Visual Acuity & Visual Acuity Remote

“The Visual Acuity Solution for Mac”

User Guide Version 1.3

By William H.A. Beaudot, PhD

KyberVision Consulting, R&D in Vision Sciences

Contact Information: KyberVision Japan LLC
2-3-17-101 Sagigamori, Aoba-ku
Sendai, Miyagi, 981-0922 Japan
Phone: +81 70-1141-0245
Email: mac@kybervision.com
Web: http://mac.kybervision.com

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INTERPRETATION OF RESULTS.

This user guide does not provide guidance on the interpretation of visual acuity measurements. The experimenter must ensure to have received appropriate training in such interpretation. For this reason KYBERVISION cannot be held responsible for misdiagnosis of results.

Symbols Used

This manual uses the following symbols to indicate special information:

Symbol	Description
❖	**Indicates tips that help you better use this app.**
➡	*Indicates important information pertaining to visual acuity.*

Terminology

This user guide uses the terms ***Experimenter*** or ***User*** to refer to the person operating the Macintosh® computer, and ***Patient*** or ***Subject*** to refer to the person undergoing the test and who may also use the remote control to provide his responses. The ***Remote Control*** refers to an iOS device (iPad®, iPhone® or iPod touch®) running the **Visual Acuity Remote** app available for free on the App Store℠.

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Overview

Visual acuity is the most important test used to evaluate eyesight. It measures the eye's ability to resolve details at near and far distance. It usually involves reading letters or looking at symbols of different sizes (optotypes) on a wall chart, similar to the famous Snellen chart found in most physician offices and developed by Dutch ophthalmologist Herman Snellen in 1862.

Visual Acuity for Mac is KyberVision's desktop solution for vision care specialists: it brings computerized versions of the "gold standard" acuity testing on the most advanced computer platform in the clinical environment and it provides fast, efficient and reliable assessment of visual acuity for literate and illiterate people as well as preschool children. Moreover, **Visual Acuity** promotes the use of the logMAR chart design recommended by the *National Eye Institute* (NEI) and the *International Council of Ophthalmology* (ICO) to address design flaws in the Snellen chart.

Visual Acuity for Mac has many useful features for the clinical environment:

- Interactive LogMAR charts
- Randomized design to prevent subjects to memorize the test
- Keep track of visual acuity history, subject/patient information and prescription
- Exporting of acuity data through email in HTML format
- Units conversion tool
- Built-in and online PDF documentation
- Free remote control app **Visual Acuity Remote** for iPad, iPhone or iPod touch

Numerous options are also available to customize acuity testing:

- Simple or ETDRS acuity scoring
- Charts composed either of single letter, single line or multiple lines
- Standard optotypes (Landolt C, Tumbling E, Sloan, HOTV, Snellen)
- Additional optotypes (Numbers, Kid, Cyrillic)
- Standard acuity units (foot, meter, decimal, VAR, logMAR, cpd)
- Black letter on white background or reverse
- Confusion bars
- 4 or 8 orientations for C and E optotypes
- Distance units and viewing distance up to 8 meters (26 feet)
- Mirror mode

Visual Acuity and **Visual Acuity Remote** are available on the Apple App Stores:

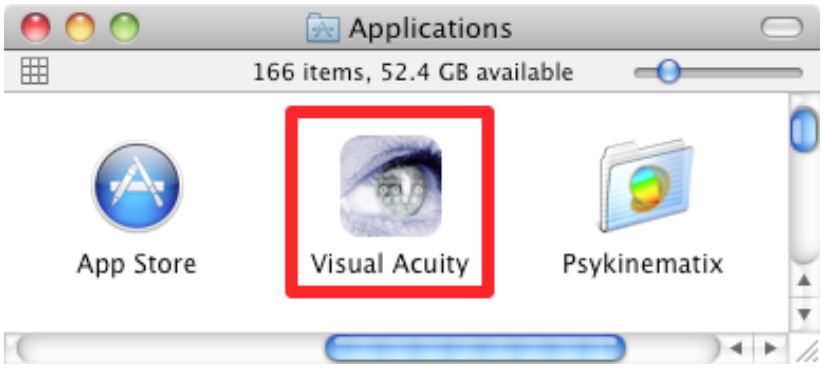
Visual Acuity

The most reliable acuity tests used today follow the ***logMAR design*** recommended by the *National Eye Institute* (NEI) and the *International Council of Ophthalmology* (ICO) to address design flaws in the 150 year-old Snellen chart: the charts provided by **Visual Acuity** follow this logMAR design by implementing a geometric progression of letter sizes and proportional spacing between letters, with standard optotypes specifically designed to appear equally recognizable and appropriate for testing literate and illiterate people as well as preschool children.

Moreover, to measure visual acuity in a precise and efficient way **Visual Acuity** provides unique ***interactive logMAR charts*** that are randomly generated to prevent the subjects to memorize the test, and fully exploits the potential of the iOS platform by using an iPad, iPhone or iPod touch as a wireless response device for the acuity testing. The **Visual Acuity** app runs exclusively on Mac computers and implements many features required for both research and clinical studies. **Visual Acuity** for Mac is exclusively available on the Mac App Store (click here to access the Mac App Store).

Getting Started

To start using **Visual Acuity**, open the Applications folder and double-click on its icon to launch it:

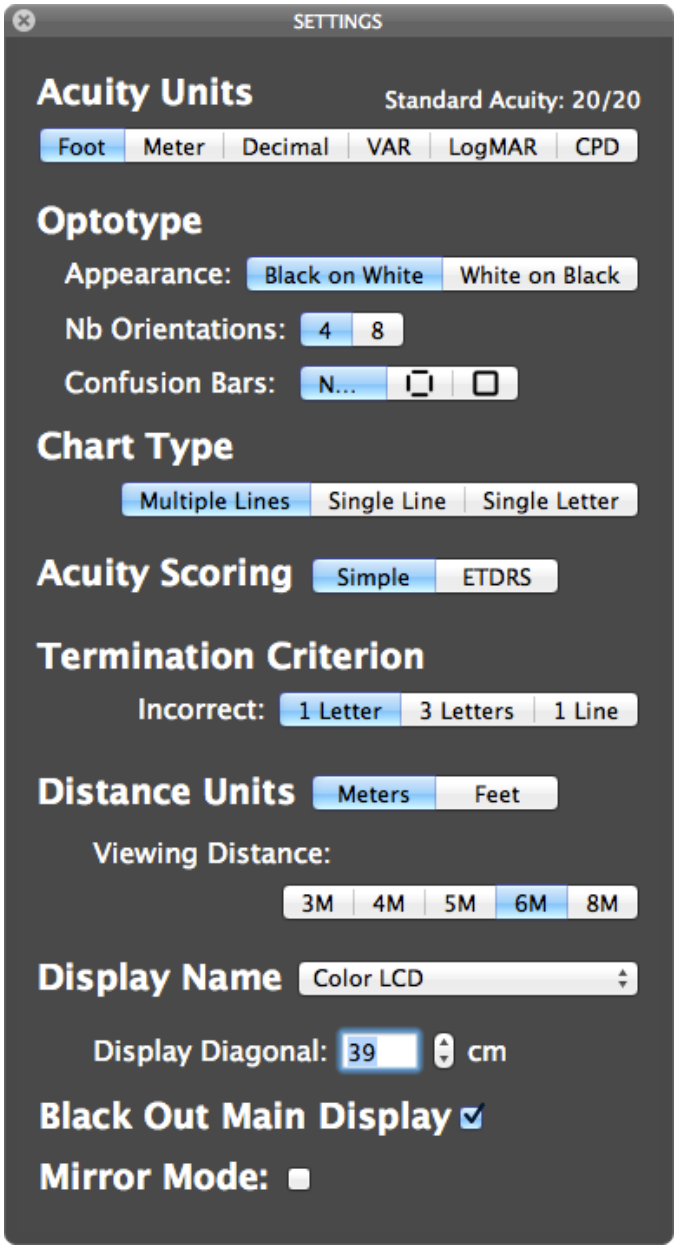


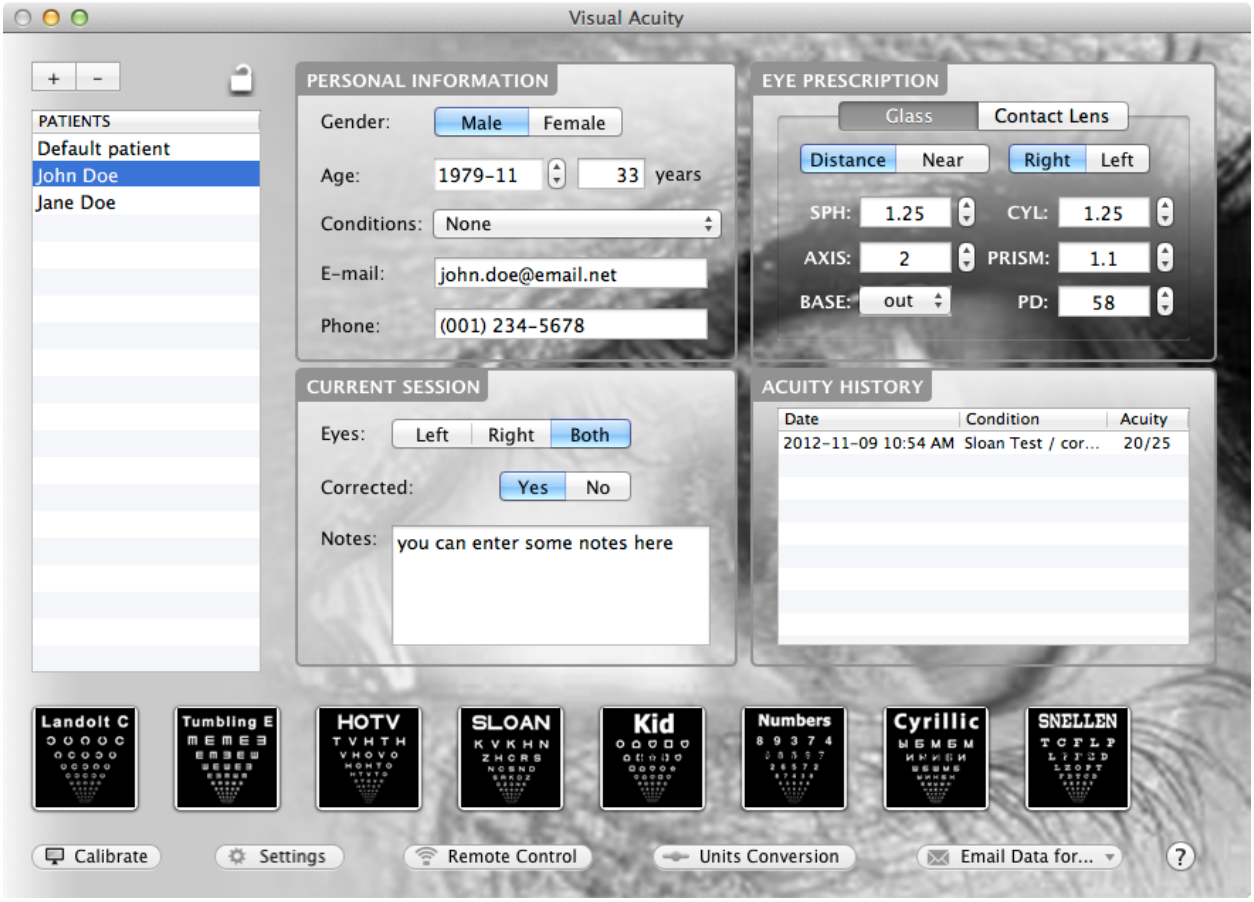
As illustrated below, a single panel shows all required information pertaining to the patient and the test:

- the patients list on the left side,

- subject specific information on the right side (personal information, eye prescription, current session settings, acuity history),

- chart-specific buttons to start the test at the bottom.





Below the chart-specific buttons, several other buttons provide access to additional facilities:

to calibrate the display geometry,

to customize the settings of the acuity testing (acuity units, optotype appearance, chart type, acuity scoring, termination criterion and distance units),

to establish a WiFi connection between the Mac and an iOS device acting as a remote control by running the optional **Visual Acuity Remote** app (both need to be connected to the same WiFi network: see FAQ),

to convert between various acuity units,

to export the acuity data through e-mail in HTML format,

to access the built-in user guide in PDF format.

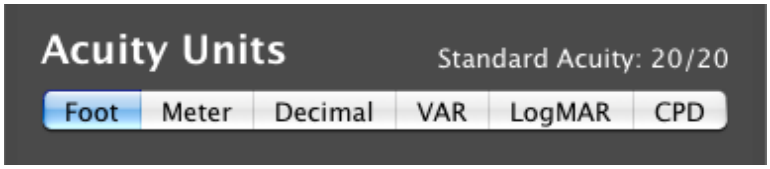
Configuring the Acuity Testing

To configure the test settings, click on the ⚙ button. This opens a panel with customizable settings:
The customizable settings include:

- The acuity units (Foot, Meter, Decimal, VAR, LogMAR, CPD). Note that the standard acuity is indicated in the selected unit (e.g. 20/20 in foot units),
- The optotype appearance: black letters on white background or white letters on black background, the number of orientations (only applies to Landolt C and Tumbling E optotypes), the presence and type of confusion bars (none, bars or frame type),
- The chart type: multiple lines, single line or single letter,
- The acuity scoring method (simple or ETDRS). Note that changing the method selection resets by default some other settings (For example selecting the ETDRS method resets the chart type to 'Multiple Lines' and the termination criterion to 3 incorrect letters),
- The termination criterion for the selected method (1 letter, 3 letters or an entire line incorrect for the ETDRS method for example),
- The display name and the geometry of the experimental setup: the spatial unit (metric or imperial), the default viewing distance and the diagonal size of the display in the same units,
- A black out option for the main display when presenting the charts on an external display,
- The mirror option to virtually increase the viewing distance which would be otherwise limited by the depth of your testing room.

Acuity Units

Visual Acuity can measure and report visual acuity in various standard units, either as Snellen fractions in foot, meter or decimal units, as logarithmic scales in logMAR or VAR units, or as resolution in cycle per degree (CPD):



- Foot units are used in the US: visual acuity is expressed as Snellen fractions in foot relative to 20/20, the standard definition of "normal" visual acuity, that is the ability to resolve a spatial pattern separated by a visual angle of one minute of arc. If you have a visual acuity of *20/x*, then if you stood 20 feet away from an object and the "normal" person stood *x* feet away, you would both see the same thing. If *x* is more than 20 feet, you have worse eyesight than normal, and if it is less than 20 feet, you have better than "normal" vision.

- Meter units are used in UK: visual acuity is expressed relative to 6/6 (meters), roughly equivalent to 20/20 (feet).

- Decimal units are used in France: acuity is defined as the reciprocal value of the size of the gap (measured in arc minutes) of the smallest Landolt C that can be reliably identified. A value of 1.0 is equivalent to 20/20. Values lower than 1.0 mean worst acuity, and values higher than 1.0 mean better acuity than "normal".

- LogMAR units are used in clinical research where acuity is expressed as the logarithm of the minimum angle of resolution. LogMAR scale converts the geometric sequence of a traditional chart to a linear scale. It measures visual acuity loss: positive values indicate vision loss, while negative values denote normal or better visual acuity. A value of 0.0 is equivalent to 20/20. Though this scale is rarely used clinically, it is more frequently used in statistical calculations because it provides a more scientific equivalent for the traditional clinical statement of "lines lost" or "lines gained", which is valid only when all steps between lines are equal, which is not usually the case.

- VAR (Visual Acuity Rating) units provide a more intuitive scoring: the VAR scale is similar to the logMAR scale, but represented as a percentage. A value of 100 is equivalent to 20/20. Values lower than 100 mean worst acuity, and values higher than 100 mean better acuity than "normal".

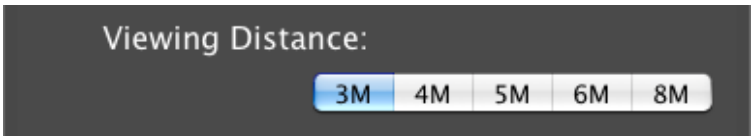
- CPD (Cycle Per Degree) units express visual acuity in term of angular resolution. A value of 30 cpd corresponds to a resolution of 2 arc minutes per line pair (ie a 1 arc minute gap in an optotype) and is equivalent to 20/20. Values lower than 30 cpd mean worst acuity, and values higher than 30 cpd mean better acuity than "normal". The upper limit is directly related to the resolving power of the cone photoreceptors in the retina center (fovea) and by the imperfect optics of the eye: for a human eye with excellent acuity, the maximum theoretical resolution is 50 CPD (equivalent to 20/12).

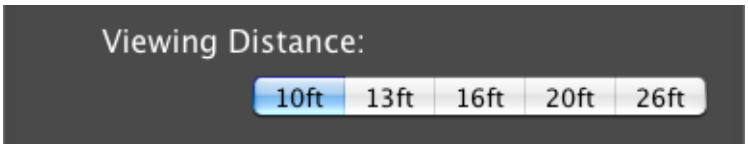
➡ *As emphasized above it is important to note that despite being referred as the normal or standard visual acuity, 20/20 and its equivalents in other units do not indicate a perfect vision but should be thought of as the lower limit of the normal visual acuity, the maximum acuity of a healthy human eye being approximately 20/16 to 20/12.*

The selected acuity unit in the settings is used by default in all acuity tests. Note that a tool is available to easily convert between the different visual acuity units (see the button at the bottom of the main panel).

Viewing Distance

The viewing distance (from the patient eyes to the computer screen that that displays the optotypes) can be expressed either in meter or foot units, and can preset to some standard values (3, 4, 5, 6, 8 meters or 10, 13, 16, 20, 26 feet).





This distance can also be changed during a test inside the chart panel or using the remote control. The last set value is used every time the application is launched. The viewing distance can be also set to any other value using the bottom slider.

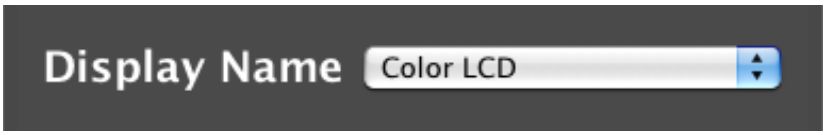
Near visual acuity is typically measured at a viewing distance of 40 cm or 16", while ***far visual acuity*** is measured for much farther viewing distance, "close enough" to optical infinity, where there is no significant accommodation by the crystalline lens, typically at 6 m or 20 ft away. Note that without a lens correction, a myopic (nearsighted) person generally will have better visual acuity at near than at far, while a hyperopic (farsighted) person generally will have better acuity at far than at near. Until the early to mid-forties, a person with 20/20 distance acuity usually also has 20/20 acuity at near. However, once presbyopia sets in, one's uncorrected near visual acuity decreases, creating the need for reading glasses or bifocals.

Note that because of the limited pixel resolution of the Macintosh screen, its use is more appropriate for measuring ***far visual acuity*** at a minimum viewing distance of 1.60 meters (63" or 5ft 3"). For measuring ***near visual acuity*** at a typical viewing distance of 40 cm or 16" we recommend using our **Visual Acuity** app for iPhone and iPod touch preferably with a Retina Display.

> ➡ *It is important to select the most appropriate viewing distance and it is even more critical to ensure that the patient is located at the specified distance from the Macintosh display since the precision of the acuity measurement depends on it.*

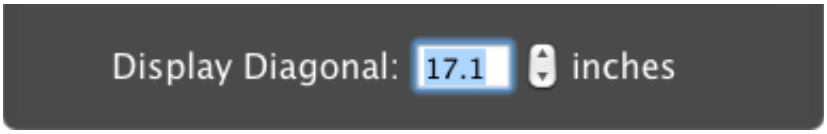
Display Name

This pop-up menu lists the displays currently attached to the computer. If several are attached to the Macintosh computer it is necessary to specify which one should be used as the optotypes screen. By default the optotypes screen is the main display.



Display Size

The display size can be directly specified in terms of its diagonal (either in cm or inch depending on the selected distance units) or using the calibration tool (see the button at the bottom of the main panel).



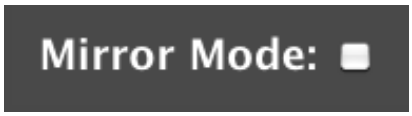
➡ It is critical to properly calibrate the display geometry to ensure a precise measurement of the visual acuity. It is recommended to regularly verify that the indicated diagonal value in the specified distance units corresponds to the size of the display that presents the optotypes to the patient. Changing the stimulus display or its resolution always requires a new geometry calibration!

Black Out Main Display

This option allows to black out the main display when presenting the charts on an external display. This may be necessary if the light of the main display interferes with the lighting condition. Alternatively, this option may be unchecked if access to the main display is still required while presenting the charts on an external display.

Mirror Mode

The mirror mode involves the use of a mirror to increase the viewing distance which would be otherwise limited by the depth of your testing room. In this mode the presented optotypes are mirror-inverted so they appear normally presented to the patient when viewing through the mirror.



➡ *It is important to note that the specified distance should be the 'virtual' viewing distance between the patient and the display, that is twice the physical distance between the patient and the mirror!*

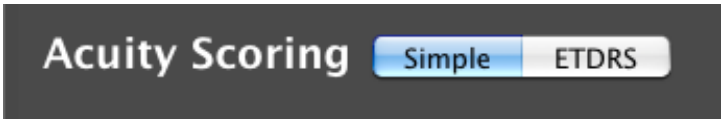
Measurement Protocol

Visual Acuity offers several protocols based on a combination of chart types, acuity scoring, and termination criterion. Are available:

- 3 types of charts:

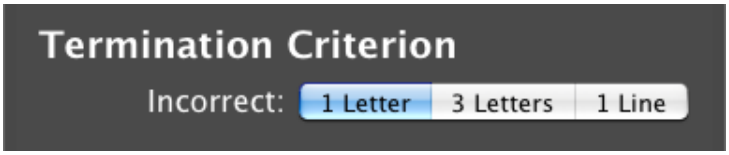
  - Multiple lines: multiple lines of optotypes are displayed according to the logMAR design (which specifies the spacing between optotypes and between lines, typically the size of a single optotype),
  - Single line: a single line of optotypes is presented with up to 5 optotypes (with a spacing corresponding to the size of a single optotype),
  - Single letters: a single optotype is presented in the center of the display,

- 2 acuity scoring methods:



  - Simple: the easy and fast way to measure visual acuity though less precise,
  - ETDRS: the standard way to measure visual acuity in clinical environment,

- 3 termination criteria based on incorrectness:



  - 1 letter: the test stops after 1 incorrect letter,

- 3 letters: the test stops after 3 incorrect letters on the same line (this is the default termination criterion for the ETDRS scoring),

- 1 line: the test stops after a whole incorrect line.

❖ **The protocol defined in the settings is only followed when running a session through the remote mode. The protocol is otherwise considered as 'manual' as the progress across the chart is under the control of the experimenter using a standard keyboard and the measurement determined by the last line validated by the experimenter which should correspond to the smallest line the patient can fully read.**

Calibrating the Display

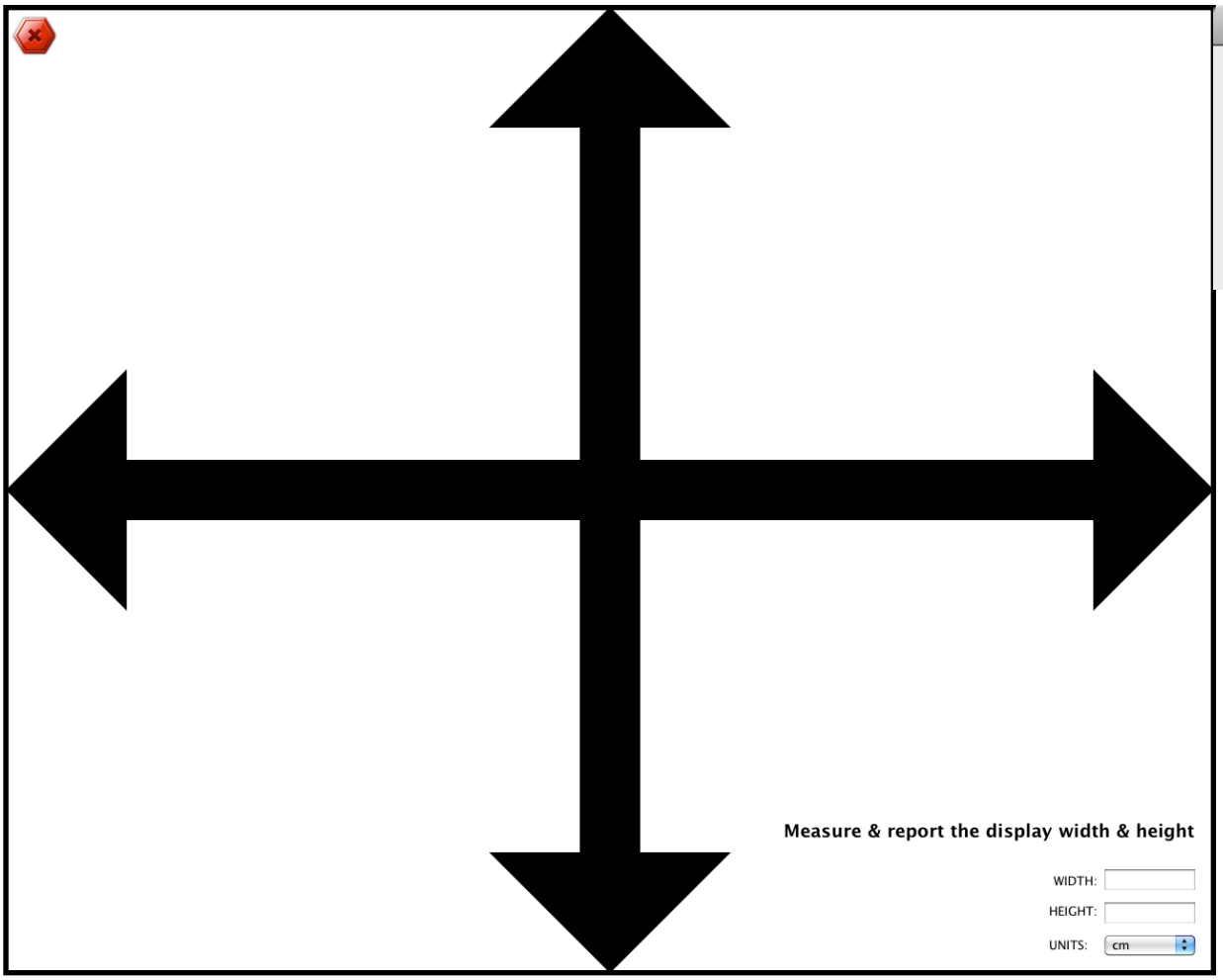
The display calibration is a critical and mandatory step before starting measuring visual acuity. However it is a very simple process that consists in measuring the width and height of the screen that displays the optotypes:

1. Click on the  button at the bottom of the main panel to switch to the calibration panel (shown below),
2. Use a measuring tape to measure the width and height of the screen (i.e. the full length of the horizontal and vertical arrows shown on the screen),
3. Report the measured values in the "WIDTH" and "HEIGHT" fields found in the bottom right corner of the panel using the unit selected in the pop-up menu,
4. Click on the  button in the top left corner to validate the calibration and return to the main panel. If the measurements reflect square pixels then the diagonal size of the display is automatically computed and updated in the Settings panel. Otherwise an alert is displayed to warn you that the calibration may be inaccurate or the display resolution inappropriate.

A similar alert is displayed whenever the display configuration has changed while running the Visual Acuity app. The "Use System Defaults" option should only be used as a temporary solution as it uses the system information about the screen dimension which is sometimes not precise enough.

Available Optotypes

Visual Acuity provides the most standard optotypes to test visual acuity in literate and illiterate people as well as preschool children, including the Landolt C and Tumbling E symbols considered as the reference optotypes by the *International Council of Ophthalmology* in its ***Visual Acuity Measurement Standard***. The standard optotypes



have been specifically designed to appear equally recognizable contrarily to those used in the Snellen chart. The available optotypes are represented as large icons in the bottom half of the main panel. Starting from the left are the 4 most modern optotypes:

Landolt 'C'

The Landolt ‘C’ optotype is a broken ring symbol that has only one element of detail, the gap, which varies only in its orientation. This gap subtends 5 minutes of arc in the 20/20 optotype and has an opening (oriented in the top, bottom, right or left) measuring 1

minute of arc. Edmund Landolt proposed the Landolt C in 1888 based on the fact that not all of Snellen's optotypes were equally recognizable. In its *Visual Acuity Measurement Standard*, the *International Council of Ophthalmology* considers the Landolt C the purest research standard and requires all other research approaches to be calibrated against the Landolt C. It is the recommended reference optotype for testing visual acuity, and the preferred visual acuity measurement symbol for laboratory experiments but gained only limited acceptance in clinical use.

Tumbling 'E'

The Tumbling ‘E’ optotype follows the same design principles as the Landolt C, but uses a stylized letter E instead. Charts based on this single optotype in various orientations were created by Hugh Taylor in 1976 to test visual acuity of Australian Aborigines. The use of the Tumbling 'E' has become standard for testing of illiterates and populations not familiar with the Roman alphabet or too young to read letters since, like for the Landolt 'C' , they simply need to indicate the orientation of the symbols. Note, however, that this optotype contains 3 times more information about its orientation than the Landolt 'C'.

HOTV optotypes

The HOVT optotype set consists in only 4 letters (H, O, T and V) which are more appropriate for testing visual acuity in preschool children under 5-6 years old. These optotypes are also assumed to be equally recognizable and maximally distinguishable. A child should be first taught the four symbols and then tested against the HOTV chart.

Sloan optotypes

The Sloan optotype set consists in 10 letters (C, D, H, K, N, O, R, S, V and Z) specifically designed by Louise Sloan in 1959 in order to avoid the problem that not all letters are equally recognizable in the Snellen chart. The Sloan chart were also specifically designed to follow a geometric progression of letter sizes forming the basis of the logMAR design.

The next 3 are more specialized optotypes in addition of the older Snellen ones:

Kid optotypes

The “Kid” optotype set is an adaptation of the LEA™ Symbol and Patti Pics™ charts using outlines of 6 figures (an apple, a house, a circle, a square, a heart and a star) to

measure visual acuity in preschool children too young to perform the HOTV test.

Numbers optotypes

The Numbers optotype set consists of 8 digits (2, 3, 4, 5, 6, 7, 8, 9) was originally. Charts based on these optotypes are also referred as "Feinbloom Number Charts" (originally designed by Dr. William Feinbloom) and are often used to test people with low vision. The one provided here follows the logMAR design.

Cyrillic optotypes

Soviet ophthalmologists S. Golovin and D.A. Sivtsev developed in 1923 the Golovin–Sivtsev table with 7 Cyrillic letters (Ш, Б, М, Н, К, Ы, И) for testing visual acuity. It is still used in some post-Soviet states. This chart uses the same 7 optotypes and follows the logMAR design.

Snellen optotypes

These optotypes are the same 9 letters (C, D, E, F, L, O, P, T, Z) found in the original Snellen chart found in most physicians' office. However it is adapted to the logMAR design so it follows a geometric progression of letter sizes and proportional spacing between letters.

> ➡ *It is important to select the most appropriate optotype set based on the patient abilities. The Landolt 'C' and Tumbling 'E' optotypes only require the patients to indicate their orientations while all other optotypes need to be identified. Using the remote control may greatly facilitate the acquisition of the patient's responses.*

Optotype settings

The optotypes presentation can be customized in the settings section:

- Appearance: the optotypes can be displayed either as black letters on white background or white letters on black background. If there is no counter-indication, acuity testing should be performed preferentially with black letters on white background,

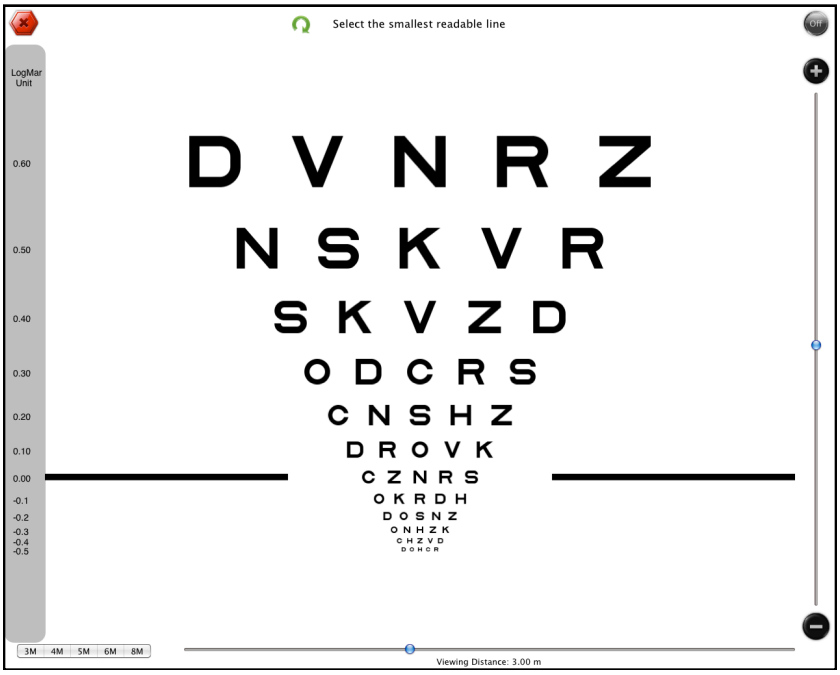
- Orientations: Landolt C and Tumbling E optotypes can have their orientation randomized among 4 or 8 directions. The use of 8 orientations for the Landolt C can improve the reliability of the acuity measurement,
- Confusion Bars: the optotypes can be surrounded to investigate the crowding effect (interaction between target in its surround) which is particularly important in Amblyopia. The surround can be either bars or a frame, and applies on the single letter, whole line or entire chart depending on the chart type, with a spacing corresponding to half the size of a single optotype.

❖ **Click on the icon corresponding to the desired optotypes to switch to the chart panel and start the testing!**

Measuring Visual Acuity

Chart Panel

After starting the acuity test, you are presented with the chart panel that displays the optotypes to be discriminated by the patients, similar to the one shown below. Note that the largest optotypes in the initial chart always correspond to an acuity of 20/200 (1 logMar unit) and depending on the default viewing distance only a few optotypes may be shown (due to the limited size of the Macintosh display and the logMAR design that constrains the spacing between optotypes on the same line and the interline spacing).



Several tools are available on the chart panel that can be controlled using either the computer mouse, the computer keyboard or the remote control (these controls are then mirrored on the remote screen):

(or ESC key) to stop the session and return to the main panel (no data is saved),

(or SPACE BAR key) to generate a new random,

(or DELETE key) to hide the controls on the Macintosh display,

(or ← and → arrow keys) to generate a new chart with optotype size increased or decreased by 0.1 log unit. Use the slider between these two buttons to set the size of the top line to any valid value (displayed in red above the chart).

The split horizontal line on the left and right sides of a multiple lines chart points to the current line the patient is asked to read. The experimenter can move up or down this line using the ↓ and ↑ arrows keys respectively (or using a mouse scroll wheel). On pressing the Return/Enter key the test is stopped and the acuity score associated with the last line is validated and recorded in the database.

to set the viewing distance to one of the preset distances. Use the slider on its right to set the viewing distance to any value up to 8 meters (26 ft). The chart is automatically scaled to maintain the selected acuity level.

The acuity bar on the left side indicates the acuity value for each line of a multiple line chart. This bar is updated each time the chart is changed.

Procedures

The general procedures for assessing visual acuity follow these basic steps (though methods may vary from practice to practice):

1. Position the patient at the appropriate distance,

2. Cover the eye not being evaluated (starting with the worst of the two eyes if known),

3. Ask the patient to read the optotypes from left to right starting with the top line,

4. Decrease the size of the optotype until the patient is unable to read or misses some of the characters on any one line,

5. Note the last line successfully read and record the incorrect result,

6. Repeat the above procedure for the fellow eye, then for both eyes together with and without corrective lenses.

The computerized solution provided by **Visual Acuity** for Mac supports two ways to enter/validate the patient responses:

- ***Manual mode*** where the experimenter interacts directly with the Macintosh through a standard keyboard,

- ***Remote mode*** where the experimenter or the patient interacts remotely with the Macintosh through an iPad, iPhone or an iPod touch running the free **Visual Acuity Remote** app which acts as a remote control.

❖ **Not all protocols are supported by these 2 modes: only the chart type is considered in the manual mode, and the remote mode should be used instead to fully take advantage of the acuity scoring and termination criterion options.**

Manual Mode

In the manual mode the experimenter interacts directly with the Macintosh using a standard keyboard. This measurement mode is as the simple scoring method. Follow these steps to run a test in manual mode:

1. Configure your test in the settings section (units, optotype appearance, protocol),

2. Create or select a patient and customize the session (tested eye, correction, notes) in the "Current Session" section of the subject panel,

3. click on one of the optotype icons to switch to the chart panel,

4. Set precisely the viewing distance using the bottom slider or using one of the preset values,

5. Adjust the vertical slider on the right to select a range of letter sizes that can be easily seen by the patient (for a multiple lines chart, this would be a range for which the subject can easily identify all letters in the first line but fails for the last one). This step can be skipped by starting with the default initial acuity level (20/200),

6. Press the down arrow (↓) or scroll down the mouse wheel to move the line indicator to the current line and ask the patient to read the optotypes from left to right,

7. If the subject can correctly identify all letters on that line, then repeat step 6 for the next smaller line until the subject fails at least once. If the last line is reached without error, then click on the '–' button (or press the right arrow →) to generate a new chart with smaller letters and repeat this step until the subject fails at least once. If the subject fails on the first line, click on the '+' button (or press the left arrow ←) to generate a new chart with larger letters and repeat this step.

8. Once an error occurs, move the line indicator back up (by pressing the up arrow ↑ or scrolling up the mouse wheel) to the smallest line the patient can successfully read, i.e. whose letters were all correctly identified, and press the Enter/Return key to validate and record the corresponding acuity score,

9. Abort a test at any time by clicking on the button  in the top left corner of the chart panel.

Remote Mode

The remote mode requires an iOS device (iPad, iPhone or iPod touch) and the free companion app **Visual Acuity Remote** that transforms this device into a remote control for the acuity testing running on the Macintosh. You can then use this remote control to provide the patient responses or self-administer the test a distance away from the Macintosh. To learn more about the capabilities of the remote control see the **Visual Acuity Remote** chapter in this user guide.

Note that in remote mode, all the controls are hidden and disabled by default because they are either unnecessary or available from the remote control. However they can be activated on demand.

Two roles are available when using the remote app:

- The experimenter role where the remote control can be used to browse across the chart similarly to the manual mode described above or to validate the subject responses and follow the specified protocol (ie the correct responses are available to the experimenter on the remote device). With this role, the test is user-terminated or self-terminating,

- The patient role where the remote control is only used to indicate the patient responses using touchable icons representing the possible choices. With this

mode, the test is self-terminating following the specified protocol: the test continues until the patient cannot reliably indicate the letter orientation or identify the letter, and stops automatically once the termination criterion is reached.

Follow these steps to run a test in remote mode with the Experimenter role:

1. Configure your test in the settings section (units, optotype appearance, protocol),

2. Create or select the patient and customize the session (tested eye, correction, notes) in the "Current Session" section of the subject panel (tested eye and correction can also be set through the remote control),

3. Click on the button on both Macintosh and remote control to establish a WiFi connection between the 2 devices (both need to be connected to the same wireless network: see FAQ),

4. Select the Experimenter role on the remote control,

5. Using the remote control, set the tested eye and whether it is corrected if not already done from the Macintosh in step 2. Set the viewing distance as well,

6. Select the optotype set to switch the Macintosh to the chart panel and start the measurement session,

7. Use the remote control to browse across the chart or validate the subject responses,

8. The test will normally self-terminate based on the termination criterion selected in the Macintosh settings and the acuity score will be saved to the Macintosh database,

9. Abort the test at any time by taping the button and optionally save the current score to the Macintosh database.

Follow these steps to run a test in remote mode with the Patient role:

1. Change the user role to Patient on the remote control,

2. Tap the "Start" button to switch the Macintosh to the chart panel and start the measurement session,

3. Use the remote control to enter the patient responses,

4. The test will automatically stop when the termination criterion is reached and the acuity score will be saved to the Macintosh database,

5. Abort the test at any time by taping the button  (no score will be saved).

❖ **The test should be first initialized with the Experimenter role to establish the connection, specify the optotype set or customize the session options. The Patient role can then be used until the optotype set or some options need to be changed.**

Scoring Methods

The procedure for measuring visual acuity consist in presenting optotypes of decreasing size until the subject is unable to discriminate between them. The scoring method is determined by the termination criterion, and the same scoring method can be applied irrespective of the chart type (multiple lines, single line and single letter).

The simple method provides an easy and fast way to measure visual acuity though less precise. The simple scoring method is the one used in the manual mode: the acuity score is the acuity level of the smallest line that can be read without any error. The advantages of this method are its simplicity and speed. However it has the main disadvantage to be prone to inaccuracy if the patient's responses are unreliable due to other factors than their limited acuity (for example due to communication errors or limited recognition and interpretation skills), and can lead to erroneously low estimates of visual acuity.

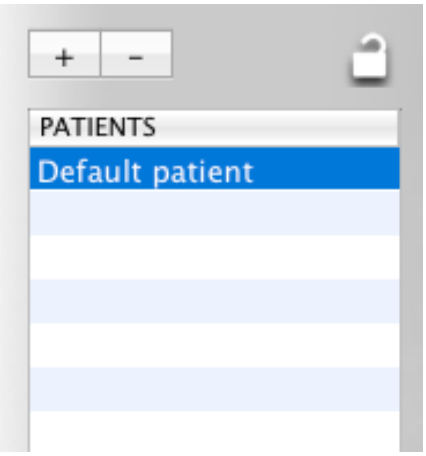
The **ETDRS** scoring method (developed in the context of "Early Treatment for Diabetic Retinopathy Study") provides a simple solution to this problem, and is the standard way to measure visual acuity in clinical environment: the termination criterion is based on several incorrect responses on the same line (typically 3 incorrect letters) rather than a single one to ensure that the subject has indeed reached their acuity limit. Moreover, the ETDRS method takes the contribution of each failed letter into account when calculating the acuity scoring (in a logMAR design with 5 letters per line and with a difference of 0.1 logMAR units between successive lines, each letter contributes for 0.1/5 = 0.02 logMAR units).
Based on the selected termination criterion, either scoring methods can be used in the remote mode. Note that since a computerized acuity test has the ability to randomly generate a new chart, retesting the same line with different optotypes could be a more efficient way to ensure that the subject error does not result from a false alarm: thus the reliability of the simple scoring method can be easily improved by retesting the erroneous line with a new set of optotypes (tap the label above the chart to generate a new random one) before deciding to terminate the test.

Managing the Subjects

The top part of the main panel always shows the information pertaining to the currently selected patient. The patient information includes:

- Some personal information (gender, age, eye condition, e-mail and phone number),
- The eye prescription (for glasses and/or contact lenses),
- The history of acuity measurements,
- The settings for the current session (tested eye, correction, notes).

Patients List

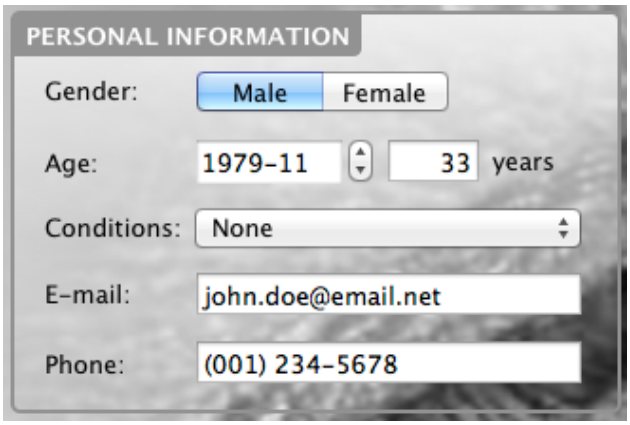


The patients list is available in the left section of the main panel. New patients can be added by clicking on the '+' button and entering their name. Patients can be removed by clicking the '–' button, a warning message will then alert you that this would also remove all associated information (acuity measurements included).

Personal Information

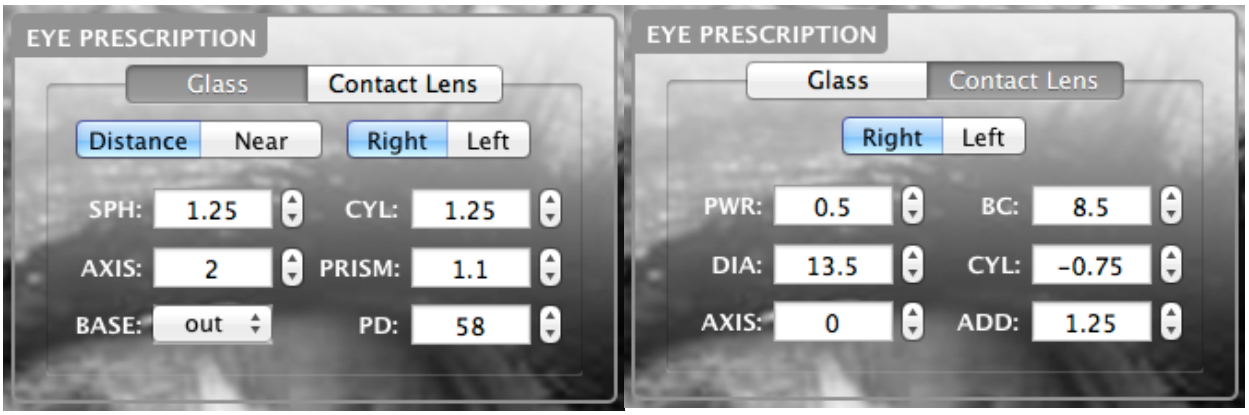
The personal information consists of:

- The patient gender,
- The patient age,
- The patient eye condition (several common conditions are available),
- The patient email and phone number.



All this information is mandatory. The personal information is locked by default. To unlock them, click on the locker icon.

Eye Prescription



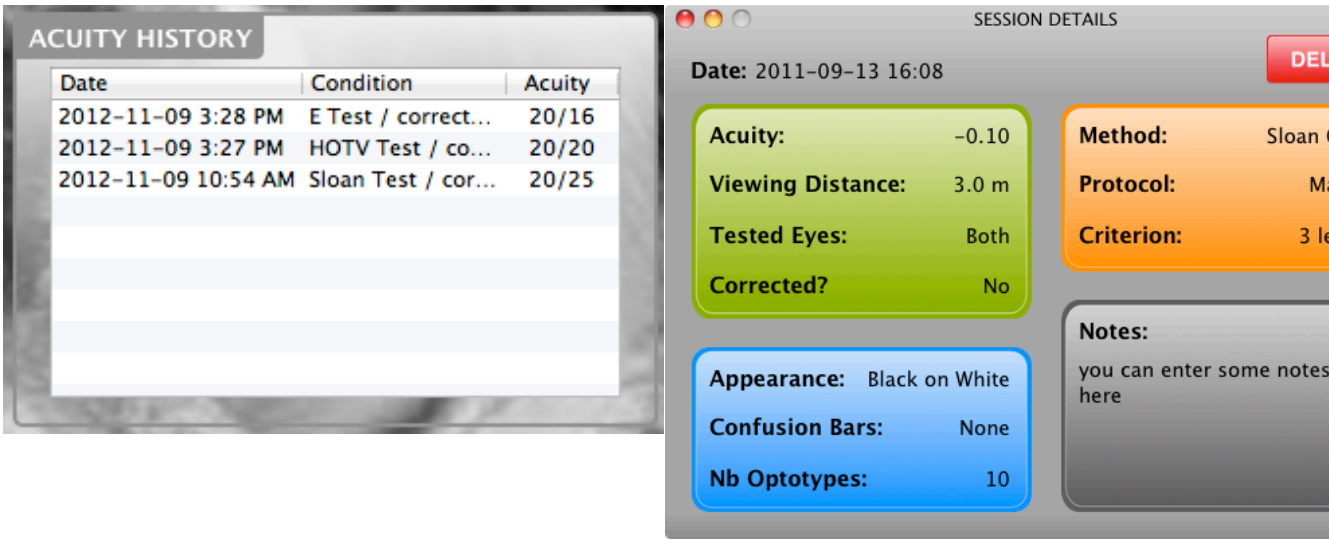
If known, the eye prescription can be entered for either glasses or contact lenses. For eyeglass prescription, both distance and near vision prescriptions can be provided. The prescription format includes all standard parameters found in the prescription provided by an eyewear prescriber, such as an optometrist or ophthalmologist.

Acuity History

Each new acuity measurement is automatically added to the patient's acuity history and is summarized in the table with its date, conditions and acuity score:
Double-click on an entry to inspect the full details of the measurement. Click on the "Delete" button in the session details to delete this entry.

Session Information

Information for the current session consists of:

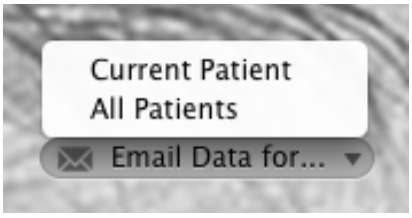


- The tested eye(s),
- Whether the eye(s) is corrected,
- Any other information that would be useful to note.

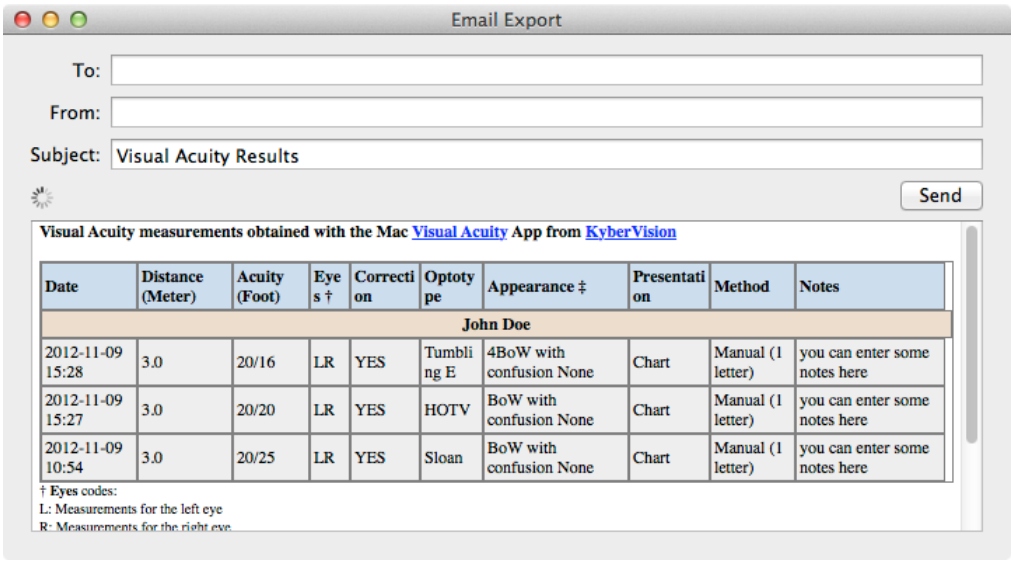
This information is recorded along with the acuity score measured for the current session so it is important to make sure it is correctly specified before running a session. This information can be retrieved through inspection of the measurement details in the acuity history. Note that the tested eyes and whether they are corrected can be also customized from the remote control when using it as the experimenter.

Exporting Acuity Data

The acuity history can be exported through email either for the currently selected patient or for all patients. You can use this feature to backup the acuity measurements. To email the data, simply click on the the Email button in the bottom toolbar and select either the current patient or all patients option:



The acuity data are presented and sent in an HTML table where each session is represented as a row where each column indicated a parameter value as shown below.



Visual Acuity Remote

The **Visual Acuity Remote** app runs on iPad, iPhone or iPod touch to remotely control through a WiFi connection the **Visual Acuity** app that runs on the Macintosh. Although the use of this app is optional, it provides a convenient access to the acuity test settings without having to physically access the Macintosh. It also allows subject's responses to be entered while standing a distance away from the Macintosh or during self-administration of the test. Either the subject or the experimenter can use it. It is available for free exclusively on the App Store (click here to access the App Store).

Getting Started

Tap the "VARemote" icon on your iOS device to start the remote control app and follow these steps (see also the Remote Mode section in the **Visual Acuity** chapter):

1. Establish a WiFi connection between the iOS device and the Macintosh,
2. Selecting the user role (experimenter or patient),
3. Start a test,
4. Run the test until it ends and save the score to the Macintosh, or abort the test,
5. Go to the step 2 to change the test or step 3 to start a new test.

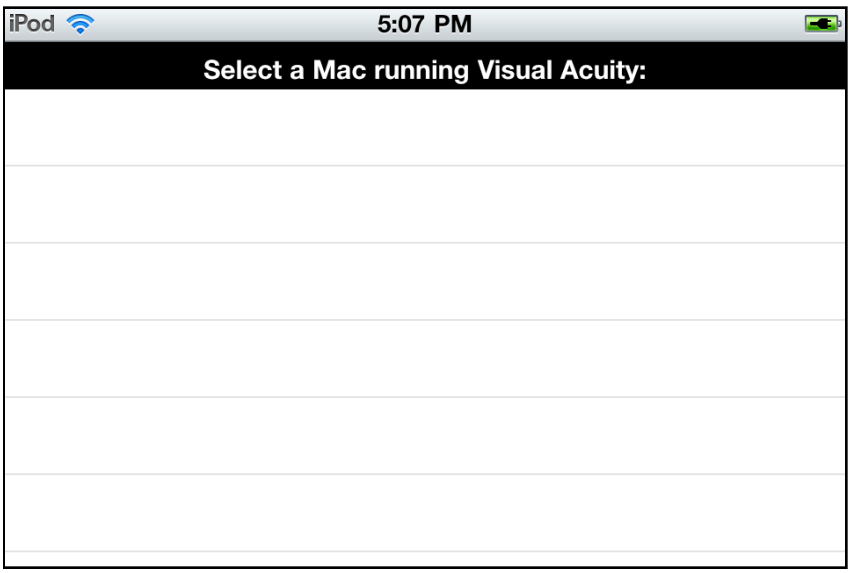
❖ **Make sure to properly configure your remote device before running a session in terms of power and settings (see the chapter Configuring your iPad/iPhone/iPod touch).**

Establishing a connection with the remote control

Here are the steps to follow to establish a working connection between the iOS device and the Macintosh:

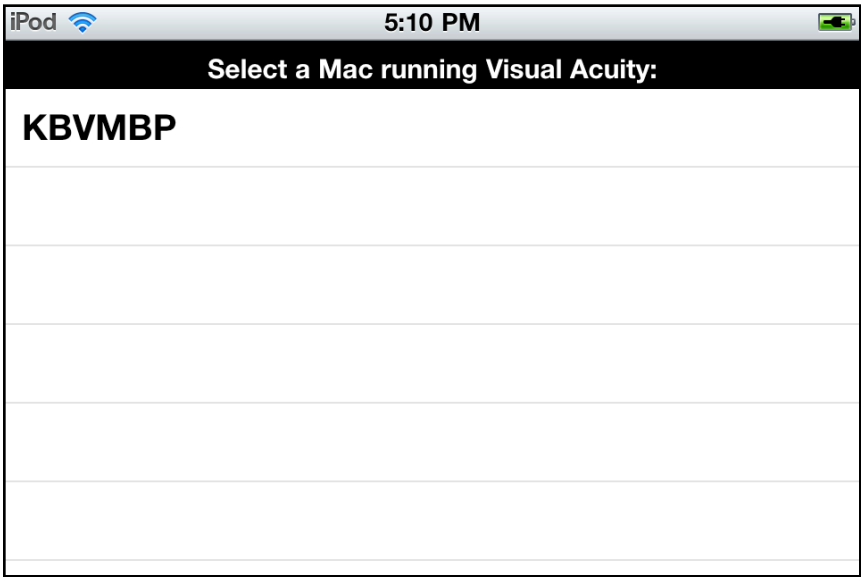
1. Make sure that both are connected to the same WiFi network (to create a local WiFi network see the FAQ),
2. Tap the large green button on the iOS device and select the Mac option,

The iOS device will start looking for available Macintosh computers running the **Visual Acuity** app:

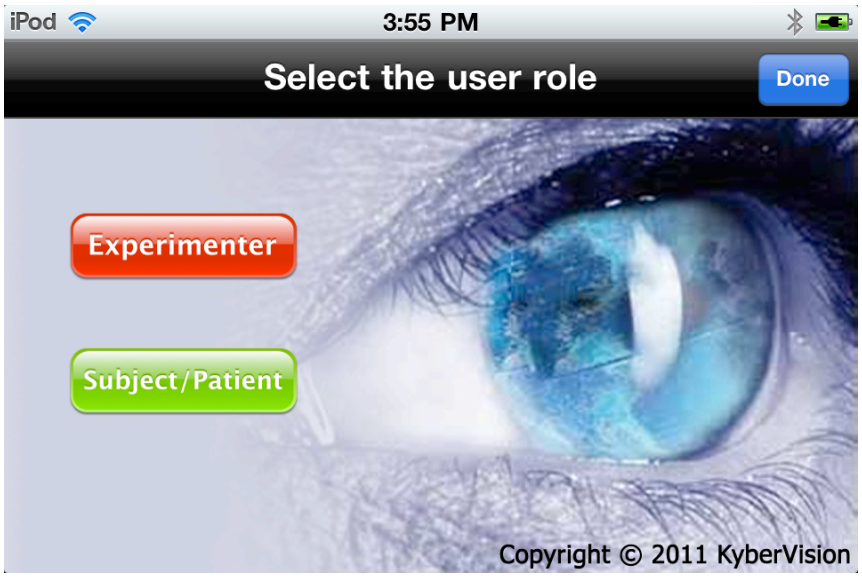


3. Launch the **Visual Acuity** app on the Macintosh if it does not run yet, and click on the button in the bottom toolbar to activate the remote capability.

4. After a few seconds, the Macintosh name should appear on the remote control screen. Tap the Macintosh name to initiate the connection:



5. The connection should establish in matter of seconds: the connection button on the Mac should be marked as connected, and the following panel should appear on the remote device and ask what role the user wants to play. Tap the button that corresponds to the intended role, experimenter or patient:



- **Some buttons are disabled in the "Visual Acuity" app running on the Mac when using the remote control: the optotypes and calibration buttons are not available anymore until the remote mode is deactivated by taping the "Done" button in the above panel or quitting the "VARemote" app .**

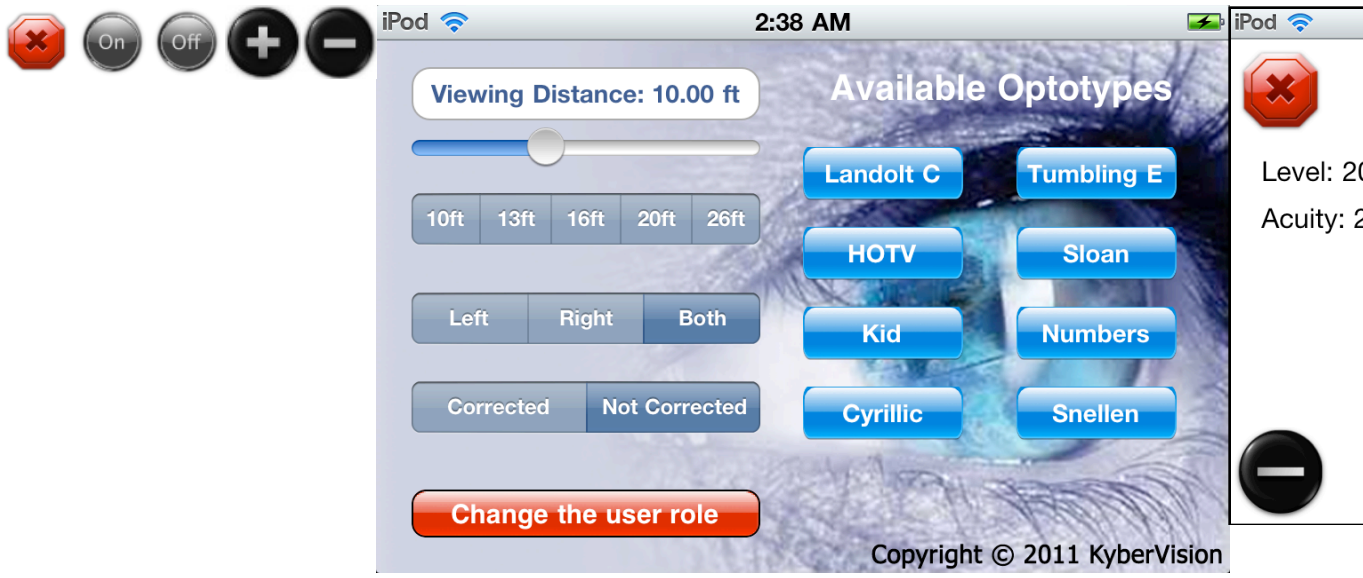
Playing the Experimenter role

In this mode, the Experimenter can manually browse through the chart lines presented on the Macintosh screen, have access to the acuity level and the currently presented optotypes, and validate the subject responses. The acuity score is automatically updated and is made available to the Experimenter who can decide to save or discard it. This mode is also useful for fast screening.

When selecting the Experimenter role, the user is presented with the following panel that provides control for the test settings: viewing distance, tested eye(s), whether the subject's vision is corrected, and the available optotype sets. The changes made through the remote control are automatically synchronized with the Macintosh app. The user role can be changed by taping the red button to return to the previous panel.
Taping one of the optotypes starts a new measurement session on the Macintosh with the selected optotypes (note that the last selected optotypes become the default optotypes used in Subject mode, see Playing the Subject role below).
The above panel is then presented on the remote control which provides the experimenter with the following controls and indications:

To stop the session and return to the previous panel,

To show and hide the controls on the Macintosh display,



To generate a new random chart with optotype size decreased or increased by 0.1 log unit,

To generate a new random chart with the same size,

To move the line indicator one line down or up in multiple lines charts. If the subject failed on the indicated line (e.g., 3 incorrect letters on the same line for the ETDRS method), the Experimenter is then presented with the option to save the score or continue (see below).

Level: <value> (<unit>) which indicates the acuity for the current line (the line pointed by the line indicator in multiple lines charts),

Acuity: <value> (<unit>) which indicates the current estimate of the subject acuity,

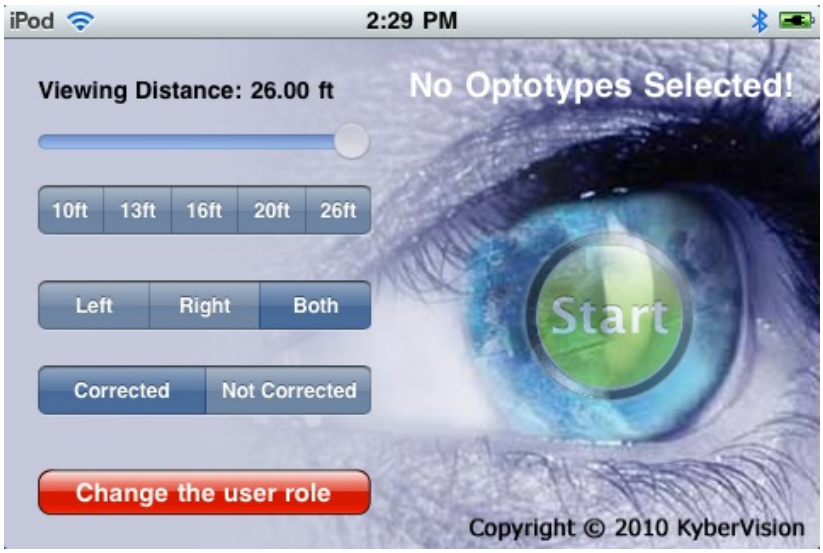
These optotypes displayed above the controls indicate the ones that the subject should recognize (i.e. those on the current line). Based on the subject response, the experimenter should tap each letter that is wrongly identified which is then shown in light grey. The acuity estimate is updated accordingly.

Once the subject fails a line, the Experimenter is presented with the option to save the score or continue: if saved, the score is recorded in the Macintosh database (see the Acuity History section). If not saved the test simply continues with the possibility to change the response for the last line.
If the test is interrupted by taping on the ‘Stop’ button, the user is asked whether to also save the current score or to abort only. If saved the score is recorded in the Macintosh database.

Playing the Subject role

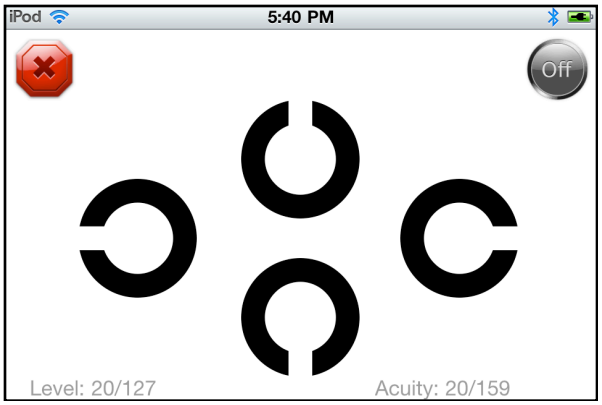
The Subject mode should be used when the subject is allowed to directly enter their responses using the remote control. Nevertheless, the Subject mode can also be used by the experimenter if the subject is unable to use the remote device or if the experimenter prefers to use this mode to enter the subject's responses himself. However, contrary to the Experimenter mode, the user cannot modify the test configuration in the Subject mode: these settings are shown but are locked (i.e. to modify them you need to return to the Experimenter mode).

The optotypes set presented to the subject is specified above the "Start" button. These optotypes are those that have been last selected by the user in the Experimenter mode (see Playing the Experimenter role section). If none has been specified yet, then this is indicated and the "Start" button gets disabled as shown below:
To start the test, the subject should simply tap the "Start" button and enter their response for each letter of the presented line from left to right. The subject is presented

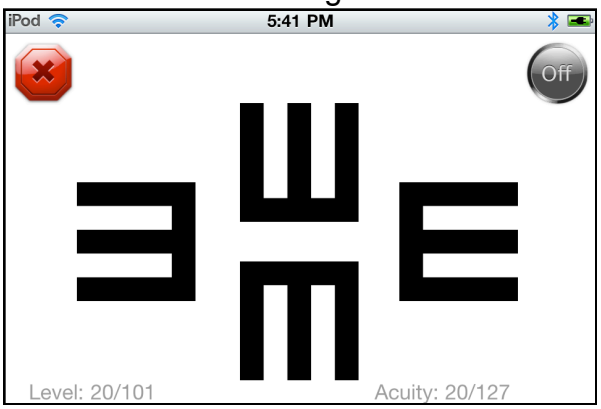


with one of the following panels where each available optotype is represented by a large button:

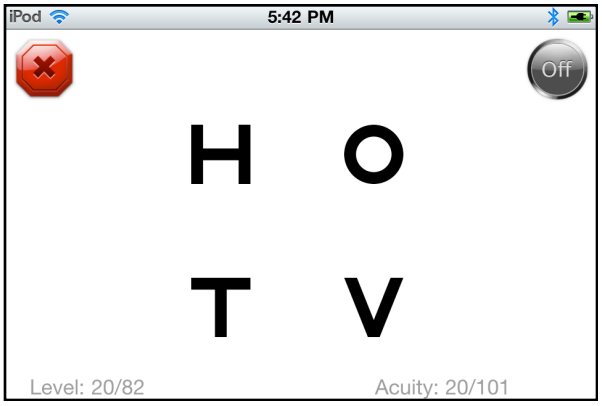
Landolt-C



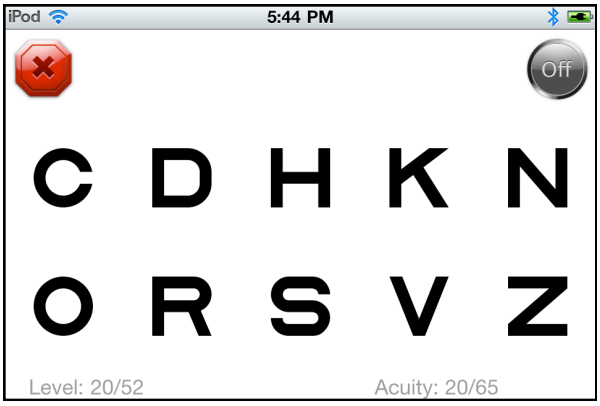
Tumbling ‘E’



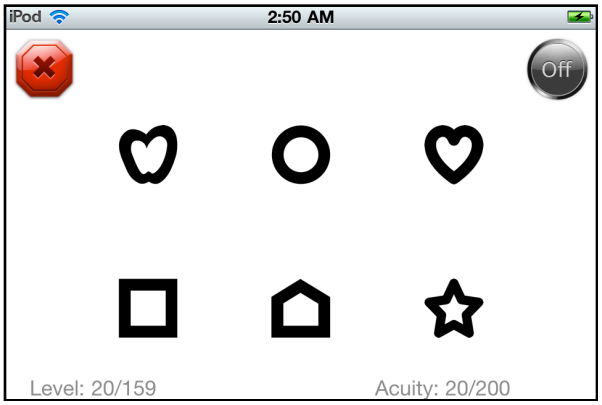
HOTV



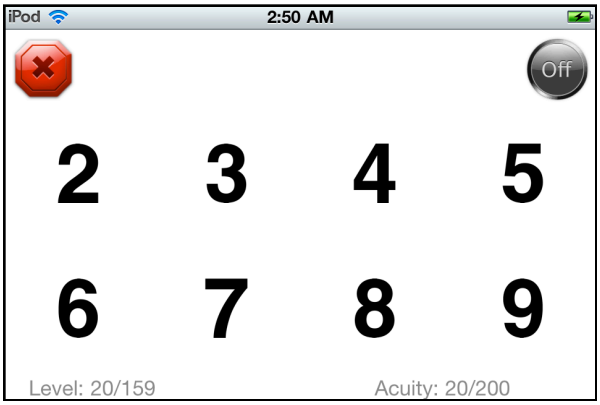
Sloan



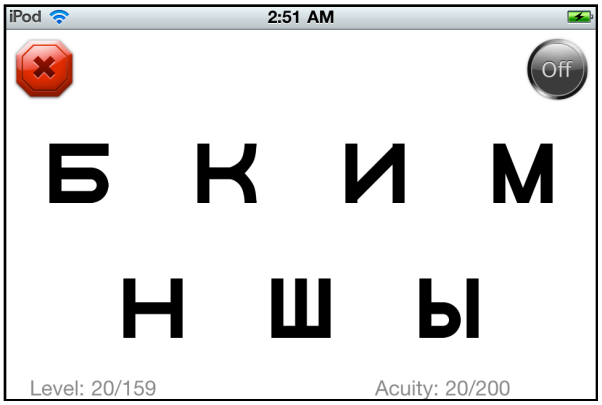
Kid



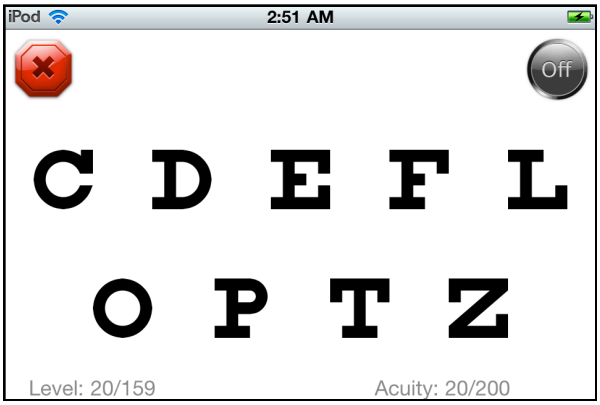
Numbers



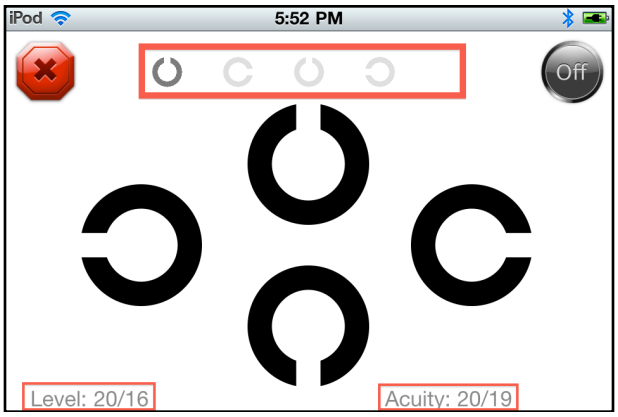
Cyrillic



Snellen



In addition of the large optotype buttons used by the subject to indicate their response, each of these panels provide the user with the following controls and indications:



 To abort the session and return to the previous panel,

To show and hide the controls on the Macintosh display,

Level: <value> (<unit>) which Indicates the acuity for the current line (the line pointed by the line indicator in multiple lines charts),

Acuity: <value> (<unit>) which indicates the current estimate of the subject acuity,

 The optotypes displayed above the controls indicate the responses already made by the subject for the current line. The light grey optotypes are those that the subject failed to recognized while the darker grey ones are those the subject successfully identified. The acuity estimate is updated accordingly, and the next line is automatically presented if the current line is successful.

On test completion (i.e. once the termination criterion has been reached), the user is presented with a message indicating the final score and with the option to record it in the Macintosh database (see the Acuity History section) or to abort the test.

Frequently Asked Questions (F.A.Q.)

Q: *Do you recommend a particular computer configuration?*

R: Any Macintosh computer with an Intel processor and running Mac OS X 10.6 or 10.7 will be able to run the **Visual Acuity** app. There is no special requirement in terms of graphics card or video memory. However we recommend to use a bright and large LCD monitor with the highest possible resolution (e.g. 2560 x 1440) to show the optotypes to the patient. For example a Mac mini or MacBook with an external display or a 27" iMac are perfectly appropriate setups. To learn more about the adequacy of the 27" iMac for measuring visual acuity see the next section.

Q: *Does this app support multiple displays?*

R: Yes. The optotypes screen used by default is the main display (i.e. the one with the menu bar which can be changed in "**Displays**" System Preferences under the "**Arrangement**" tab). However if several displays are attached to the Macintosh computer it is necessary to select which one should be used as the optotypes screen from the Settings panel. This way it is possible to use a MacBook to show the optotypes on a large external display instead of the smaller built-in display.

Q: *Which screen resolution should be used?*

R: It is always recommended to use the **native resolution** for a LCD display. The native resolution ensures the highest precision in the measurement of visual acuity because it specifies the highest pixel density and that the pixels are perfectly square. The screen

resolution can be changed in "**Displays**" System Preferences under the "**Display**" tab. Note that the calibration tool ( button) always makes sure that the selected resolution provides square pixels.

Q: *I cannot use my iOS device as a remote control because there is no WiFi network to connect to! Is there a solution?*

R: Most Macintosh computers support WiFi and can either share their wired internet connection through WiFi (see the "Internet Sharing" option in "**Sharing**" System Preferences) or create their own local *Ad Hoc Wireless network* (see the "Create Network..." option in the **Airport menu** ). Both of these solutions allow the WiFi connection of the iOS device acting as the remote control to the Macintosh computer running the **Visual Acuity** app. For more information check the following links:

- Turn your Mac into a WiFi hotspot using OS X's internet sharing

- How to Set Up an Ad Hoc Wireless Network

Q: *The connection between the remote control and the Mac does not seem to work properly. What can be done to resolve this issue?*

R: To properly communicate the remote control and the Mac need to be on the same WiFi network. However network congestion may affect the reliability of the communication between the 2 devices and it is recommended to create your own local WiFi network to minimize communication delay (see above solution).

Q: *Can I use the keyboard to enter the patient's responses?*

R: The keyboard can only be used so far to move up and down (↓ and ↑ arrows keys) the indicator of the current line and to validate the measurement (Enter/Return key). Although a wireless keyboard can be used, we highly recommend to run the **Visual Acuity Remote** App on an iOS device (iPad, iPhone or iPod touch) which can then be used as a remote control which offers a more user-friendly way to enter the patient's responses.

Adequacy of the 27” iMac for Visual Acuity Testing

Display Specifications

- Technology: LED-backlit IPS LCD
- Resolution: 2560 x 1440
- Size: 16:9 ratio with 27" diagonal
- Pixel density: 109 ppi (4.3 ppm)
- Glossy screen

- Min Luminance: ~ 0.4 cd/m^2
- Max luminance[1]: ~ 375 cd/m^2
- Max contrast ratio[2]: ~ 1000:1

Specifications for visual acuity testing

- Recommended minimum distance: 63" (5ft 3" or 1.60 meters) to provide a maximum resolution of 60 cpd or 20/10 acuity

- At a distance of 3 meters (10 ft), the 27” iMac screen provides:

    - A visual angle of 11 x 6 degrees
    - A maximum visual resolution of 114 cpd
    - A pixel size of 15.5 arc seconds

Lightning Conditions & Brightness

Visual acuity 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 of 85 cd/m^2.

Pros & Cons

The iMac screen is a very high quality LCD display, with a high brightness and a high contrast ratio, well suited for acuity testing. Its pixel density is adequate for measuring a 20/10 visual acuity (60 cpd) at a distance of 63". However, when following a logMar design, the main limitation is its resolution/size limited to 11 x 6 deg at a distance of 10 ft: a maximum of 3 letters only can be presented on the same line at a 20/200 acuity level.

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[1] Luminance information for other iMacs

[2] Contrast information for other iMacs

Another potential problem is the screen glossiness: glossy screens are more susceptible to glare, reflecting light from windows and light bulbs. On the contrary matte screens tend to handle glare better, due to a polarized coating over the glass that diffuses ambient light. A side effect of the matte finish is a slight blurring, reduced contrast and a narrower viewing angle. Consequently we recommend choosing a matte screen if available as an option or using a screen filter that provides the best trade-off between glare reduction and blurring.

Configuring your iPad/iPhone/iPod touch

The iOS device used as a remote control needs to be properly configured before running any visual acuity test. Here are a few important recommendations to follow before carrying out a test to ensure a smooth process:

Power Adapter vs Battery

If the iPad, iPhone or iPod touch is not plugged to an electrical outlet or a computer system while running the acuity testing, make sure that their batteries are fully charged beforehand (the battery level is indicated in the top right hand corner). While they can provide several hours of battery life, the use of the WiFi connection can significantly reduce this time. Keep handy a USB cable for charging through an electrical outlet or a computer system.

Settings

Make sure that there is no system setting on both devices that interfere with the testing process. Open the "Settings" app and verify the following settings in the:

- "Notifications" section:
    - "Notifications" set to OFF
- "General" section:
    - WiFi enabled in the "Network" option and connected to your local network
    - "Location Services" set to OFF
    - "Auto-Lock" set to NEVER
    - "Bluetooth" set to OFF

Useful Accessories

You may find the following accessories very useful for carrying out visual acuity testing (*Note that we do not endorse any of these products: similar products may be available from different manufacturers at different prices*).

Apple Wireless Keyboard

The completely cable-free **Apple Wireless Keyboard** uses Bluetooth technology to connect with your Mac or iPad. So you're free to move the keyboard just about anywhere within range and wirelessly type away. And its slim, compact design takes up much less space on your desk.

Provider: http://store.apple.com
Price: US$69

Game Pad

The **Gamer Action** for iPhone 3G and 3GS, and iPod touch 2G and 3G provides a rubber grip texture that gives more comfort and control of the iPhone and iPod touch running the Visual Acuity Remote app. Note: This accessory is currently not compatible with iPhone 4 and iPod touch 4G though you may find some cases that would make your device fit into this accessory (eg, the dermaSHOT Silicone Case from **Incipio** for the iPod touch 4G provides the same form factor than the iPhone 3G).

Provider: http://www.boxwave.com/
Price: US$24.95