this app.



Important information pertaining to MNREAD testing.

2. Copyright

Members of the development team include Aurelie Calabrese, Long To, Gordon E. Legge, J. Stephen Mansfield, Chuck Bigelow and Michael Crossland.

Here is how to cite the MNREAD app in publications:

Calabrese, A., Gamam S., Mansfield J.S., Legge G.E. Implementing the MNREAD Reading Acuity Test on an iPad3. *Invest Ophthalmol. Vis. Sci.* 2014;55(13):5601.

For questions, please contact Dr. Calabrese at acalabre@umn.edu

The MNREAD app uses the proprietary font Times LT Roman, Version 6.04, property of Heidelberger Druckmaschinen AG and exclusively licensed through Linotype Library GmbH. The same font typeset is used in the printed chart.

English and Spanish versions of the MNREAD charts are available from:

Precision Vision, Inc.

1725 Killkenny Court, Woodstock, IL 60098, USA

Phone: +1-815-223-2022

Fax: +1-815-223-2224

www.precision-vision.com

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3. Overview

The MNREAD app is a digital version of the printed MNREAD ACUITY CHARTS, a continuous-text reading-acuity test suitable for measuring the reading acuity and reading speed of normal and low-vision patients. This test was developed at the Minnesota Laboratory for Low-Vision Research, University of Minnesota, Minneapolis, Minnesota, USA, in research funded by the National Institutes of Health.



- Click [here](#) for detailed instructions of the printed MNREAD charts.
- Click [here](#) for general information about the printed MNREAD charts.

The MNREAD app is designed to run on an iPad (*3rd generation or above*) and features the following functions:

- Sentence display;
- Reading time recording;
- MNREAD curve fitting;
- MNREAD parameters estimation;
- Data recording and export;
- Practice test.

The MNREAD app contains several versions of the test with different test sentences. Each of these versions is available with either black-on-white (regular contrast) or white-on-black (reverse contrast).

The MNREAD app can be used to measure:

- **READING ACUITY** - The smallest print that the patient can read without making significant errors;
- **CRITICAL PRINT SIZE** - The smallest print that the patient can read with maximum speed;
- **MAXIMUM READING SPEED** - The patient's reading speed when reading is not limited by print size;
- **READING ACCESSIBILITY INDEX** - The patient's average reading speed measured over the 10 largest print sizes on the MNREAD acuity chart, normalized by the mean value for a group of normally sighted young adults. This single-valued measure represents the patient's visual access to commonly encountered printed material.

3.1 Testing procedure

1. The sentences are presented from the largest to smallest print. Patients should read the test sentences aloud, starting either from the first sentence (largest print) or from several steps above their previously recorded letter acuity. Note that displaying the full range of sentences is recommended in order to get a correct estimation of the Reading Accessibility Index.
2. Instruct patients to read the sentences as quickly and accurately as possible.
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.

3.2 Test design

3.2.1 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 spaces between 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.

3.2.2 Print sizes

Each test contains a series of 14 sentences with print decreasing in size by 0.1 log unit. Note that the number of sentences is reduced from the printed version, due to screen size and resolution limitations.

The physical print sizes range from 6.3 M to 0.32 M (in Sloan M notation) or 9.3 mm to 0.5 mm (in x-height). From the recommended viewing distance of 40 cm (16 inches) the corresponding angular print size ranges from 1.2 to -0.1 logMAR (Snellen equivalents 20/320 to 20/16). This range can be extended by using a shorter or longer viewing distance (see section 8.1).



- Print size is measured as the height of a lower-case 'x'.
- LogMAR print size is calculated as follows:
$$\log_{10} [(\text{angle subtended by } x\text{-height}) / (5 \text{ arc min})]$$

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 1.2, or for patients whose activities require correction to specific distances.

3.2.3 Font

Sentences are displayed in Times Roman, a proportionally spaced font, similar to that found in many newspapers and books. The text is rendered with high contrast.

3.3 Device requirements

The MNREAD app is designed for iPad use, with the following requirements:

- iPad 3rd generation or above
- 9.7-inch (diagonal) retina display
- 2048-by-1536 resolution at 264 pixels per inch (ppi)
- iOS 7.0 or above

4. Getting started

4.1.1 Setting up the iPad

The iPad should be placed at a well-illuminated location that does not produce screen reflections visible to the patient. Because of the very glossy nature of the iPad screen, it is recommended to install an antiglare screen protector. Keep handy a cleaning cloth to remove fingerprints or smudges from the screen.

Ideally, the iPad should be mounted on a stand perpendicular to the patient's line of sight to present the sentences at eye level and avoid glare or reflection.

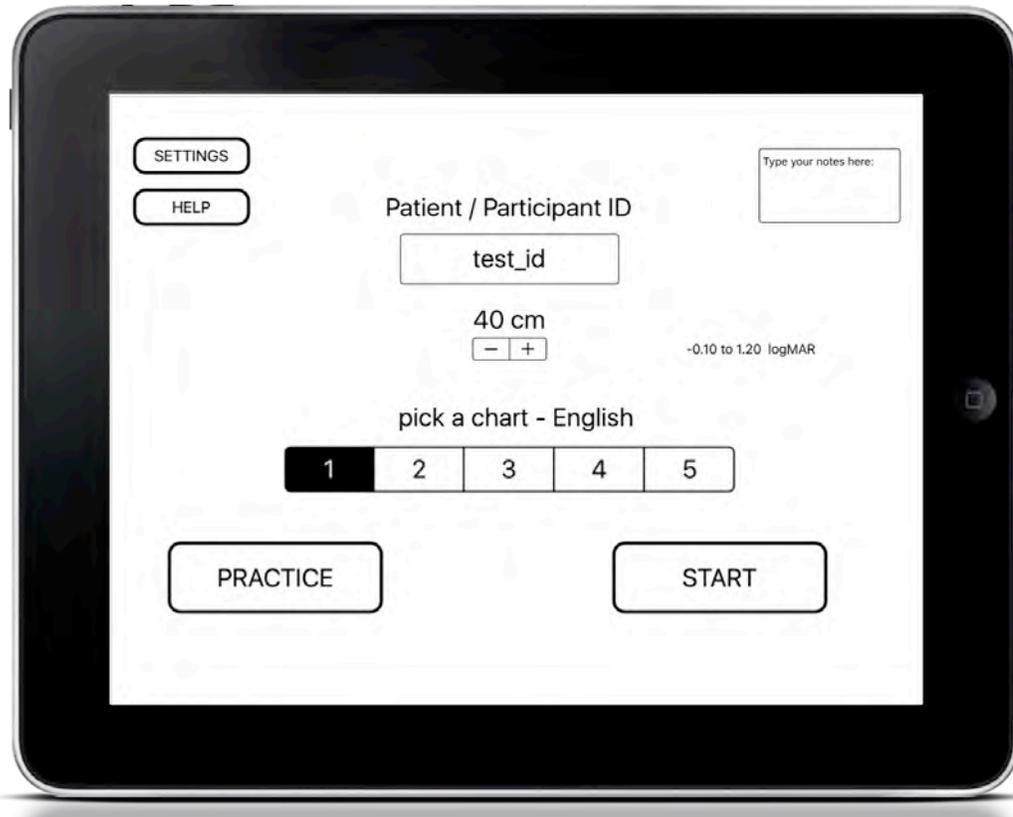
The examiner should sit next to the patient and operate the iPad by either touching the screen or using an external Bluetooth keyboard connected to the iPad (see section 8.4 for more details about the keyboard option).

Make sure to choose a viewing distance to cover the patient's legible range of print sizes (see section 8.1). Before starting the test, measure this distance from the patient's eyes to the center of the screen. Throughout the test, make sure that the patient maintains the chosen distance and does not move forward.

4.1.2 Launching the app



To start using the MNREAD app, tap its icon. The app opens on the home screen.



- To set the test parameters (language, contrast polarity, viewing distance, ...) click on “SETTINGS” (see Section 8 for a detailed list of parameters and how to set them up);
- Click on the “Notes” box to enter and save notes about the test (e.g., eye tested, ...);
- Enter the subject identifier into the “Patient/Participant ID” field;
- If the testing distance is different from the default value of 40 cm (16 inches), modify the viewing distance by clicking on the ‘+’ or ‘-’ buttons, or by accessing the general settings by clicking on “SETTINGS”;
- Select a chart number (the number of available charts will change depending on the language selected);
- To run a practice test, click on “PRACTICE”;
- To run a real test, click on “START”.



Below are the default settings of the MNREAD test:

- Language: English
- Polarity: Normal (‘black-on-white’)
- Viewing distance: 40 cm (16 inches)

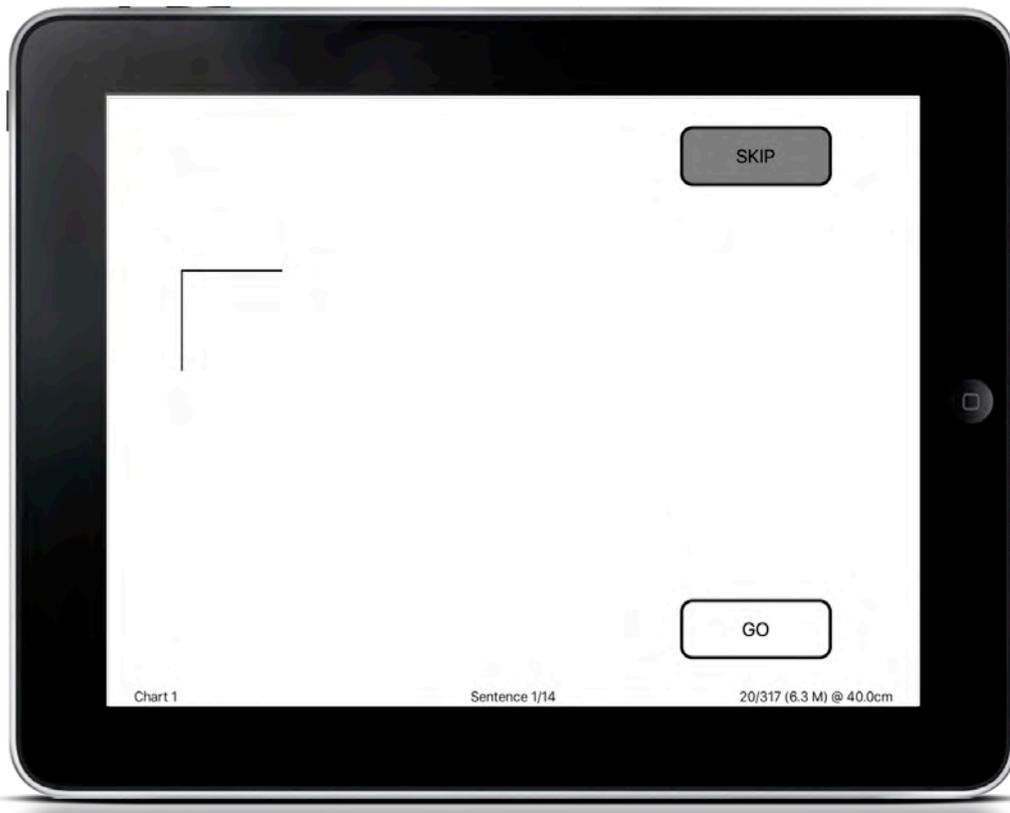
5. Running a 'practice' test

To familiarize a subject with the task, it is possible to run a practice test by clicking on "PRACTICE" from the Home Screen. Sentences will be displayed as for a recorded test, but no data will be saved. The sample sentences are shown in the first 5 largest print sizes of a real test. The sentences displayed during a practice test won't be shown again during a recorded test.

6. Running a test with Saved Data

From the Home screen, click on "START" to begin running the MNREAD test. Each sentence is preceded by a 'preparation' screen showing the position of the upcoming sentence. The bottom line of the preparation screen provides information about the test and the sentence to come:

- The chart number;
- The sentence number;
- The angular print size adjusted for the viewing distance (logMAR, Snellen or Decimal);
- The physical print size (M or Point units):
- The viewing distance.



To display the first sentence, click on “GO”, or hit the keyboard spacebar. Make sure that the subject is ready to start reading before you launch the trial.



In some cases, the examiner may want to skip one or several trials, either to save time, or because the patient cannot read large print (for example, in presence of a ring scotoma). To skip the upcoming trial and go directly to the next sentence, click the button “SKIP”. No data will be recorded.

Clicking on “GO” launches the first trial and the first sentence appears on the screen. The subject should start reading out loud and as fast as possible as soon as the sentence appears on the screen. Once the subject has finished reading the sentence, the user can terminate the trial and stop the timer by clicking on the right part of the screen, or on the keyboard spacebar (note that taps within the first second of a trial are not accepted to avoid user mistap). The time (in seconds) is recorded automatically by the app.



In some cases, the subject may want to trigger the trials him/herself by clicking the “Go” button. This shows the advantage of engaging him/her into the test. Nevertheless, we advise the user to remain in charge of ending each trial in order to avoid delays and improve time recording consistency.

Once a trial has been stopped, the score screen appears. It shows:

- The sentence just displayed to help the user count errors made during reading;
- An 'Error count' column with buttons from 0 (default) to 10 (or more). Record the number of errors made during the trial by clicking on the corresponding button. In addition, one can use the "Unable to read" button that sets the error count to 10;
- The reading time (in seconds);
- A 'STOP' button to terminate the testing and display the final score screen containing a plot of the MNREAD data;
- An "IGNORE" button one can click to ignore the data from the present trial. This option can be used for example, if the subject got distracted during the reading, or if the experimenter stopped the trial too early by clicking on the screen by mistake;
- A 'CONTINUE' button to go to the Preparation Screen for the next sentence.



7. Interpreting the results

Once the test is complete, either because all the sentences have been displayed, or because the user terminated the test, the final score screen is displayed.

The reading speed is plotted as a function of print size according to the general MNREAD graphing procedure. Each data point represents a sentence with the number of misread words displayed above it (only when different from 0).

Print size is shown both:

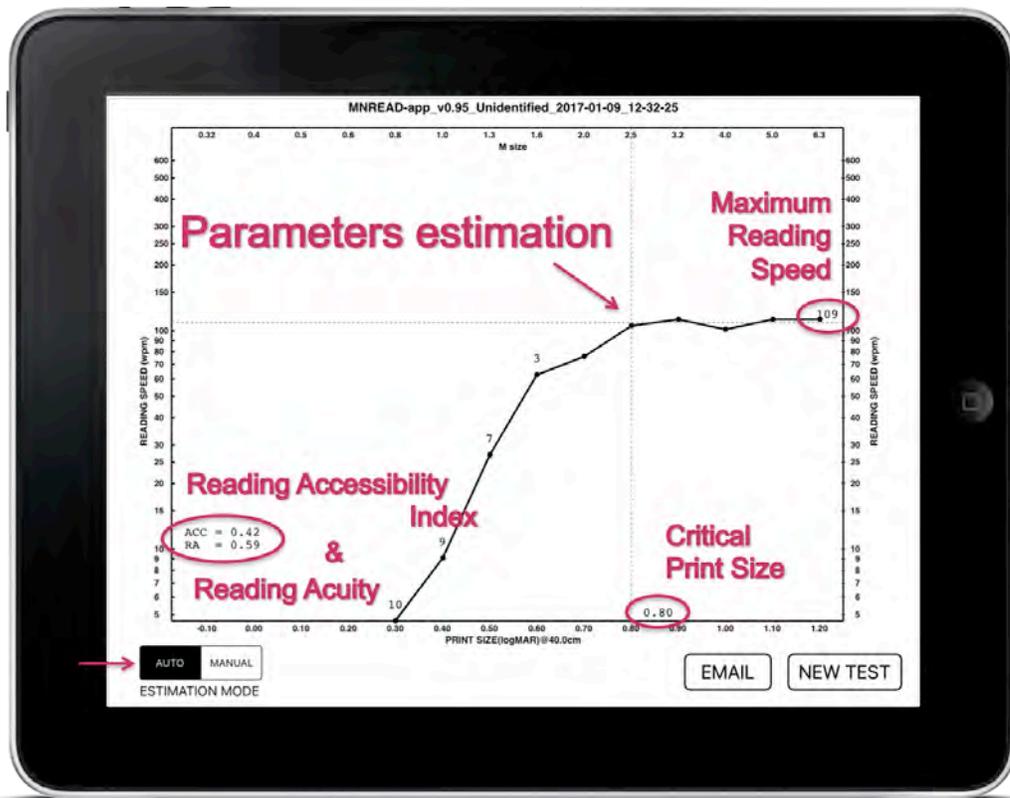
- in angular units on the bottom x-axis (LogMAR, Snellen or Decimal) and
- in physical units on the top x-axis (M or Point).

Any non-standard viewing distances (ie. different from 40 cm) are taken into account by the angular print size scales.

7.1 Automatic estimation of the MNREAD parameters

Maximum Reading Speed and Critical Print Size are estimated automatically by the app and shown on the plot (see the Information Box below for details about the automatic parameter estimation).

The Reading Acuity (RA) and Reading Accessibility Index (ACC) are also calculated by the app and displayed on the plot. Note that in order to estimate these two values reliably, the test has to continue until NO WORD CAN BE READ ACCURATELY by the subject.



Values of all four parameters are stored in the data spreadsheet saved at the end of each test (see section 7.3).

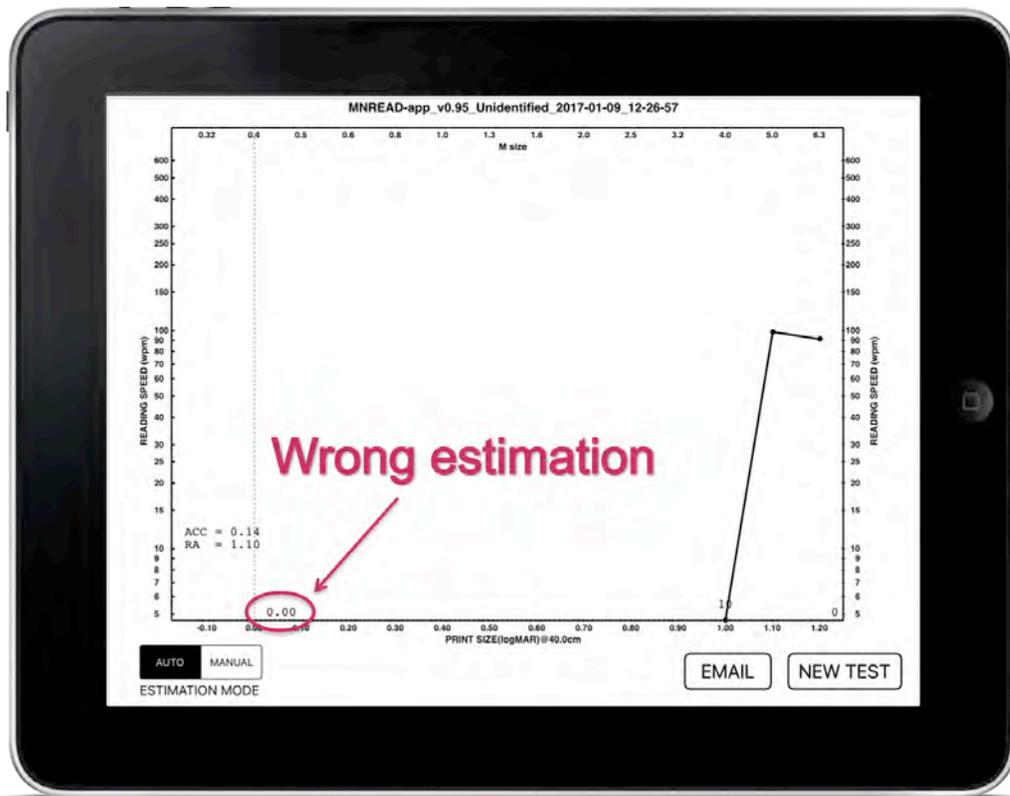


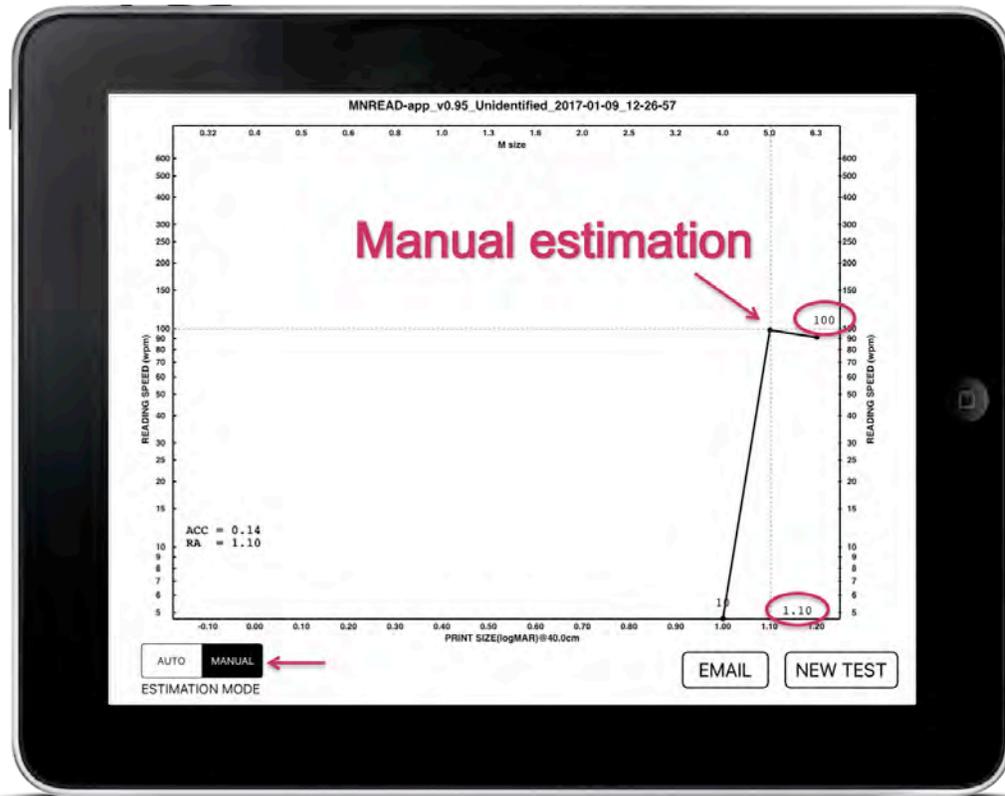
- The Critical Print Size is defined as the print size at which subsequent smaller print sizes were read at 1.96 SD slower than the mean of the preceding print sizes.
- The Maximum Reading Speed is estimated as the mean reading speed for sentences in print larger than the Critical Print Size.

7.2 Manual estimation of the MNREAD parameters

In case the algorithmic estimation does not provide a good fit (see Figures below), the user can over-write the computation and perform a manual estimation.

After clicking on “MANUAL” at the bottom left of the screen, a double-tap on the screen will re-position the dashed crosshair to the chosen “tap” position and overwrite the automatic estimation of the Maximum Reading Speed and Critical Print Size. The estimation can be refined by dragging the crosshair with one finger.





7.3 Data storage

For each test run, the data are saved and stored in the internal memory of the iPad within two different files:

1. An image of the MNREAD curve (.png format)
2. A data spreadsheet (.csv format) including:
 - Settings used during the test (polarity, viewing distance, etc.);
 - The four MNREAD parameters (Maximum Reading Speed, Critical Print Size, Reading Acuity and Reading Accessibility Index)
 - Individual data for each sentence read (reading time, error, etc.)

7.4 Data sharing and retrieving

At the end of a test, one can share the current results via email. From the final score screen, click the “EMAIL” button to send both data files (curve and spreadsheet) to the recipient of your choice. If the same email address is used frequently, one can set up a default address in the Settings (see section 8)

One can also retrieve results from previous tests via iTunes by following these steps:

1. Connect the iPad to your computer and access its info through iTunes;
2. Access the Apps tab of your iPad in the left panel of the iTunes window;
3. Scroll down the main panel to access the “File Sharing” section;

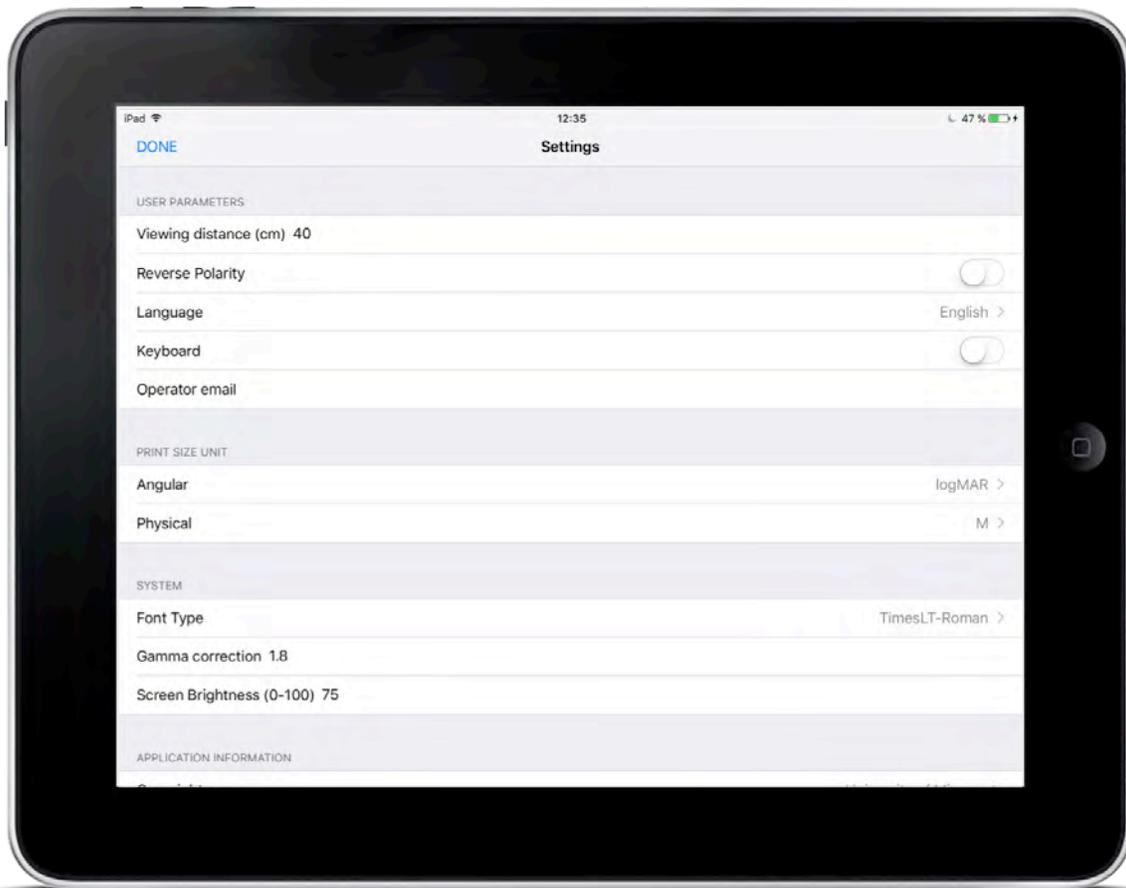
4. In the left panel, select the MNREAD app.;
5. In the right panel there is a list of folders, each one corresponding to a MNREAD test;
6. Select the folders of interest and click “Save to” to store the data on your computer.

7.5 Starting a new test

From the score screen, click on the button “NEW TEST”.

8. Settings

To configure the settings of the MNREAD test (viewing distance, polarity, etc.), click on the button “SETTINGS” from the home screen.



8.1 Viewing distance

The standard viewing distance to run the MNREAD test is 40 cm (16 inches).

However, to compensate for the smaller number of print sizes that can be accurately displayed on the iPad, the range of print sizes can be extended:

- To larger angular values by testing at a shorter viewing distance (for low vision);
- To smaller values by testing at a longer viewing distance (for normal vision).

The values of angular print size will be adjusted in accordance with the selected viewing distance.

The viewing distance can be modified:

- From the home screen, by changing the value using the '+' and '-' buttons before running a test;
- Through the settings by entering the desired value in the 'Viewing distance' field. The value set here will be used as a default for subsequent tests and can be overwritten from the Home Screen.

See the *Helpful Tips* below for suggested values of viewing distance. These values are offered for guidance only.



- Low Vision: 20 to 40 cm (8 to 16 inches)
- Normal Vision: 60 to 80 cm (24 to 32 inches)

8.2 Contrast polarity

By default, the contrast polarity is set to the standard black-on-white.

To enable the reversed contrast polarity option (white-on-black), click on the button "SETTINGS" from the home screen and enable the 'Reverse polarity' option.

8.3 Language

Five languages are currently supported by the MNREAD app: English, Italian, French, Spanish and Portuguese. To enable a specific language, click on the button "SETTINGS" from the home screen, open the 'Language' field and select the language desired.



8.4 External keyboard

To connect an external keyboard via Bluetooth, first make sure that the Bluetooth option is enabled on your device. Open the “Settings” app of your iPad and go to under “Bluetooth”. First, make sure the Bluetooth option is turned on. Identify your keyboard in the list of devices, and connect it to your iPad.

To turn the Bluetooth keyboard option on in the MNREAD app, go to “SETTINGS” and enable the ‘Keyboard’ option.

Note that to close the keyboard after entering something in the “test id” or “notes” fields on the home screen, one has to press the keyboard icon on the lower right hand side of the keyboard.

See the “Tips” box below for a list of key functions.



Home Screen	Numeric 1-5 to choose a chart Spacebar to “START” a test
Pre-stimulus	Spacebar to "Go"
Stimulus screen	Spacebar to end presentation
Scoring screen	0-9 and 10-19 for scoring U = unable to read I = ignore
Result screen	No key - must use touches

8.5 Operator email

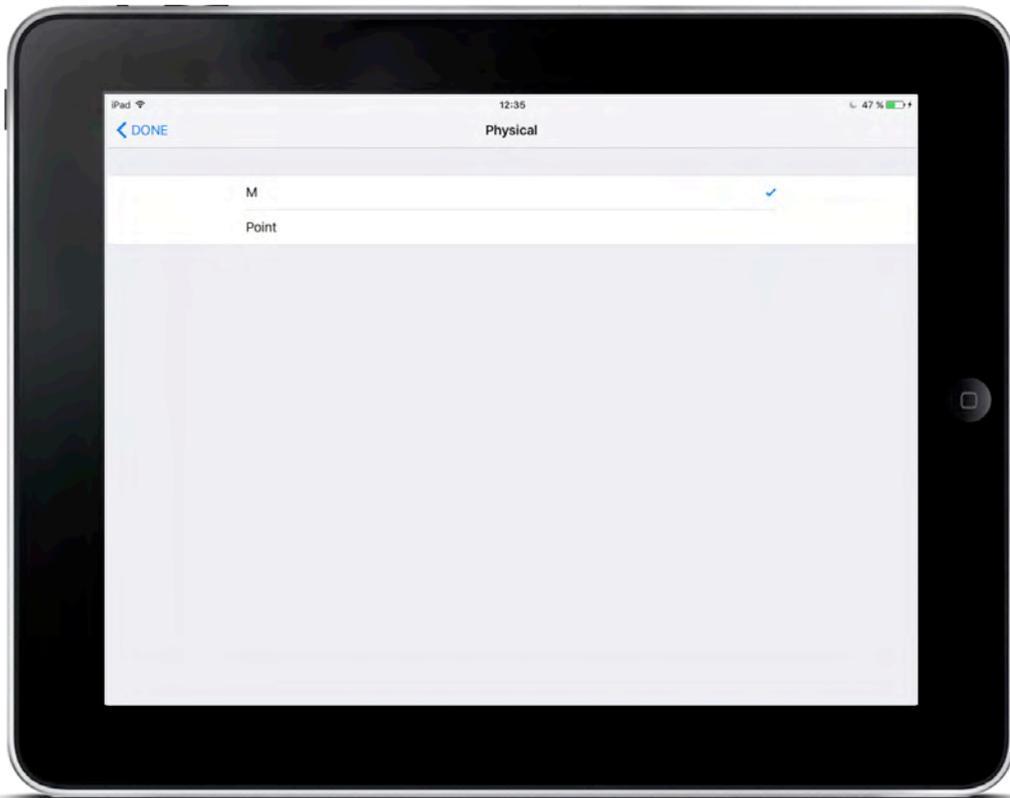
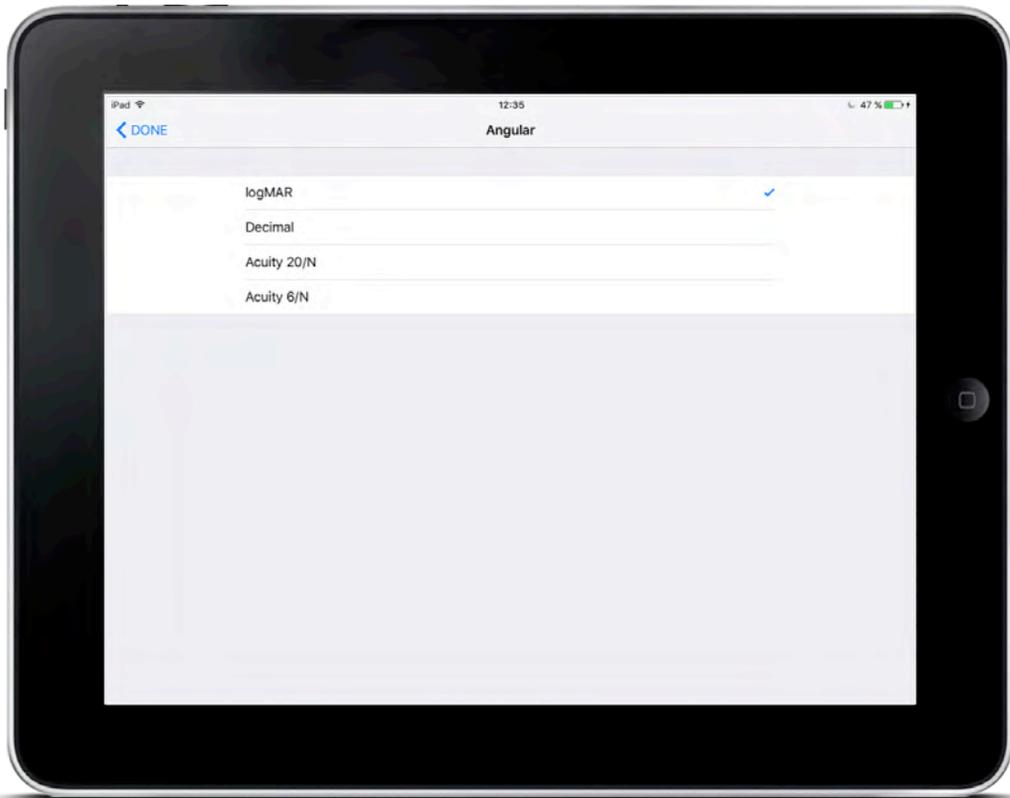
One can share test results via email. If the same email address is used frequently, one can set up a default recipient address in the “Operator email” field.

8.6 Size unit

Print size can be expressed both in angular and physical units. Angular units are dependent on the viewing distance, whereas physical units are not. Here are all the print size units available in the MNREAD app:

- Angular print sizes
 - LogMAR
 - British Snellen notation (20/200 for example)
 - Metric Snellen notation (6/60 for example)
 - Decimal (0.1 for example)
- Physical print sizes
 - Sloan M
 - Font Size in points

Throughout the test, print size will be expressed in both angular and physical units. To select the units to use, click on the button “SETTINGS” from the home screen, open the “Print size unit” field and select the desired angular and physical units.



9. Lighting Conditions & Brightness

MNREAD testing should be conducted under standardized lighting conditions.

The test light level recommended by the National Academy of Sciences and by the American National Standards Institute for ETDRS is a minimum luminance of 85 cd/m².

We recommend setting the brightness level to about 75% of the maximum brightness level provided by the iPad display. To do so, go to “SETTINGS” and enter 75 in the field ‘Brightness (0-100)’. This setting will overwrite the general Brightness of the iPad ONLY when using the MNREAD app.



- The percentage stored in the app *Settings* refers to the brightness ratio of a white screen to the maximum (white) luminance that the screen can show.
- The iPad screen at its maximum brightness is 400cd/m².
- A 75% setting produces a 300cd/m² background in normal-polarity tests.

10. Appendix

10.1 Conversion table between logMAR and Snellen acuity units

Table A
LogMAR adjustments for non-standard viewing distances

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

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 $\times 10^{(\text{logMAR acuity})}$ 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)

10.2 Conversion table between logMAR, font size and M units

In order to share results with patients in a comprehensible manner, the app uses font size (in points) to express print size values. Thanks to this feature, it will be easy to give the patients an estimate of their Critical Print Size to help them optimally set the font size on their computer screen. Below is a table summarizing the conversion between LogMAR, Font size (Pt) and M.

<i>LogMAR (at 40 cm)</i>	<i>Font Size (Pt)</i>	<i>M</i>
2.0	370	--
1.9	295	--
1.8	235	--
1.7	185	--
1.6	150	--
1.5	120	--
1.4	90	--
1.3	75	--
1.2	60	6.3
1.1	46	5.0
1.0	38	4.0
0.9	30	3.2
0.8	24	2.5
0.7	18	2.0
0.6	14	1.6
0.5	12	1.3
0.4	9.2	1.0
0.3	7.4	0.8
0.2	5.9	0.6
0.1	4.6	0.5
0.0	3.7	0.4
-0.1	2.9	0.32
-0.2	2.3	--
-0.3	1.8	--