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Operational Based Vision Assessment Automated Vision Test Collection User Guide



**Elizabeth Shoda, Alex van Atta, Marc Winterbottom,
James Gaska**

May 2017

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14. ABSTRACT The U.S. Air Force School of Aerospace Medicine Operational Based Vision Assessment Laboratory has developed a set of computer-based, automated vision tests, or AVT. Development of the AVT was required to support threshold-level vision testing capability needed to investigate the relationship between ocular health and operationally relevant performance. Existing standard tests often do not support the level of accuracy and repeatability to support correlation analysis. The AVT research grade tests also support interservice, international, industry, and academic partnerships. The AVT software has been provided to key partners to support ongoing research collaboration. This document describes the installation of the software, provides information concerning various menu options and operation of the test, and provides a brief description of each of the automated vision tests.					
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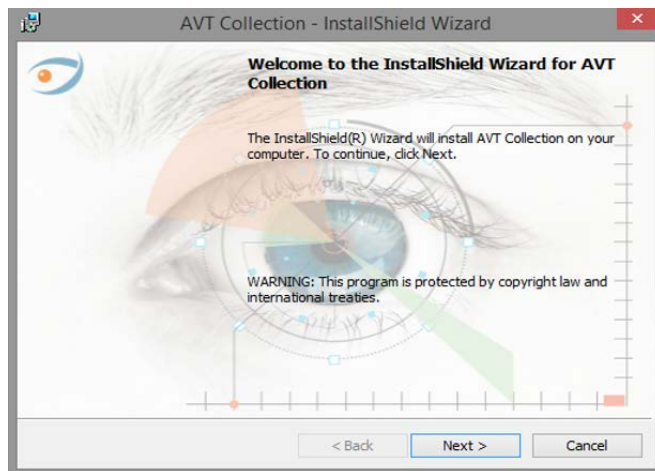
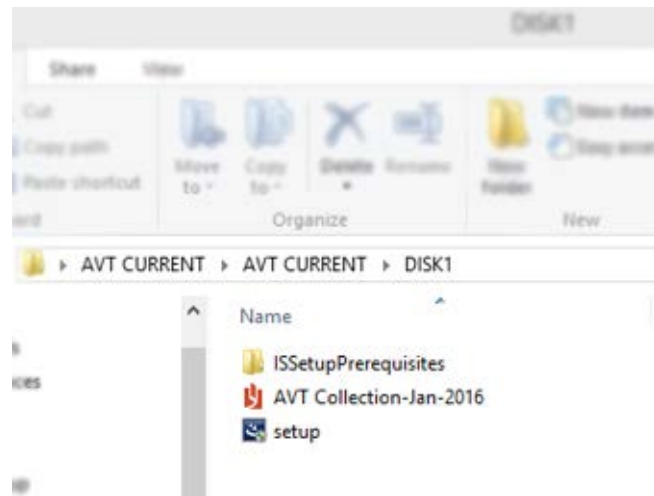
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1.0 INTRODUCTION

The U.S. Air Force School of Aerospace Medicine Operational Based Vision Assessment (OBVA) Laboratory has developed a set of computer-based, automated vision tests, or AVT. Development of the AVT was required to support threshold-level vision testing capability needed to investigate the relationship between ocular health and operationally relevant performance. Existing standard tests often do not support the level of accuracy and repeatability to support correlation analysis. The AVT research grade tests also support interservice, international, industry, and academic partnerships. The AVT software has been provided to key partners to support ongoing research collaboration. This document describes the installation of the software, provides information concerning various menu options and operation of the test, and provides a brief description of each of the automated vision tests.

2.0 INSTALLATION

To install the AVT Collection software, first extract the folder called AVT Current. Once extraction is complete, click through the folders until you are in the “Disk 1” folder. Here you should see three items: a folder, a pdf file, and an executable file. Double click on the “setup” icon to open the installer. The installer will install the main AVT Collection software, as well as the programs in the prerequisite folder; therefore, you do not need to manually install the items in the prerequisite folder, as the installer will do that automatically for you.



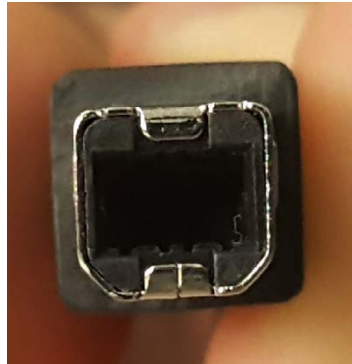
Follow the instructions and the prompts on the screen to install the AVT Collection software. If you need further assistance, please refer to the readme file called AVT Collection-Jan-2016, which contains more detailed installation instructions and troubleshooting information.

3.0 DUAL MONITOR INSTALLATION

One feature of the AVT Collection software is its ability to use dual monitors while running on only one machine. Because of the various types of visual tests included in the AVT, it is necessary to use both an NEC and a three-dimensional (3D) capable monitor to be able to properly run all of the tests contained in the collection. The instructions below will explain how to configure your computer system for a dual monitor setup.

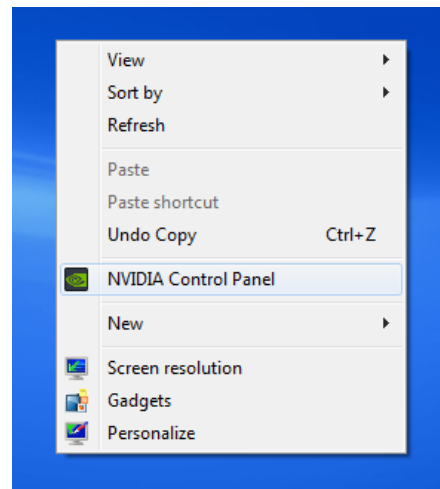
3.1 System Setup

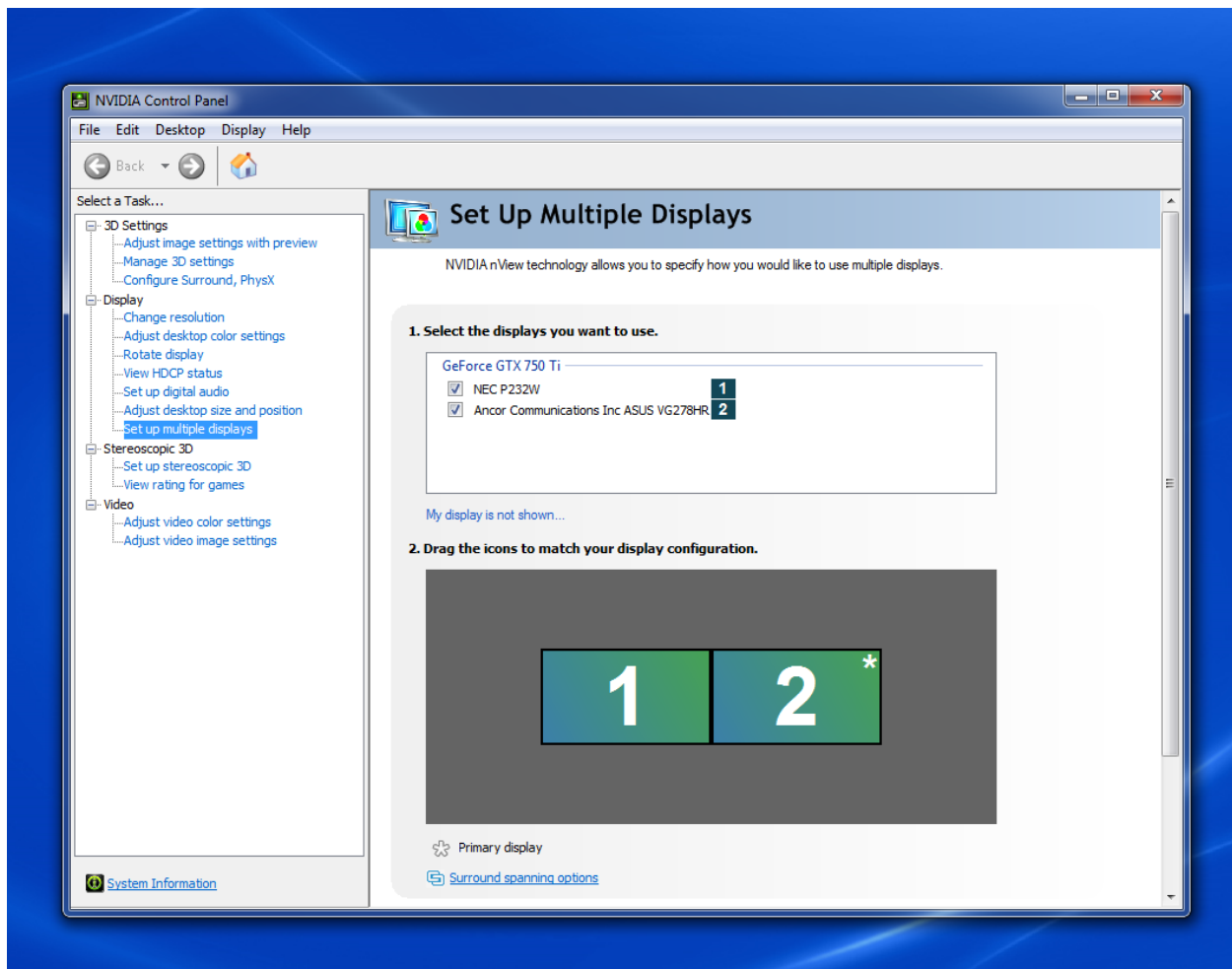
1. Connect the NEC color monitor to the computer via HDMI cable.
2. Connect the 3D monitor to the computer via dual-link DVI cable.
3. Make sure that the NEC color monitor is also connected to the computer via a USB-C printer-style cable. The picture below shows which end of the cable should be plugged into the NEC monitor.



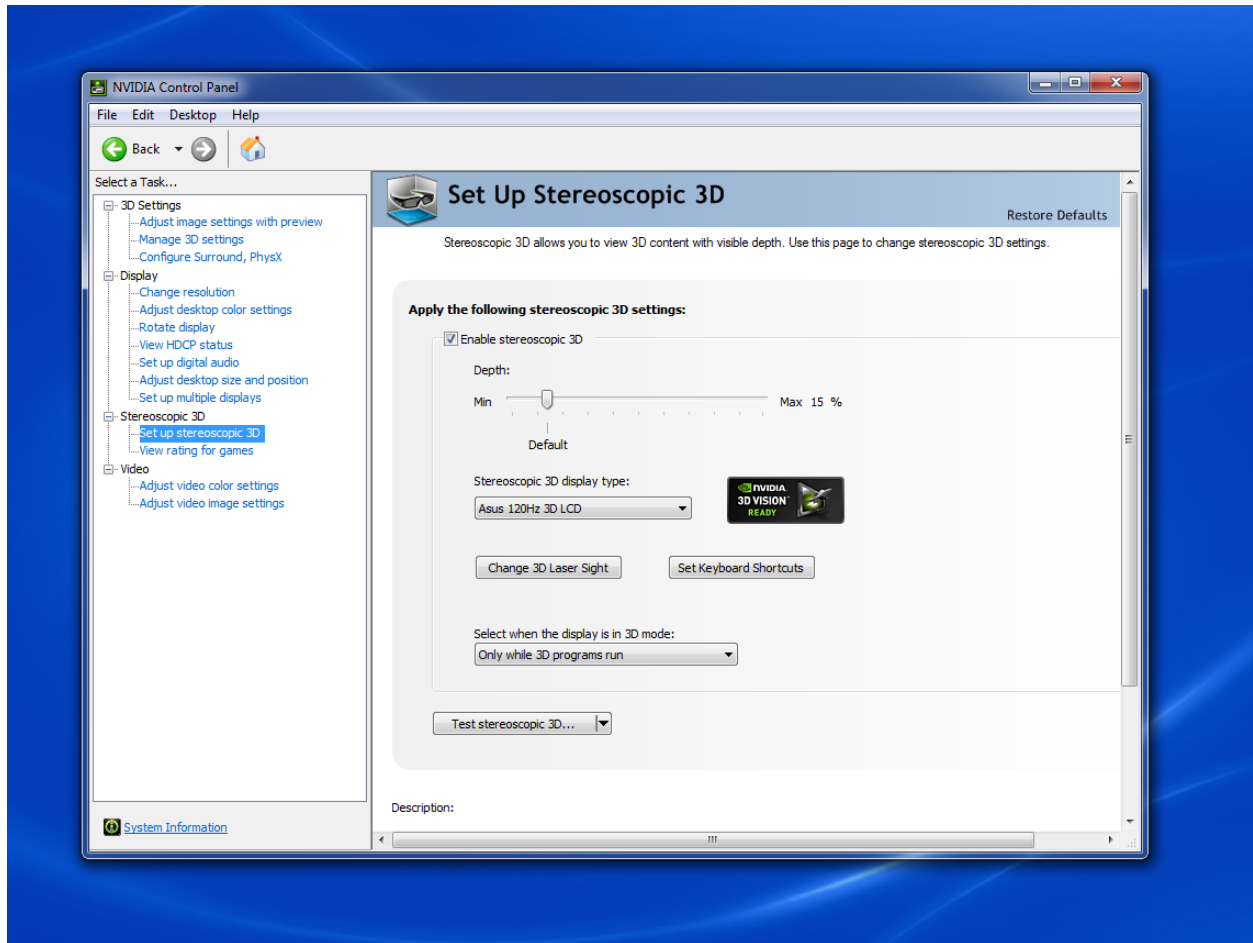
3.2 NVIDIA Setup

To properly run the AVT Collection on two monitors, the 3D monitor **MUST** be set as the primary display. To do this, right click on any unoccupied space on your desktop to bring up the settings list and click on “NVIDIA Control Panel.” From there, click on “Set up multiple displays.”

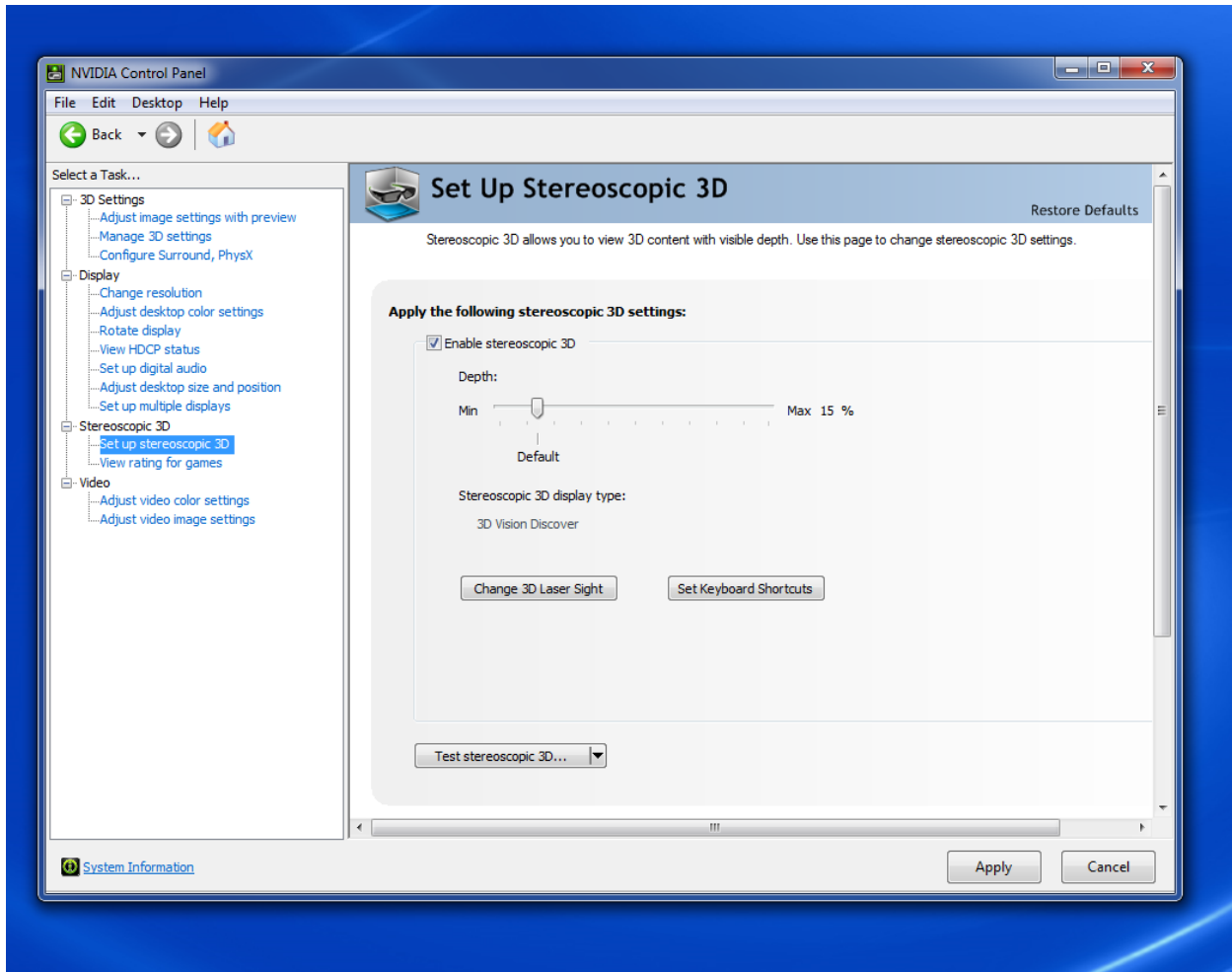




In the example above, our 3D monitor is already selected as the primary display as indicated by the white star icon. However, if the NEC monitor was selected as primary, we would need to change that by right clicking on the box representing our 3D monitor (in this case 2) and then clicking on “Make Primary.” To verify that our monitors are configured correctly, click on “Set up stereoscopic 3D,” which is located directly under the “multiple displays” tab that we were just on. If not already checked, make sure to check the box next to “Enable stereoscopic 3D.” A correctly configured setup screen should look like this:



If your 3D monitor is not configured properly, the setup page may look like this:



If your 3D monitor is not correctly configured and is not being recognized by the NVIDIA driver, then your 3D display type will indicate “3D Vision Discover” versus the actual name of your 3D monitor. In that case, go back and ensure that your 3D monitor is, in fact, set as primary, and verify that your 3D monitor is plugged into the computer with the correct cable.

3.3 Configuring Monitors: NEC

Open the AVT Collection software and click on “Launch Study” in the Landolt Contrast Sensitivity Test (LCST) box. A “New Display Setting” box will appear the first time you run the software with a new monitor connected. Ensure that the display is set to “non-stereo display” and that the resolution is set to 1920x1080. Measure the dimensions of your NEC monitor and input those measurements into the appropriate boxes.

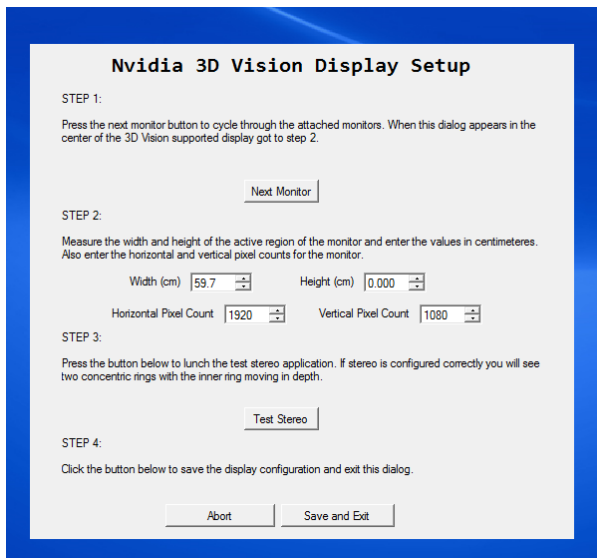
On the graphical user interface (GUI), click on “Calibration Center” and use your X-Rite i1 Display Pro colorimeter to properly configure your monitor. Place the colorimeter in the center of the screen and press the “s” key on the keyboard to begin calibration. These instructions should be written at the top of the calibration screen. If they are not, you may need to click on the “calibrate” button in the bottom right-hand corner of the screen first before pressing “s” to begin calibration. Once calibration is successful, the software will return you to the GUI. For more details on how to

operate the GUI, select, edit, and create new mode settings, or to change the existing mode settings of an experiment, please refer to the appropriate sections of this user guide for more help.

You will notice on the bottom of the GUI that “Display” is set to either 0 or 1. If you attempt to run an LCST test and it is being displayed on the incorrect screen, try toggling the display by using the menu bar to select “Settings” – “Admin Options” – “Toggle Screen.” If the settings are locked, click on “Toggle Menu Lock” and enter the password (obva). Once the display is toggled, the LCST test should now appear on the correct screen. Under a typical setup, the LCST GUI should be showing “Display 1” on the bottom.

3.4 Configuring Monitors: 3D Display

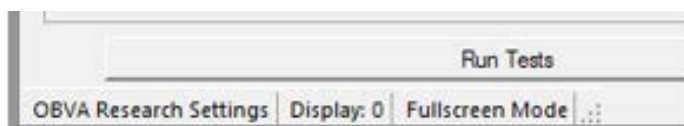
When running either the KC-46 Test Battery or the Stereo Comparison Study for the first time, the NVIDIA 3D Vision Display Setup screen will appear. Be sure to measure your monitor and type in the correct screen dimensions.



Follow the remaining steps to complete setup of your NVIDIA 3D display. To verify that your 3D monitor is correctly connected and configured, launch the KC-46 Test Battery from the main AVT window. Click on the “P” located next to “Near Threshold Test.” [Note: You must have a subject ID selected to begin a test. See user guide instructions on how to add test subjects.] If the near threshold tests appear to have a red and green anaglyph tint to it versus a true stereoscopic look, then the display is not configured properly. Again, check to make sure that all cables are properly connected and that the 3D monitor is set as the primary display.

3.5 Troubleshooting

Situations may arise where the stereoscopic tests appear on the NEC monitor and where the color and contrast tests appear on the 3D monitor. In other instances, a test may attempt to start but then “error out” and force close. If these issues happen, make sure that the 3D monitor is set as the primary display. This should fix most issues involving the display of tests on the proper screens. Additionally, if the 3D monitor is set as primary but the LCST battery of tests is appearing on the 3D monitor instead of the NEC monitor, make sure to toggle the display in the settings menu of the LCST GUI. As a reminder, with the 3D monitor set to primary, the LCST display will most likely need to be set to “1.” See below for a picture of the display indicator, which is located at the bottom of the GUI. Note: In the picture below, the display is set to 0.



Please refer to the NEC monitor configuration section for more detailed instructions on how to toggle the display.

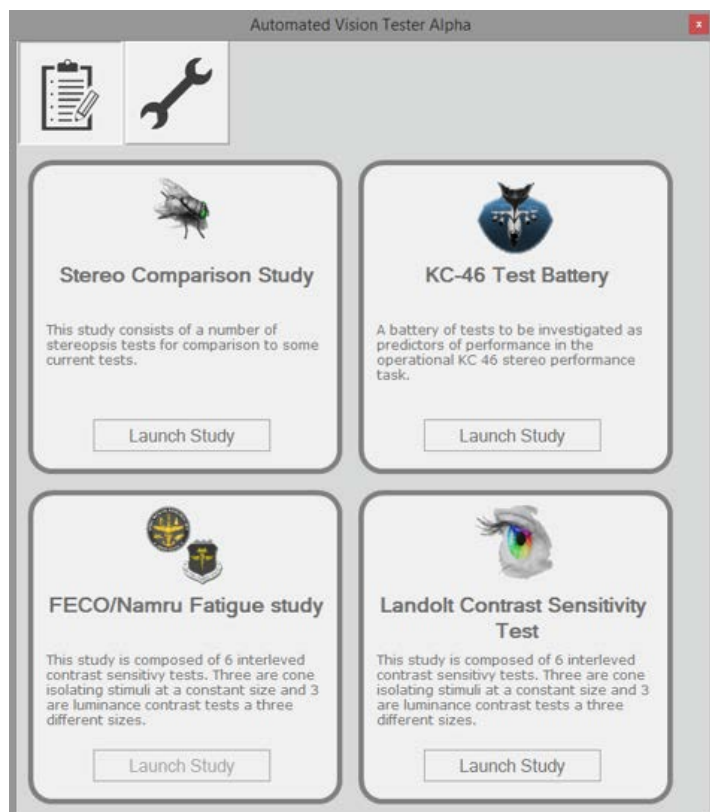
If the tests are not appearing on their respective screens correctly, or if errors in configuration cause a test to error out, you may need to delete the configuration files and repeat the respective configuration. To access the AVT configuration files, navigate to the following location on your computer: “User” [the name of this folder may vary depending on what you have set as the username of your computer] → “App Data” → “Roaming” → Automated Vision Test” → “Settings” → “Calibration.”

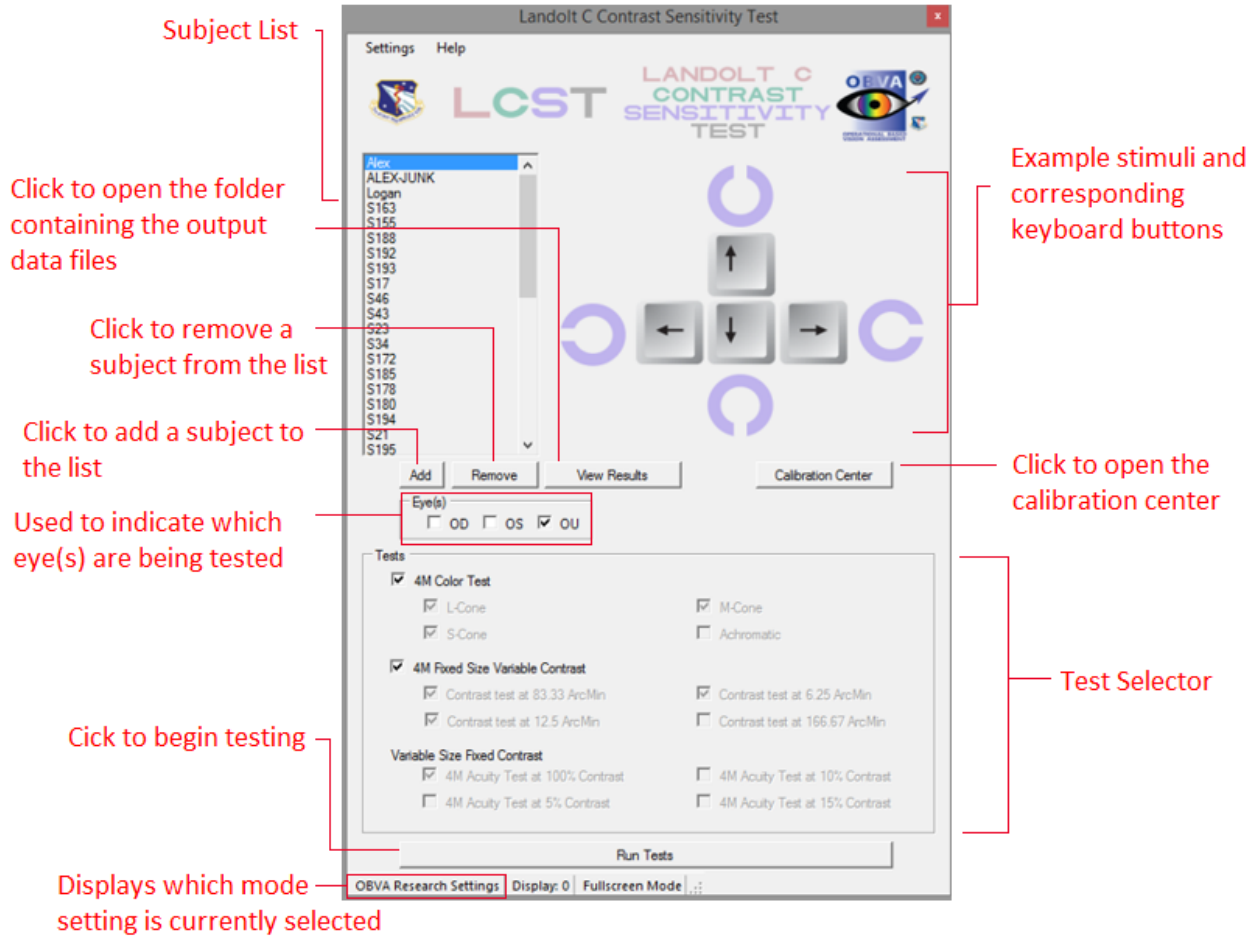
Once inside the “Calibration” folder, remove any configuration files that are stored there and repeat the calibration process again. If you do not see the “App Data” folder in the “User” folder, then you will need to enable hidden files and folders. For Windows 7, click on the arrow next to the “Organize” menu button in the top left of the explorer window. From the pull-down menu, select “Folder and search options.” When the folder options window pops up, click on the “View” tab, and then click on the bubble next to “Show hidden files, folders, or drives.” Click “apply” and then “ok.” For operating systems other than Windows 7, please refer to the manufacturer’s guide for viewing hidden files and folders.

4.0 LCST SETUP

When you launch the AVT Collection software, the screen to the right will appear.

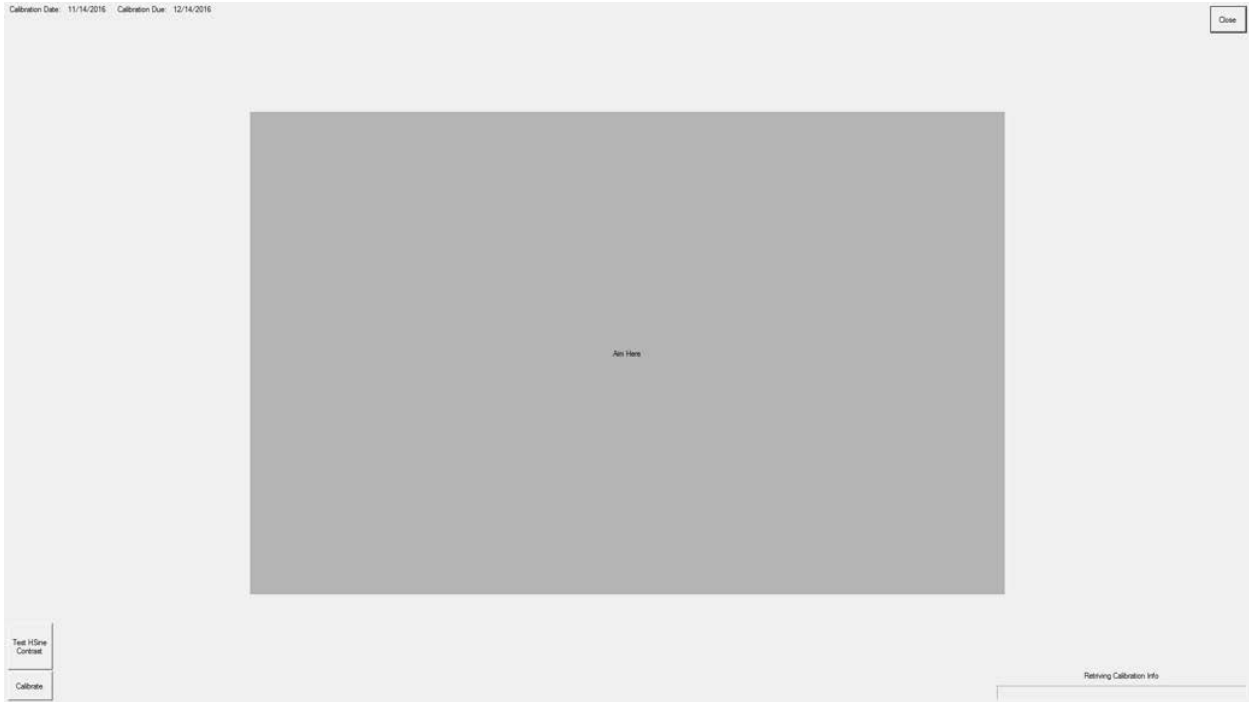
To access the LCST, click on “Launch Study” under the LCST box. The menu below will appear when you launch the LCST study.





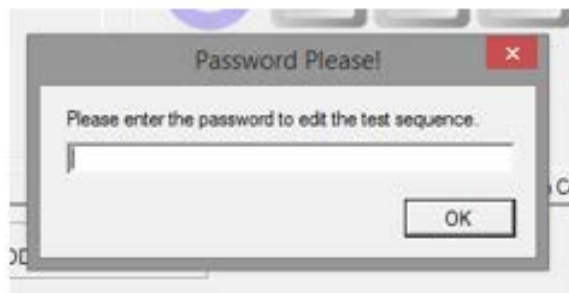
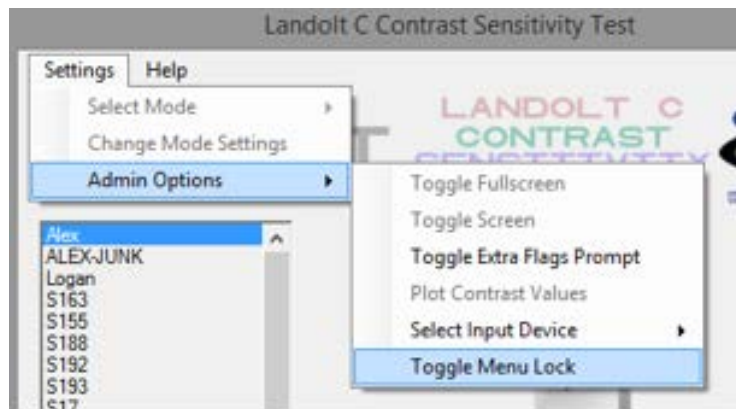
4.1 Calibration Center

The first time you access the LCST study, you will be prompted to calibrate your monitor. Follow the instructions on the screen to calibrate your monitor. If the screen below does not automatically appear, click “Calibration Center” to open the calibration settings.



4.2 Selecting Tests

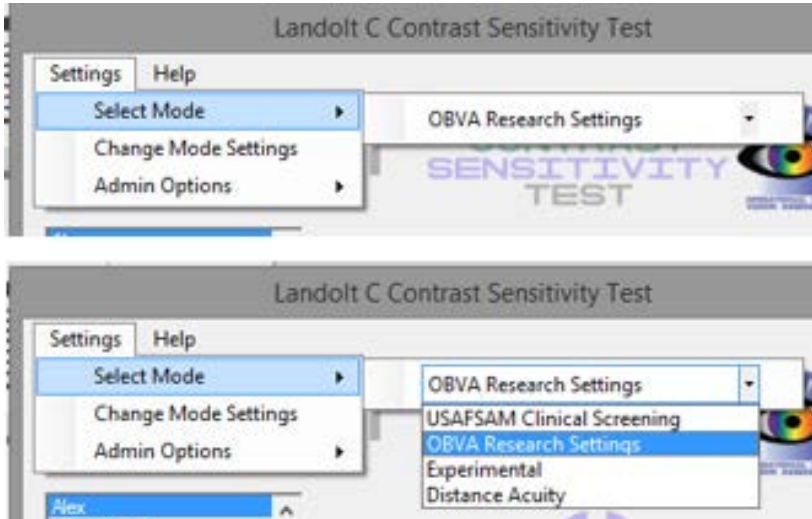
You will notice upon opening the LCST GUI that all of the subtests are grayed out and cannot be checked or unchecked. This is the default setting to avoid accidental/unintentional test selection. To unlock the test selection feature, click on the “Settings” option at the top left of the GUI. From there, click on “Admin Options” and then “Toggle Menu Lock.” When prompted to enter a password, type “obva” (minus quotation marks). No notification will appear indicating that the interface has been unlocked, but if the test selection area is no longer grayed out, and you are able to check and uncheck boxes, then your unlock attempt was successful.



4.3 Selecting Modes

With the interface now unlocked, you can choose which tests to run, as well as edit tests and test parameters.

[Note: To lock the interface again, simply follow the same steps as above. Once you enter the password again, the interface will be locked. Alternatively, completely exiting the AVT Collection program and re-opening it will also lock the interface.]



These settings are contained within the program’s modes. Each mode contains mode-specific settings for all 12 tests (four subtests for each of the three main tests: color, contrast, and acuity). Notice in the example interface above that the mode is set to “OBVA Research Settings” (as indicated in the bottom left of the interface). When in this mode, the default settings for OBVA research will be selected. To change to a different mode, click on “Settings” at the top left of the screen and then “Select Mode.” Click on the arrow next to the currently selected mode to open a pull-down menu of the available modes. Click on whichever mode you wish to select, and the interface will update with the default settings for that mode.

4.4 Editing Modes

You can change which tests are presented in a given experiment, or change the parameters of the stimuli, by editing the mode settings. To get to the mode editor, click “Settings” and then “Change Mode Settings.” After you finish editing any of the mode setting options, be sure to click “Apply” to save your changes. Your changes will now be reflected on the main LCST GUI. When editing modes, make sure you select the tabs in the following order: Mode, Ocular Setting, Test. Here is an example of what the mode settings editor screen will look like:

These tabs represent the available modes. The dark tab is the currently selected mode.

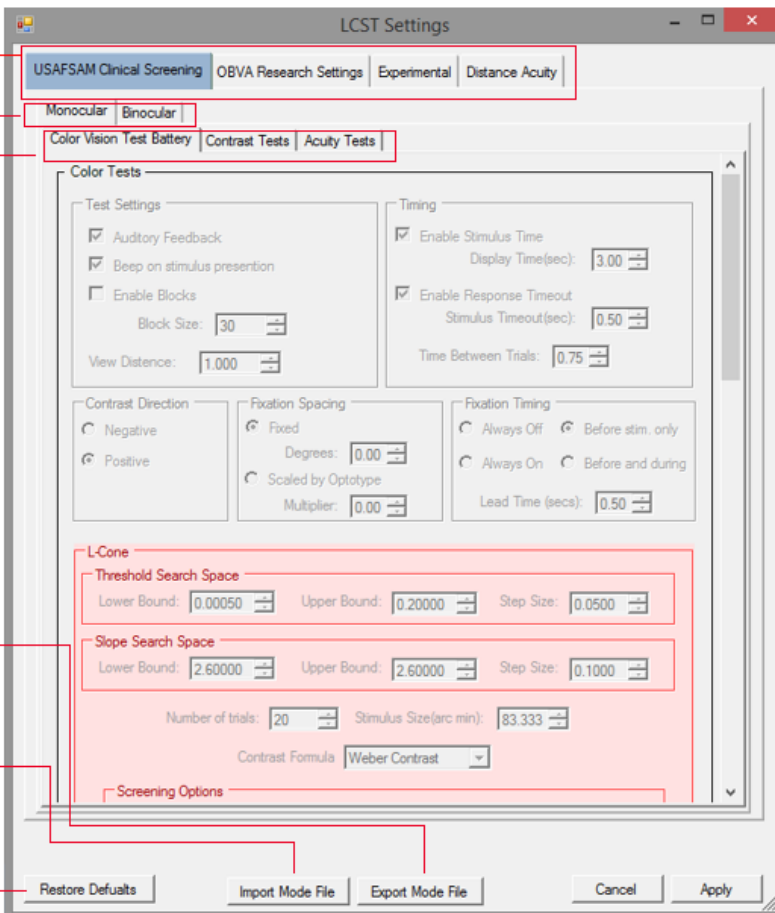
These tabs allow you to choose between monocular and binocular settings

These tabs allow you to select which test to edit

Click this button to export the current settings to a file

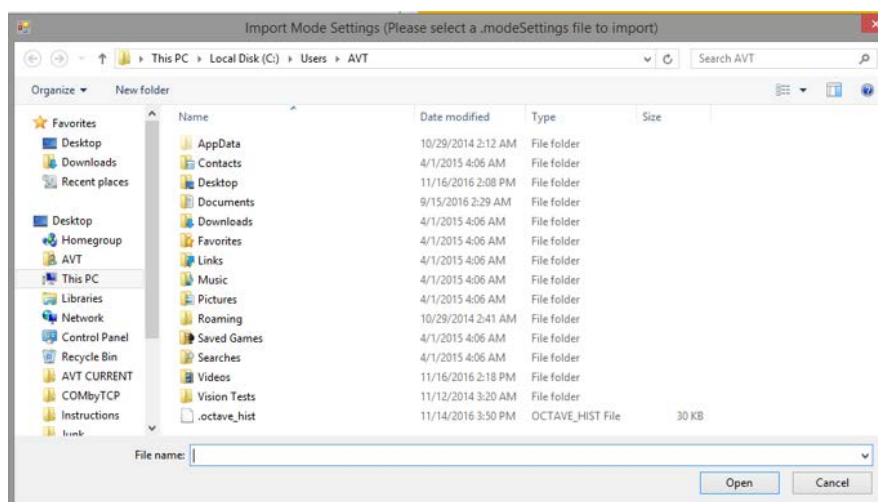
Click this button to import a mode setting file

Click this button to restore the default settings and erase any changes that have been applied



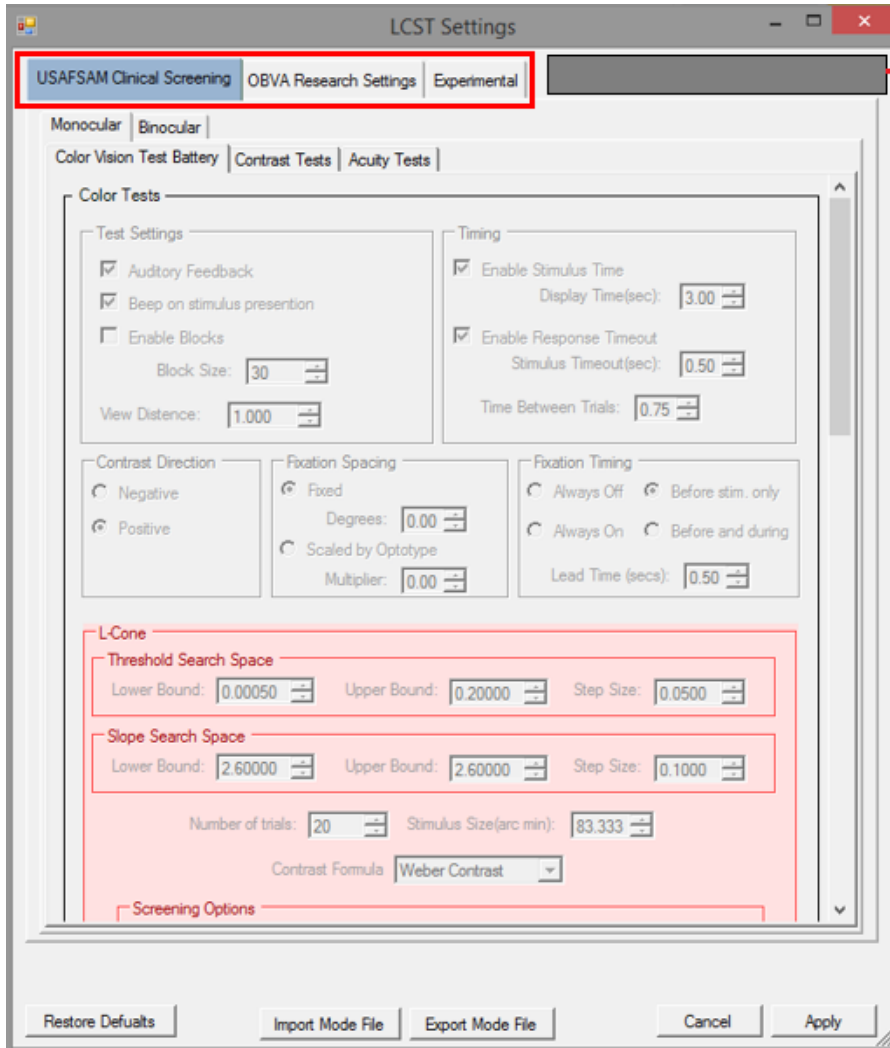
4.5 Import/Export

The AVT Collection software includes an option to import or export mode setting files. To import a previously saved mode setting file, simply click on “Import Mode File” and then use the file explorer to navigate to, and select, the appropriate file. To export your current mode configuration settings to a file, click on “Export Mode File” and select the location you wish to save your file.



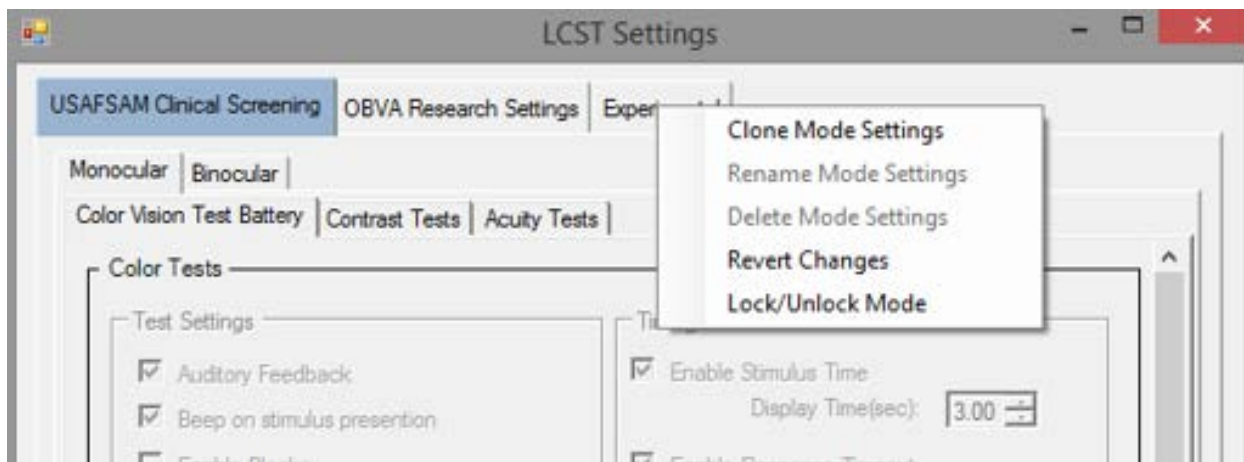
4.6 Creating New Modes

Occasions may arise where you may need to create new modes, for instance, if you are conducting a new study or testing different experimental settings. The example below illustrates how to create and edit new modes. You will notice in the example settings menu below that there are three settings modes: USAFSAM Clinical Screening, OBVA Research Settings, and Experimental.

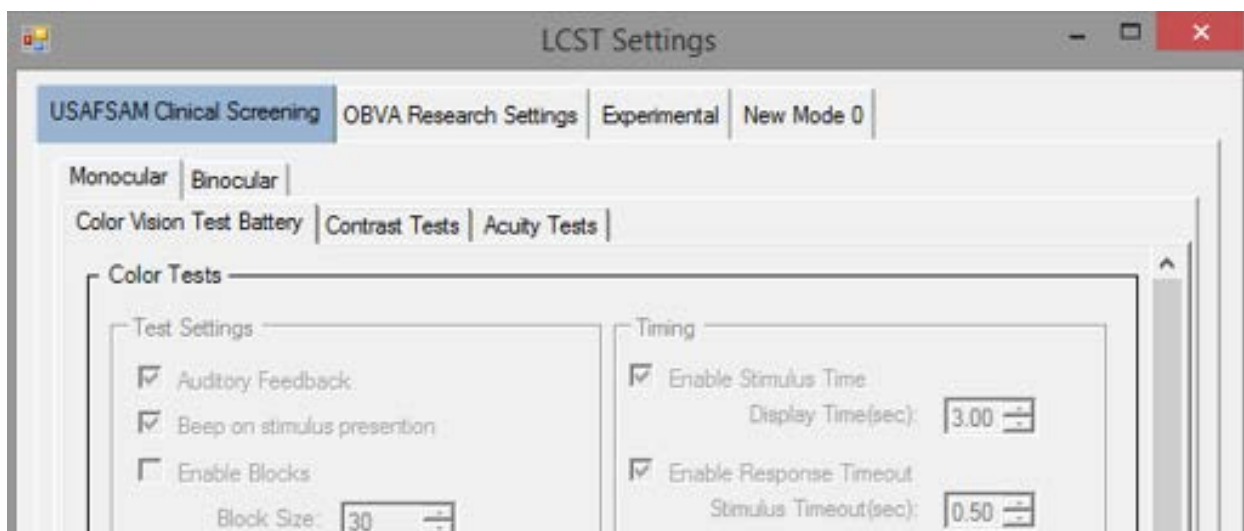


This area will not respond to right clicks

To create a new settings mode, right click on any of the tabs or anywhere within the settings box (except for the area shown in the figure above). After right clicking, you will see the following options appear on the screen.



To add a new mode settings tab, click on “Clone Mode Settings.” As you can see below, the interface now has our new settings tab right next to the “Experimental” tab.

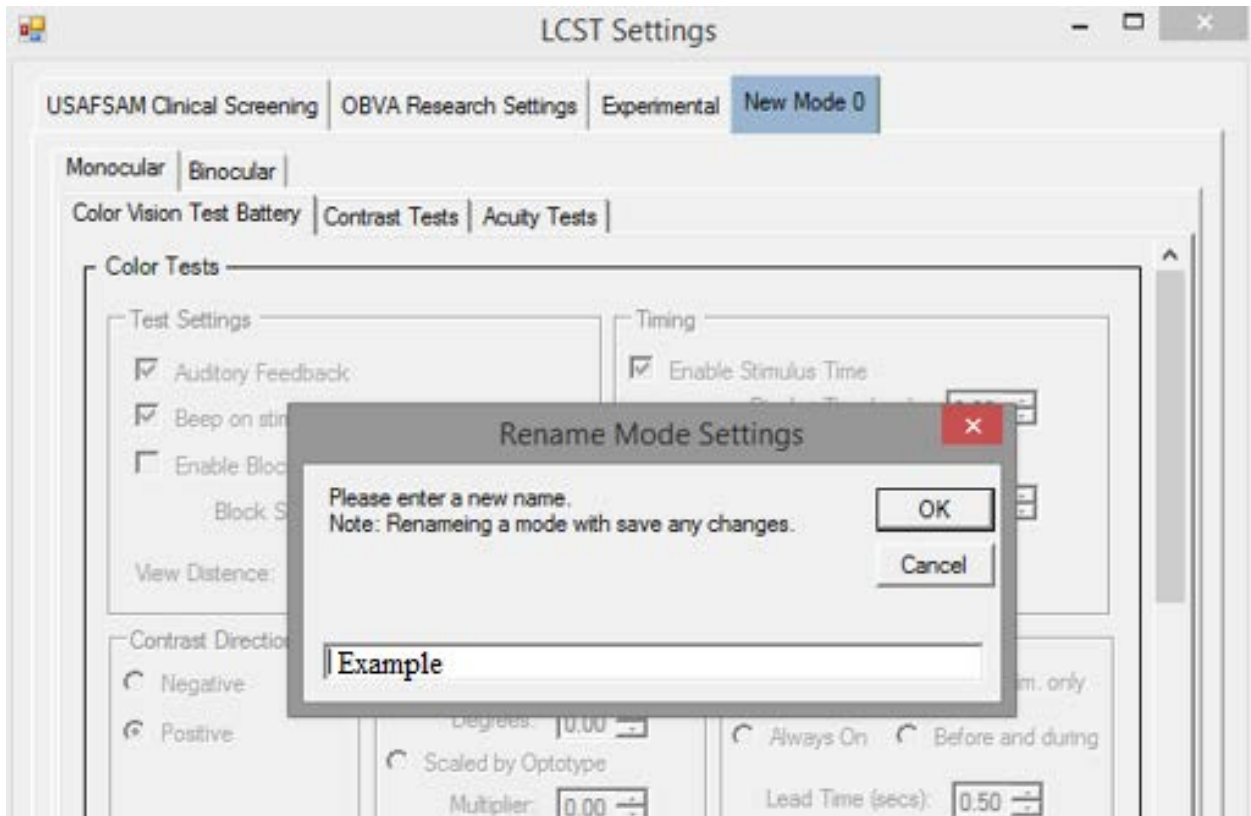
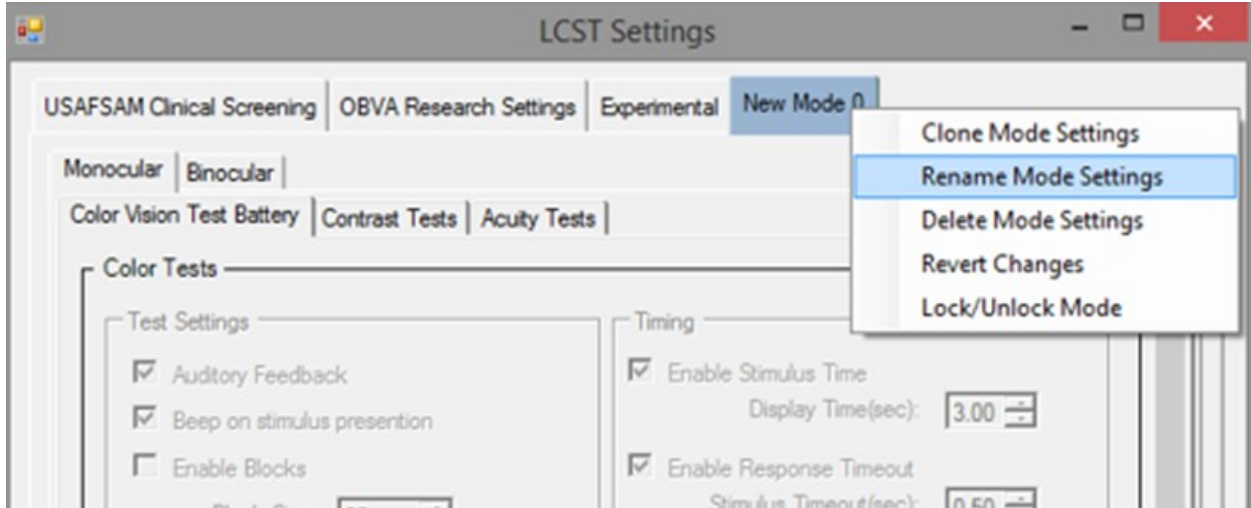


To rename this tab, click on the “New Mode 0” tab. The mode that you wish to rename MUST be the actively selected mode, which is indicated by a blue shading within the tab.

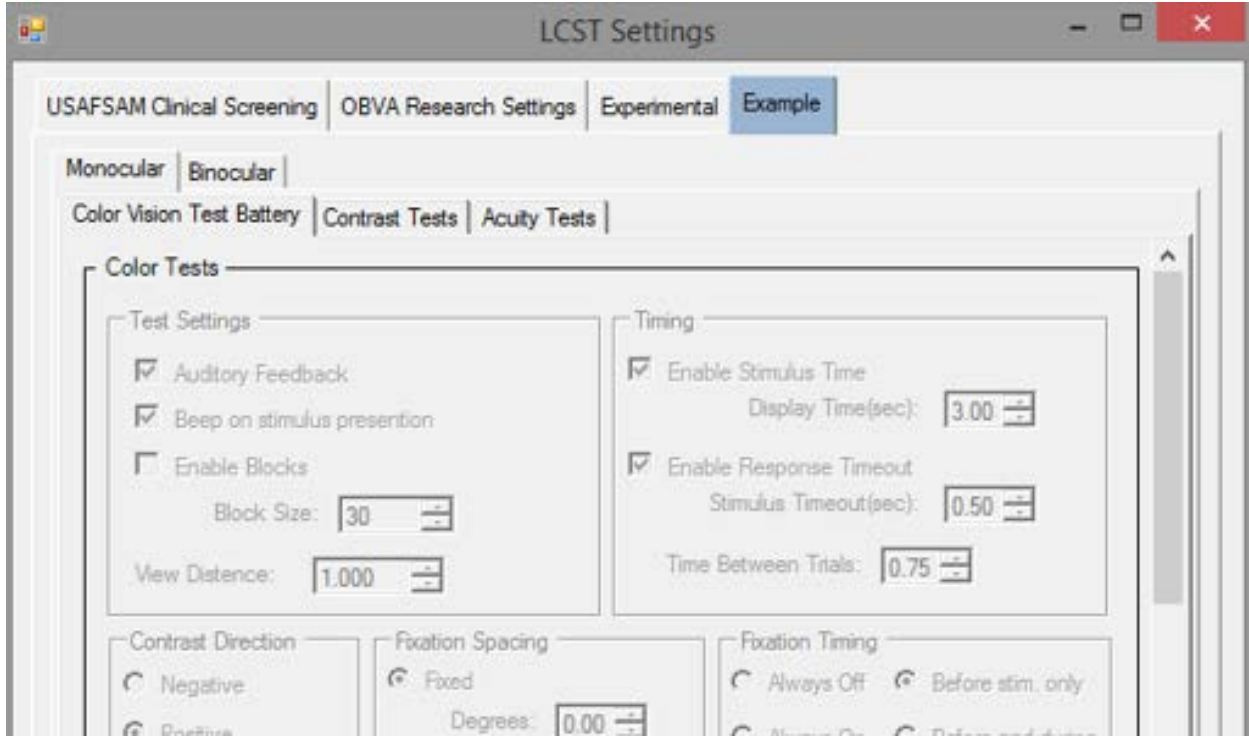
Once the mode you wish to rename is selected, right click directly on the mode tab and select “Rename Mode Settings.”

[Note: If the “Rename Mode Settings” option is grayed out and unable to be clicked on, you may need to click on “Lock/Unlock Mode” to unlock the mode for editing if the mode that you cloned was locked prior to cloning. If prompted for a password, enter “OBVA” (minus quotation marks and in all capitals).]

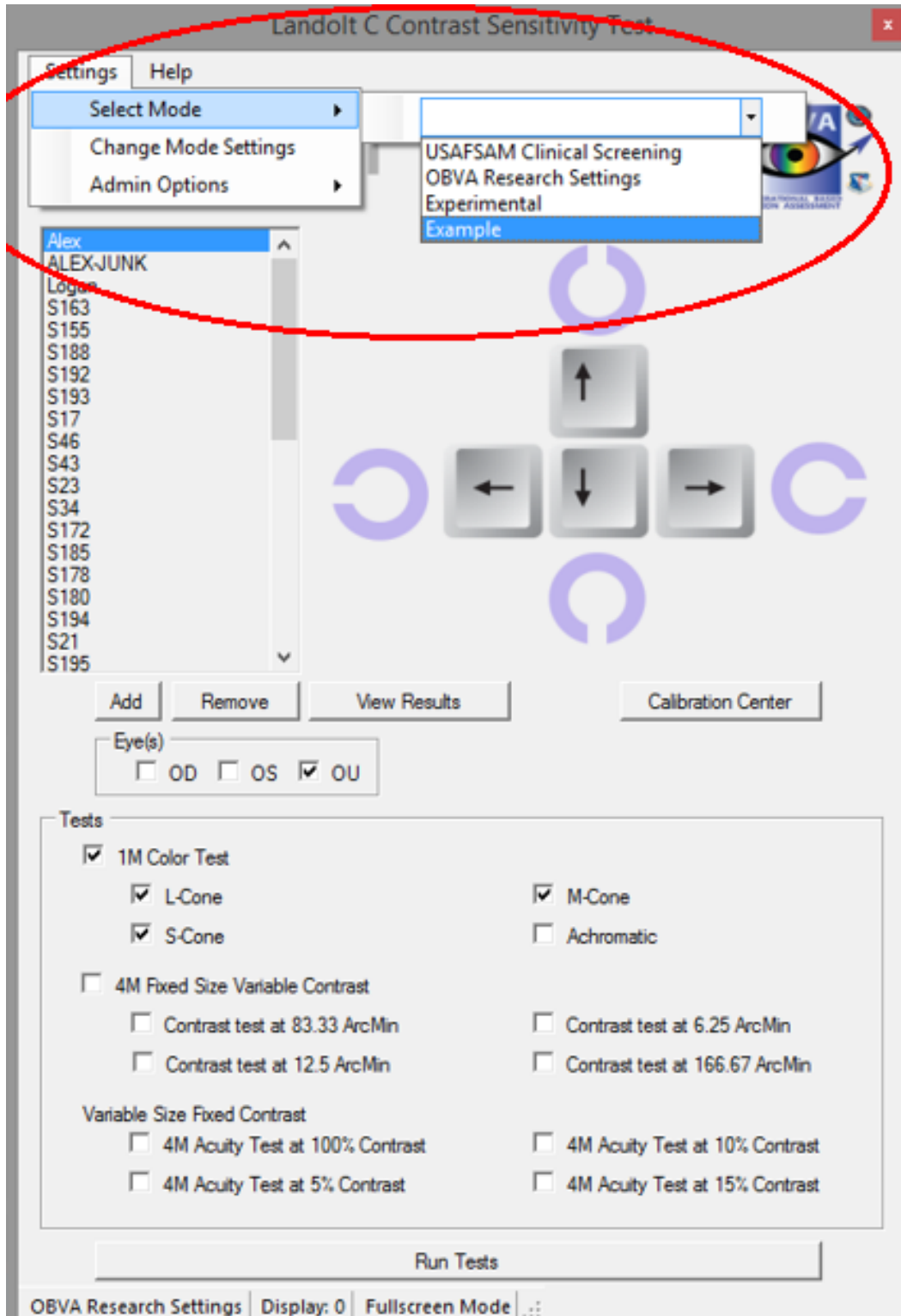
Enter the new name of your tab in the dialogue box and click “OK.”



As shown below, the settings interface has updated the tab with our new name.



If we go back to the main LCST GUI and click through the “Settings” tab, we can now see our newly created mode, as well as select it for use.



4.7 Color Vision Test Battery

When you click on the “Color Vision Test Battery” tab in the LCST Settings menu, you will see five subcategories of test options: “Color Tests,” “L-Cone,” “M-Cone,” “S-Cone,” and “Achromatic.” “Color Test” includes general settings for the color tests as a whole. The four remaining color subcategories contain options to control each color subtest, respectively. Because all options across color tests are identical, only one of them is described in the example below.

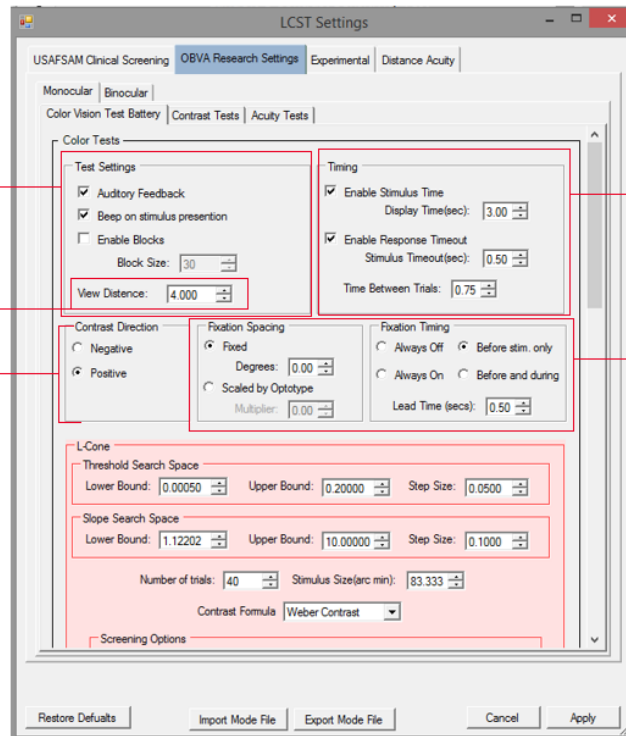
These settings control the physical features of the test such as auditory feedback and the presence or absence of blocks

This option allows you to change the distance that the experiment will be viewed from (in meters)

This setting allows you to choose whether to display positive or negative contrast in your experiment

These settings allow you to change the rate and duration of stimuli presentation

These settings allow you to alter or remove fixation cues before the stimuli are presented



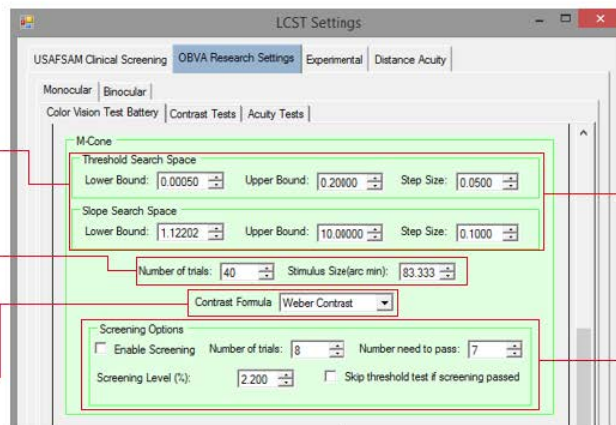
These options allow you to adjust parameters of the algorithm used to calculate threshold and stimuli presentation

Use these options to adjust number of trials in the subtest and size of the stimuli

Chose which algorithm is used to calculate contrast (note: you will almost always want this set to "Weber Contrast")

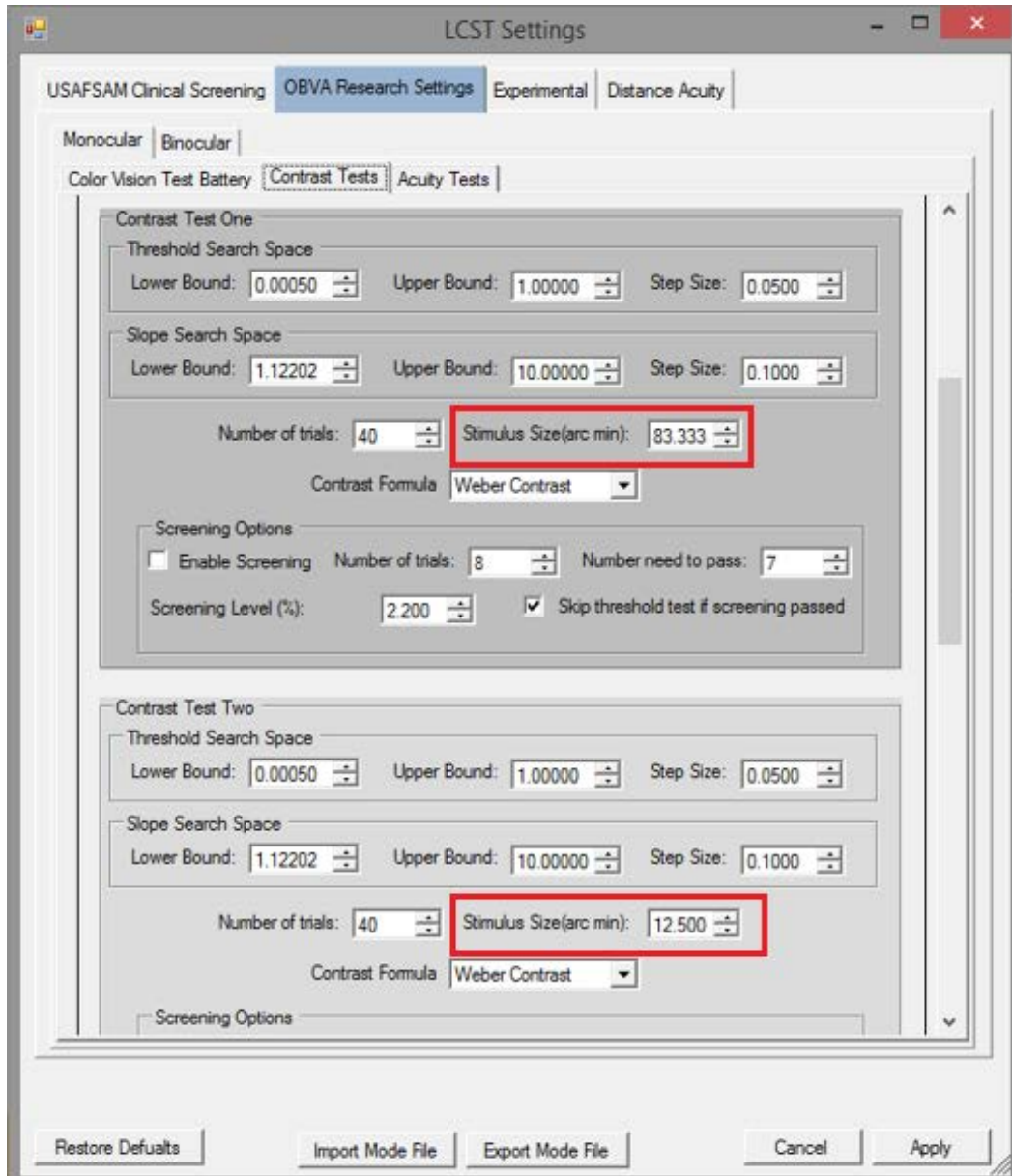
If the interstimulus interval seems unexpectedly long or variable, check the search space settings and consider using a smaller search space

If desired, these options allow you to enable a screening test that the participants must pass in order to move on to the actual experiment. Once enabled, you can adjust the parameters of the screening, such as number of trials and minimum passing threshold



4.8 Contrast Tests

Similar to the Color Vision Test Battery, the Contrast Tests settings menu contains options for general test parameters and the four contrast subtests. The menu options for Contrast Tests One and Two are shown below. Please refer to the Color Vision Test Battery section for more information on adjusting the general test parameters. Each of the four contrast subtests contains identical settings. By varying or holding constant certain parameters of the subtests, you can choose which independent variables you wish to test. For instance, in the example below, for each of the four subtests, we manipulated the stimulus size setting but kept all other parameters constant. As with the other tests, remember to click “Apply” to save any changes made to the test settings.



4.9 Acuity Tests

Unlike the previous two tests, the Acuity subtest settings each contain parameters for adjusting the general test settings, timing, contrast direction, fixation spacing, and fixation timing, as well as the ability to override the default test name. **It is important to note** that if the viewing distances are changed, the new distance will not appear in the GUI labels for the monocular tests. For OBVA research, most, if not all, vision tests will be administered binocularly. Thus, this minor bug/error is unlikely to be corrected in future updates.

The screenshot shows the 'LCST Settings' dialog box, specifically the 'OBVA Research Settings' tab. The 'Acuity Tests' sub-tab is selected. The dialog is divided into several sections:

- Test Name:** A checkbox for 'Override default test name' and a text field for 'Test Name'. A red box highlights this section with the annotation: "This setting allows you to override and change the name of the test displayed in the GUI".
- Test Settings:** Includes checkboxes for 'Auditory Feedback' (checked), 'Beep on stimulus presentation' (checked), and 'Enable Blocks' (unchecked). A 'Block Size' field is set to 30. A 'View Distance' field is set to 4,000. A red box highlights this section with the annotation: "General test settings".
- Timing:** Includes checkboxes for 'Enable Stimulus Time' (checked) with a 'Display Time(sec)' field set to 8.00, and 'Enable Response Timeout' (checked) with a 'Stimulus Timeout(sec)' field set to 0.50. A 'Time Between Trials' field is set to 0.75.
- Contrast Direction:** Radio buttons for 'Negative' (selected) and 'Positive'. A red box highlights the 'Force Max Contrast' checkbox, which is unchecked, with the annotation: "Check this box to set contrast to 100%".
- Fixation Spacing:** Radio buttons for 'Fixed' (selected) and 'Scaled by Optotype'. A 'Degrees' field is set to 0.00 and a 'Multiplier' field is set to 0.00.
- Fixation Timing:** Radio buttons for 'Always Off', 'Before stim. only' (selected), 'Always On', and 'Before and during'. A 'Lead Time (secs)' field is set to 0.50.
- Threshold Search Space:** Fields for 'Lower Bound' (75.00000), 'Upper Bound' (9000.000), and 'Step Size' (0.0500).
- Slope Search Space:** Fields for 'Lower Bound' (1.12202), 'Upper Bound' (10.00000), and 'Step Size' (0.1000).
- Number of trials:** Set to 40. **Stimulus Contrast(%):** Set to 5,000. **Contrast Formula:** Set to 'Weber Contrast'.
- Screening Options:** Includes a checkbox for 'Enable Screening' (unchecked), 'Number of trials' (8), 'Number need to pass' (7), 'Screening Level (arcmin)' (5,000), and a checked checkbox for 'Skip threshold test if screening passed'. A red box highlights this section with the annotation: "Enables and adjusts a pre-screening test".
- Threshold and Stimuli Calculations:** A red box highlights the 'Threshold Search Space' and 'Slope Search Space' sections with the annotation: "Changes the settings related to threshold and displayed stimuli calculations".

At the bottom of the dialog are buttons for 'Restore Defaults', 'Import Mode File', 'Export Mode File', 'Cancel', and 'Apply'.

5.0 KC-46 BATTERY SETUP

To access the KC-46 Test Battery, click on the “Launch Study” button in the KC-46 Test Battery box on the main AVT software screen. The menu below will appear when you launch the test battery.



Subject List

Click to add or remove subjects from the list

Opens a folder containing output data files

List of tests included in the battery. Click on the name of a test to launch that test.

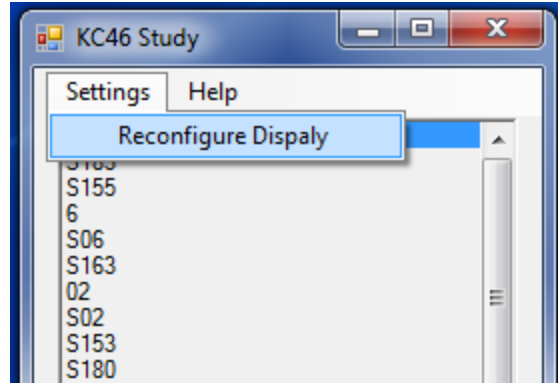
Clicking "Edit" next to a test will bring up a text document which specifies test parameters. It is here you can edit features of the test.

Clicking "P" next to the test name will begin a practice mode

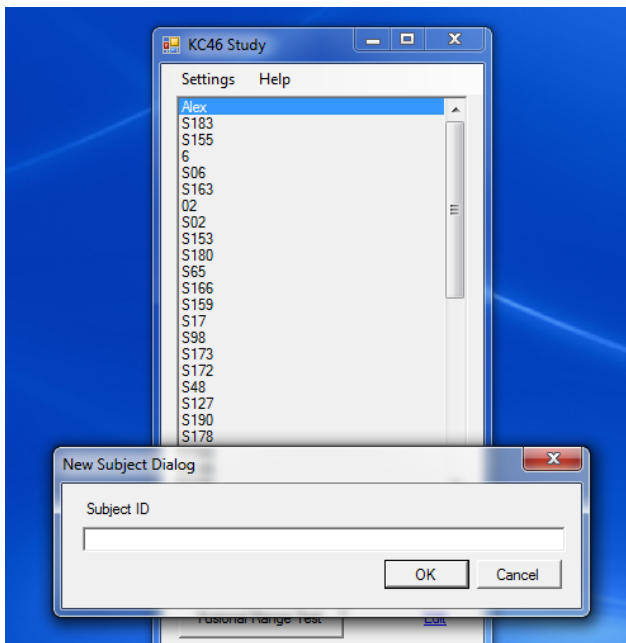
Test Name	Practice Mode (P)	Edit Link
Near Threshold Test	P	Edit
Fusional Range Test		Edit
Far Threshold Test	P	Edit
Stereo Tracking Test		Edit
Positional Tracking Test		Edit
Dual Ring Pedestal Test	P	Edit
Mental Rotation Test	P	Edit
3D Mental Rotation	P	Edit
Landolt C Speed Test	P	Edit

5.1 Configuring Display

If your screen needs to be configured or reconfigured at any time, you can do so by clicking on “Settings” and selecting “Reconfigure Display” from the pull-down menu. This will bring up the NVIDIA 3D Vision Display Setup screen. For more information on this, please refer to section 5.4 under the Dual Monitor Installation section.



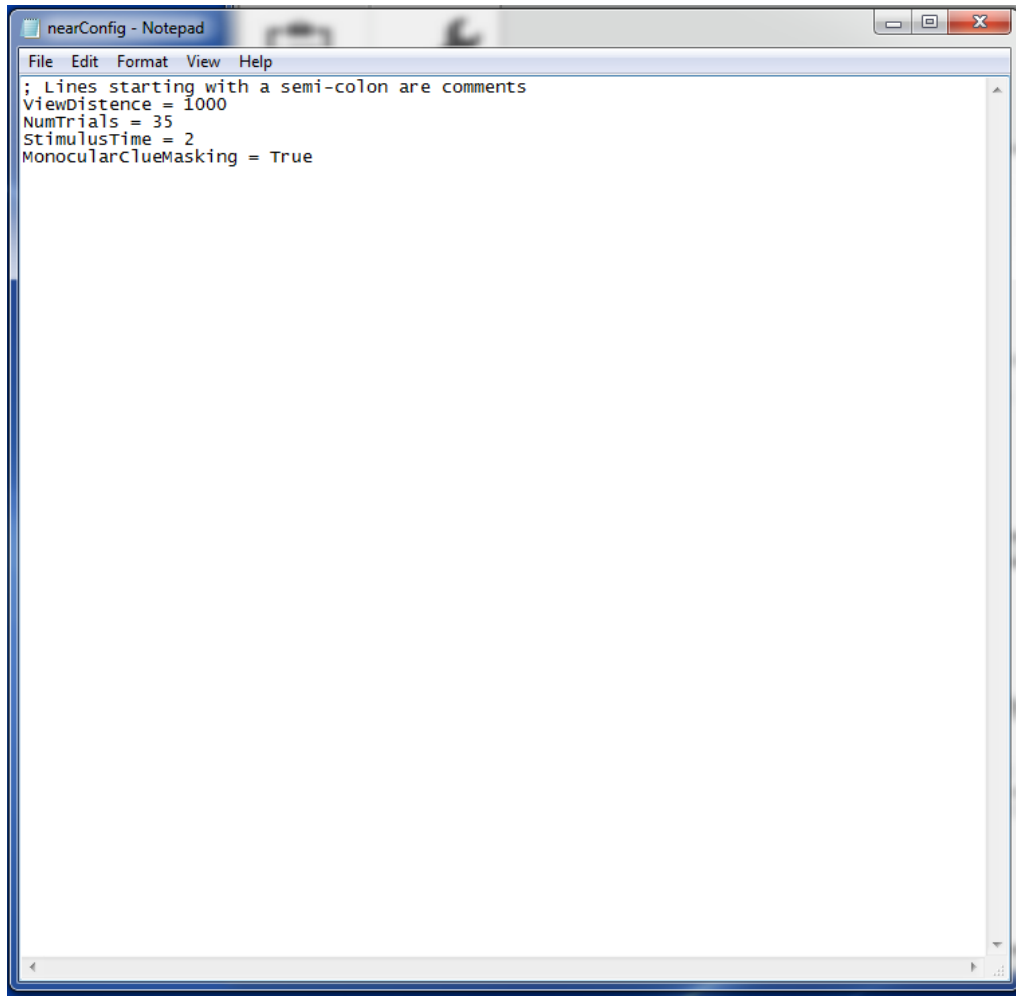
5.2 Adding or Removing Subjects



To add or remove subjects, simply click on either “Add” or “Remove” under the subject list. For example, clicking “Add” will bring up a dialogue box where you will be prompted to type the name or number of the subject you wish to add.

5.3 Editing Tests

To edit a test, click on the “Edit” button next to the test you wish to edit. A dialogue box will appear prompting you for a password. The password is “obva” (minus quotation marks). Correctly inserting the password will bring up a text file that contains a list of test parameters. After you have made the desired changes to the test, make sure to re-save the file to overwrite the test parameters with the new features you have chosen. Below is an example of the edit test file for the near stereo test.

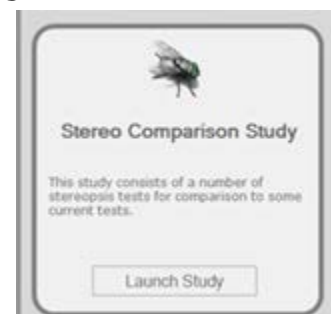


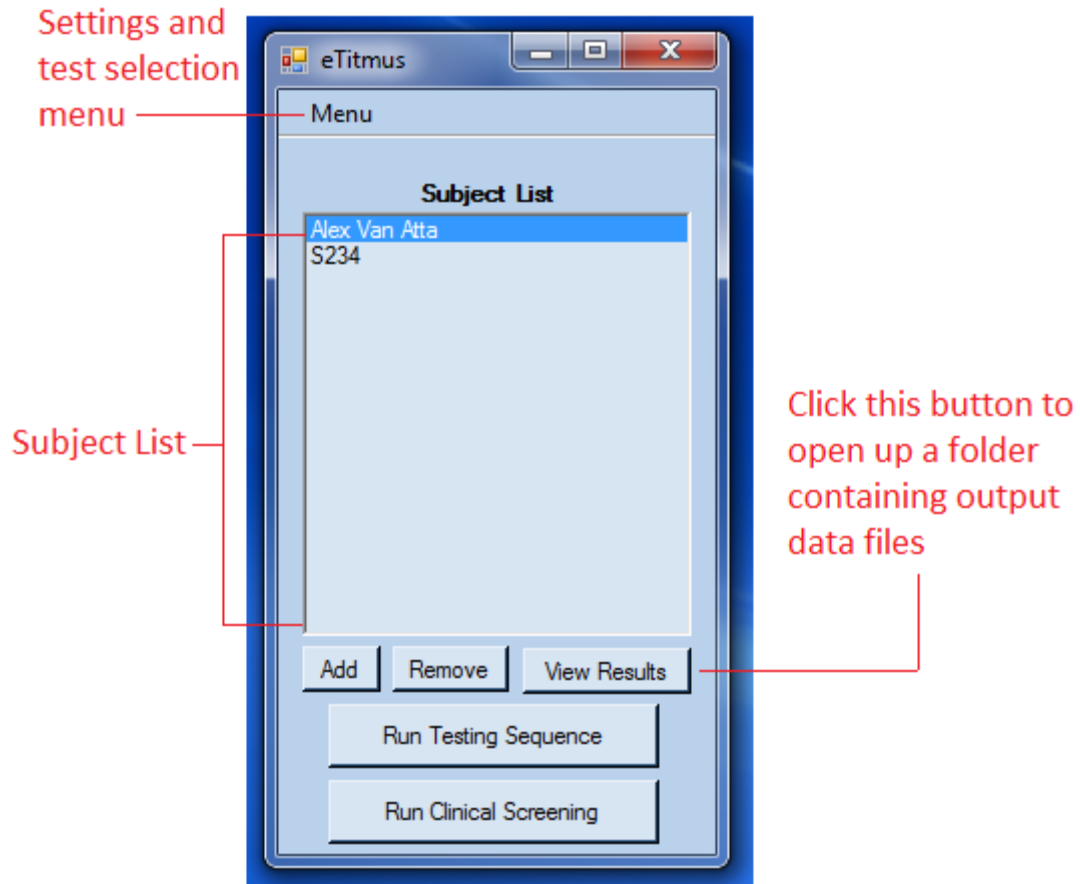
```
nearConfig - Notepad
File Edit Format View Help
; Lines starting with a semi-colon are comments
ViewDistance = 1000
NumTrials = 35
StimulusTime = 2
MonocularClueMasking = True
```

6.0 STEREO COMPARISON (aka eTitmus) TEST SETUP

6.1 Test Description

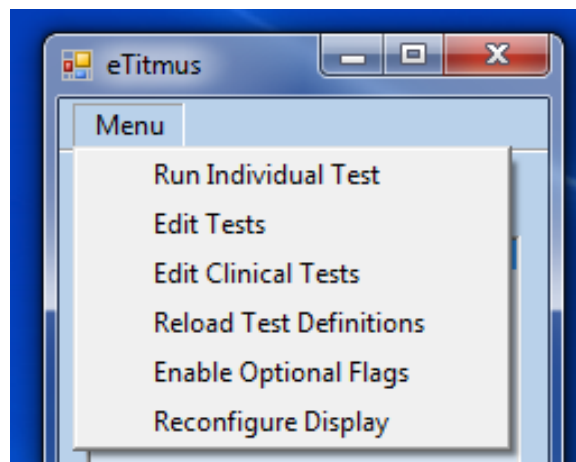
This test was designed to compare the results of the standard booklet circles test to an electronic version of that test. There are several modes included in the menu options described below. The “Clinical Screening” mode is most similar to the booklet test in that it is crossed-only disparity and is scored similar to the booklet – simply based on the total number correct. The disparity for each trial matches that of the booklet at the standard 14-inch viewing distance. The “Testing Sequence” has the same appearance, but uses Quest (Watson & Pelli, 1983) to estimate threshold stereo acuity. This test has three modes: 1) crossed-only disparity, 2) uncrossed-only disparity, and 3) crossed or uncrossed disparity, requiring two response entries – which circle, then direction of apparent depth. Note that these tests will run sequentially if the “Testing Sequence” button is selected. See 6.2 below for more test options. To access the eTitmus test, click on “Launch Study” under the Stereo Comparison Study box. The menu below will appear when you launch the stereo comparison study.



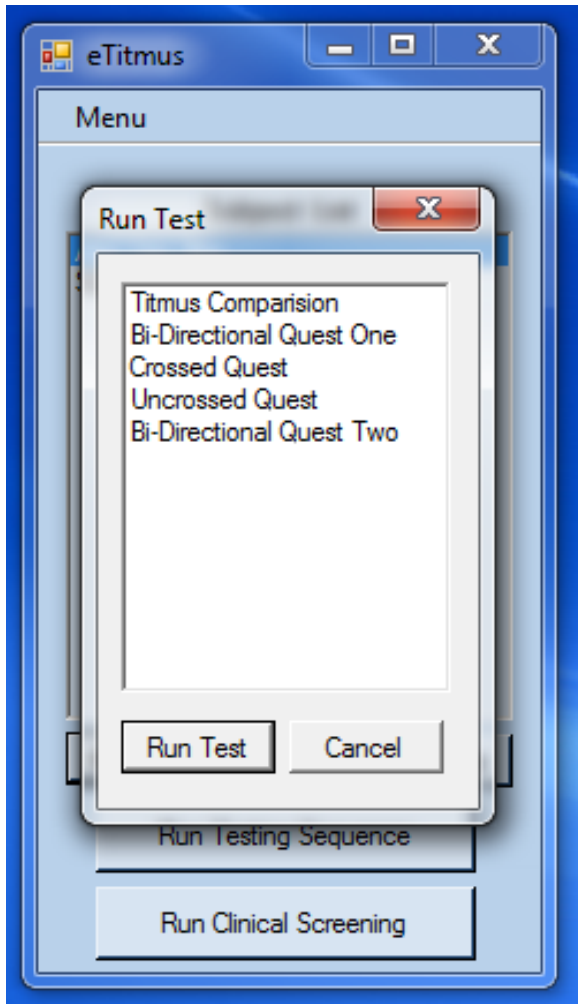


6.2 Menu Options

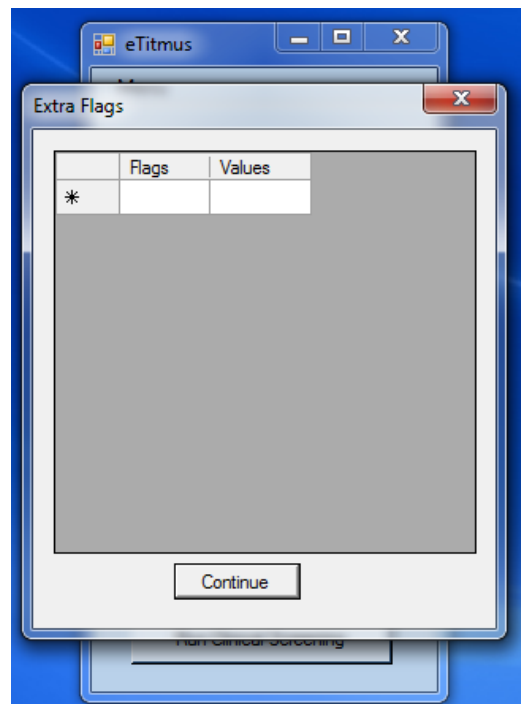
Click on the “Menu” tab on the top left corner of the eTitmus display to open up a drop-down list of options and settings.



Several features are worth noting here. “Run Individual Test” allows you to run a specific test in the eTitmus battery versus running through the entire program. The picture below illustrates the possible individual tests available to run.



Another useful feature is “Enable Optional Flags,” which allows you to append information, such as run number and condition, to output data file. When you click “Enable Optional Flags” in the pull-down menu, the following screen will appear to allow you to add additional information.



7.0 OBVA VISION TEST DESCRIPTIONS

The vision test battery described here was developed to support research concerning aircrew vision standards and screening. These tests support one of the objectives of the OBVA Laboratory, which is to establish quantitative relationships between clinical, or laboratory, tests of vision and operational aircrew performance. The test software itself was developed using Visual Basic (<http://msdn.microsoft.com/en-us/library/2x7h1hfk.aspx>), Matlab (www.mathworks.com), and Octave (<http://www.gnu.org/software/octave/>). However, only the executable applications will be released to international, industry, academic, and interservice collaborators. Thus, no software code is being released, only an executable version of the software. As described above, three different test batteries are enabled: 1) Stereo Comparison Study, 2) KC-46 Test Battery, and 3) Landolt C Contrast Sensitivity test. A fourth test battery, FECO/NAMRU Fatigue Study, is no longer in use and has been disabled. A description of each of the tests contained in each test battery follows.

7.1 Stereo Comparison Study

The eTitmus test is an electronic version of the Randot stereo test, in which subjects are shown an array of four circles and are asked to identify which of the four circles appears to be displaced in depth (i.e., nearer to them or farther from them). Experimenters have the choice of running the full test battery by selecting either “Run Testing Sequence” or “Run Clinical Screening.” Alternatively, an individual test can be selected from the pull-down menu (see section 6.2 above). Note that unlike the KC-46 near and far stereo acuity tests, the eTitmus test does not provide auditory feedback.

7.1.1 Titmus Comparison. For the Titmus comparison test, subjects will be instructed to use the keyboard arrows to indicate which of the four rings appears *nearer* to them than the others (i.e., popped out in depth, crossed-only disparity) (Figure 1).

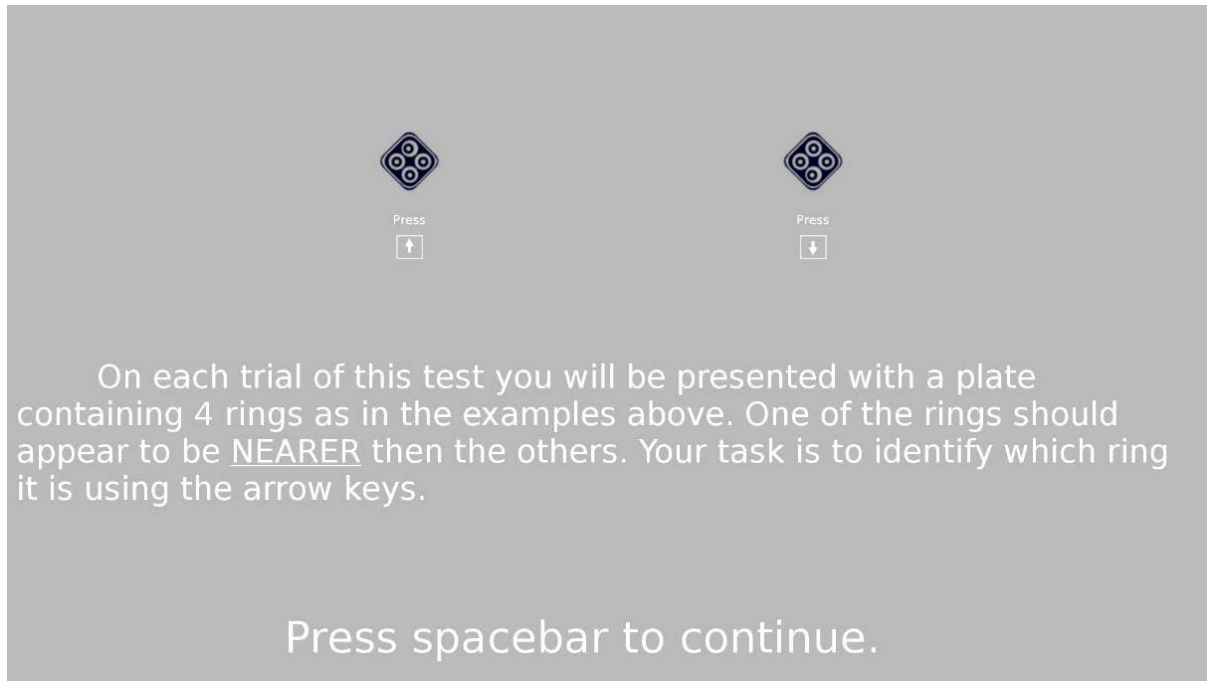


Figure 1. Individual Titmus comparison test instruction screen.

7.1.2 Bi-Directional Quest One and Two. For the bi-directional quest eTitmus test, subjects will be instructed to identify which of the four rings appears to be displaced in depth and whether that ring is nearer or farther to them by using the arrow keys to indicate the ring and then either the Ctrl key if the ring is nearer or the Shift key if the ring is farther. This two-button response is confusing for some subjects, so it is important to provide an opportunity for adequate practice before beginning data collection (Figure 2).

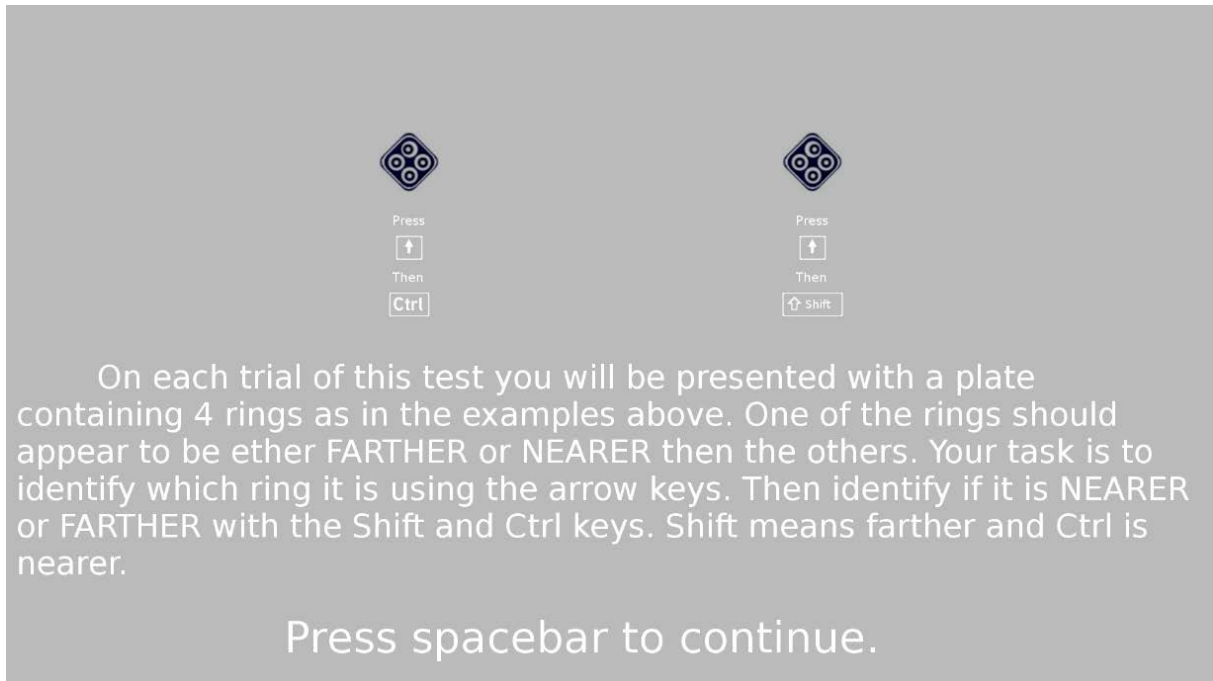


Figure 2. Individual bi-directional quest instruction screen.

7.1.3 Crossed Quest. For the Titmus crossed quest comparison test, subjects will be instructed to use the keyboard arrows to indicate which of the four rings appears *nearer* to them than the others (i.e., displaced in front of the screen, crossed-only disparity) (Figure 3).

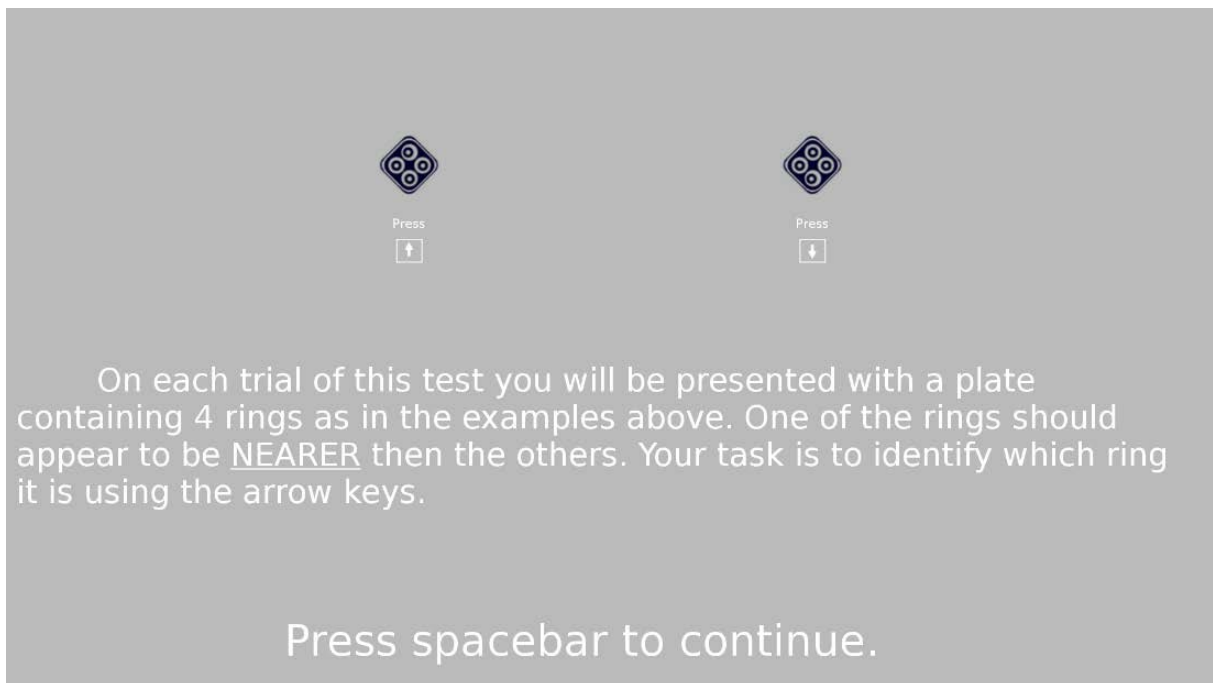


Figure 3. Individual crossed quest instruction screen.

7.1.4 Uncrossed Quest. For the Titmus uncrossed quest comparison test, subjects will be instructed to use the keyboard arrows to indicate which of the four rings appears *farther* to them than the others (i.e., displaced behind the screen, uncrossed-only disparity) (Figure 4).

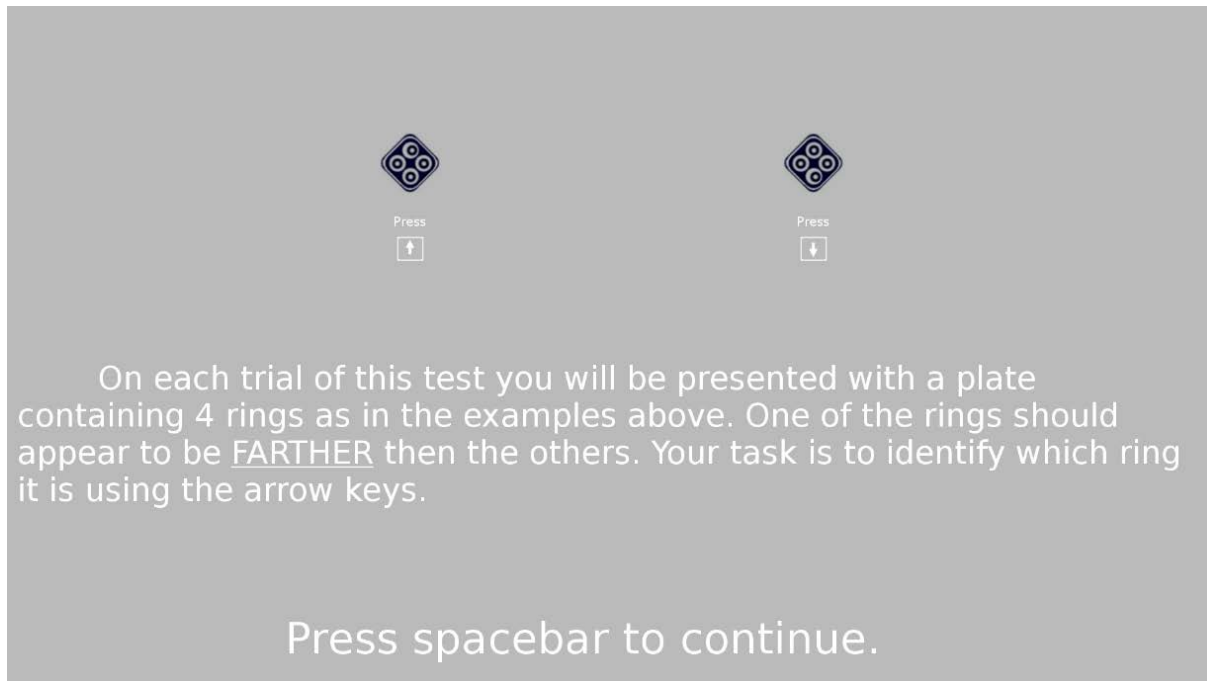


Figure 4. Individual uncrossed quest instruction screen.

7.2 KC-46 Test Battery

7.2.1 Near Stereo Acuity Test. This test involves depth discrimination of a center circle relative to a larger outer circle presented on a stereo display (Figure 5) for a near viewing distance (default distance is 1 meter). For this test, the circles are presented for 2 seconds. This test requires that the participant indicate whether the smaller inner circle appears to be in front of or behind the larger outer circle (see Figure 6) using buttons on a commercially available game pad (Figure 7). The duration that the circles are displayed (e.g., 2 seconds), number of trials, and viewing distance can be entered by the experimenter using a text file. The application determines the stereo disparity based on the correct and incorrect responses of the participant using adaptive procedures described in publicly available literature (Kingdom & Prins, 2010). The threshold disparity, or stereo acuity, is recorded and saved to a text file. Speakers or headphones should be used to enable auditory feedback. Correct responses are indicated using a positive/pleasant sound (“ding”), while incorrect responses are indicated using a negative/unpleasant sound (buzzer). This stereo acuity test is similar in concept to another computer-based stereo acuity test described in previous research (Bach, Schmitt, Kromeier, & Kommerell, 2001). Providing an opportunity to practice is recommended to achieve more stable results.

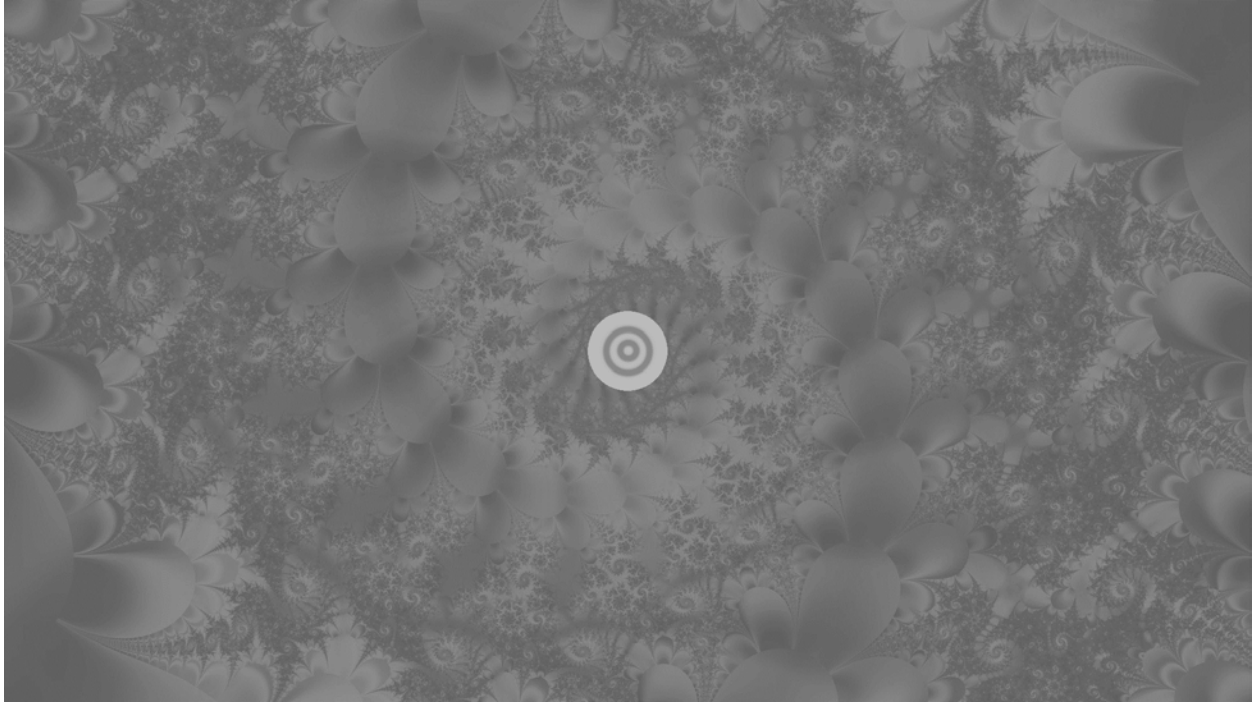


Figure 5. Near stereo acuity test stimulus.

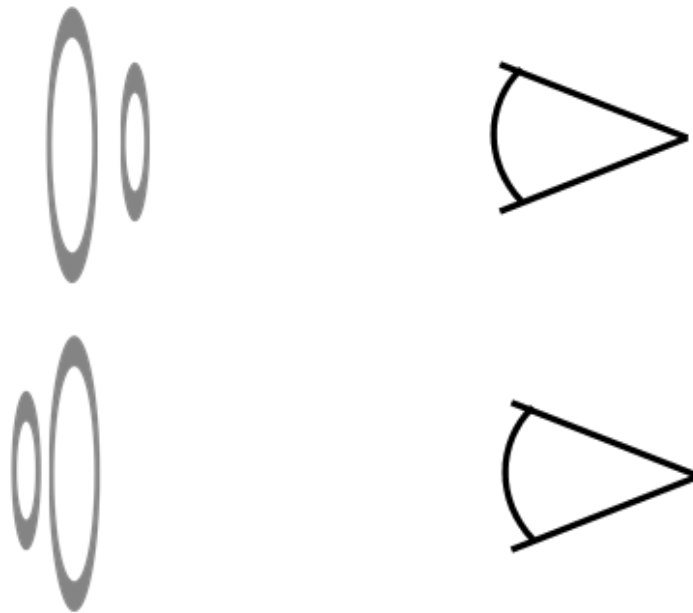


Figure 6. Perspective view of stereo acuity rings as viewed from the side. Top: small ring in front of larger ring – press green button. Bottom: Small ring behind – press yellow button.



Figure 7. Logitech game controller used to enter responses for vision tests.

7.2.2 Far Stereo Acuity Test. This test involves depth discrimination of a center circle relative to a larger outer circle presented on a stereo display (Figure 5) for a longer viewing distance (default distance is 4 meters). For this test, the circles are presented for 2 seconds. This task is the same as that described for the near stereo acuity test – the participant indicates whether the small inner circle appears to be in front of or behind the larger outer circle using the game controller. The duration that the circles are displayed (e.g., 2 seconds), number of trials, and viewing distance can be entered by the experimenter using a text file. The application determines the stereo disparity based on the correct and incorrect responses of the participant using adaptive procedures described in publicly available literature (Kingdom & Prins, 2010). The threshold disparity, or stereo acuity, is recorded and saved to a text file. Speakers or headphones should be used to enable auditory feedback. Correct responses are indicated using a positive/pleasant sound (“ding”), while incorrect responses are indicated using a negative/unpleasant sound (buzzer). This stereo acuity test is similar to another computer-based stereo acuity test described in previous research (Bach, Schmitt, Kromeier, & Kommerell, 2001). Providing an opportunity to practice is recommended to achieve more stable results.

7.2.3 Dynamic Stereo Acuity Tracking Test. This test also uses two circles similar to those shown in Figure 5. However, for this test, the inner circle oscillates in depth relative to the outer circle. This oscillation is created using a sum of sines. The amplitude and frequency of each sine wave can be modified by the experimenter by editing the values in the configuration text file (see instructions above). The task is to use a computer mouse to continuously cancel that motion in depth, or, in other words, keep the inner circle at the same perceived depth as the outer circle. To cancel the motion, participants will move the mouse forward to push the inner circle into the

display, or pull the mouse backwards to move the inner circle towards them, or out of the display. The duration of the task is 2 minutes. Prior to collecting data, participants should be allowed to practice until they understand the task and are familiar with the mouse's control of depth. During practice, feedback is provided in the form of a pointer that indicates deviation in depth relative to the reference circle (Figure 8). The test records the error in position of the inner circle relative to the outer circle for the duration of the trial. This error is recorded and saved to a text file every 50 milliseconds.

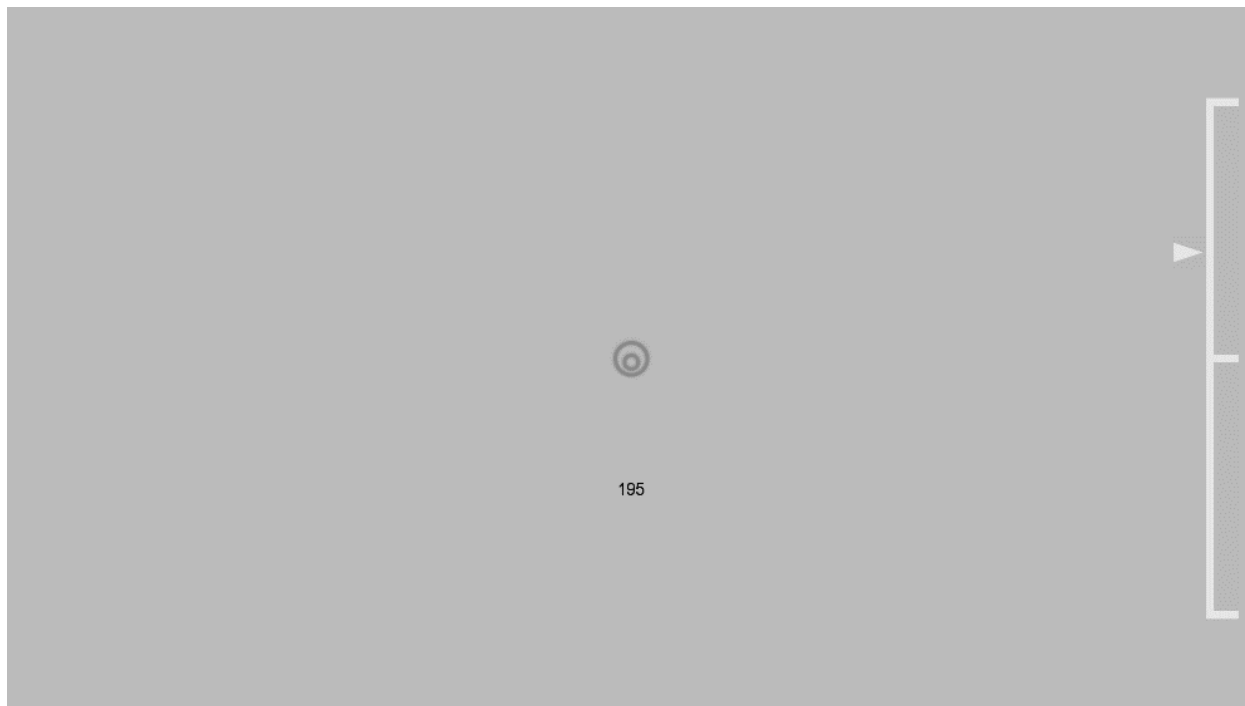


Figure 8. Feedback pointer used in the stereo acuity and positional tracking tasks.

7.2.4 Two-Dimensional (2D) Positional Tracking Test. This test also uses two circles similar to those in Figure 5. However, for this test, the inner circle moves up or down within the outer circle on a 2D plane. The task is to cancel out the vertical motion by using the mouse to keep the inner circle perfectly centered within the outer circle. The task duration is 2 minutes and participants should be allowed to practice prior to beginning the task. Figure 9 depicts various positions of the inner circle relative to the outer circle.



Figure 9. Examples of the positional tracking test in the up (right image), down (middle image), and correctly cancelled out center (left image) positions.

7.2.5 Vertical and Horizontal Fusion Range Test. This test uses the stereo monitor and 3D shutter glasses to present a pair of circles separately to the right and left eyes. At the start of a trial, the right and left eye circles will have identical positions at the center of the monitor and will appear as single circle (Figure 10). As the trial proceeds, the left and right circles will move in opposite directions, increasing the separation between them. For small separations, participants may continue to see a single “fused” image. However, as the separation increases, the single fused image will break, and the circles will appear doubled or “diplopic.” Participants should be instructed to press the green button on the game pad as soon as the circles appear to become doubled. The separation between the left and right eye images will then begin to decrease as the left and right circles reverse direction and begin to come back together. Instruct participants to press the green button when they again see a single fused circle. This test will be repeated several times to estimate fusion range. The test will be repeated for several directions of separation between the circles: horizontal crossed, horizontal uncrossed, and vertical (right eye up, and right eye down). Participants should try to adjust the position of their eyes (i.e., crossing/uncrossing their eyes) to maintain a single fused image to the best of their ability. The application records the amount of separation between the left and right eye images and saves that information to a text file for each trial. Examples of vertical and horizontal stimuli can be seen in Figures 11 and 12, respectively. The speed of separation and number of repeated trials can be edited by the experimenter in the configuration text file (see instructions above).

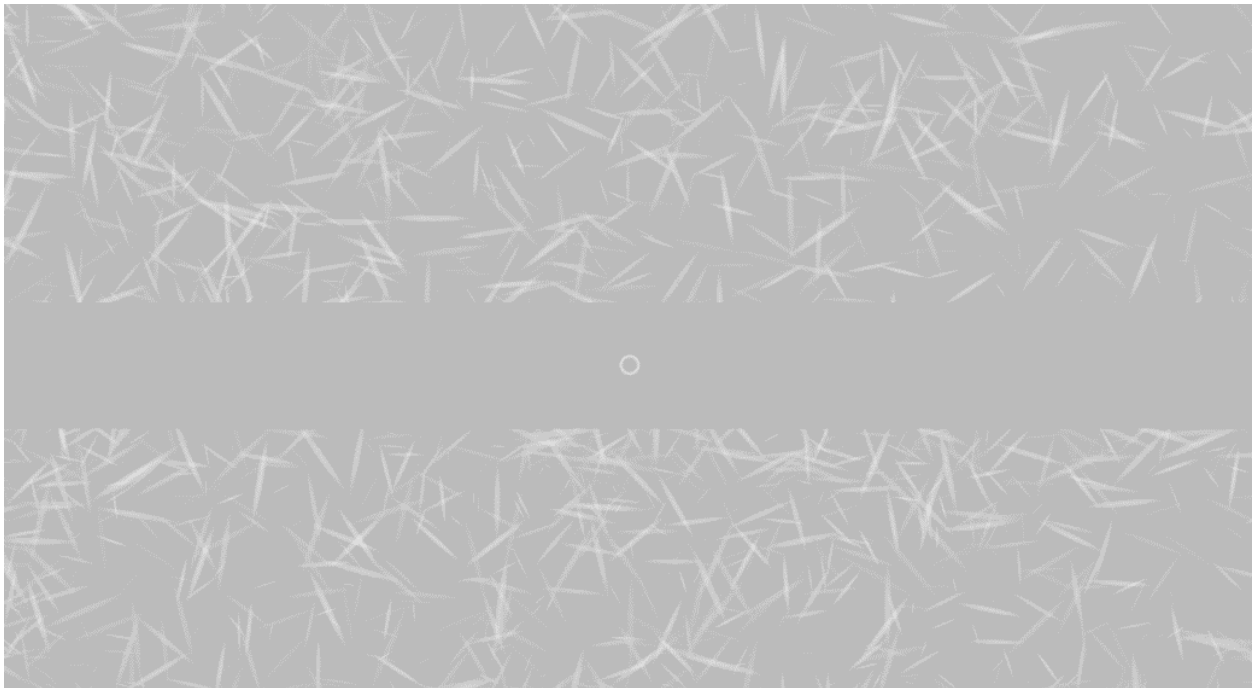


Figure 10. Single “fused” circle.



Figure 11. Vertical fusion range stimuli (showing both left and right eye images).



Figure 12. Horizontal fusion range stimuli (showing both left and right eye images).

7.3 LCST Test Battery

The LCST test battery consists of color, contrast, and acuity tests. For these tests, a Landolt C is presented on the display with the gap in the C at four possible positions: left, right, top, or bottom. The participant's task is to identify the gap location using the keyboard arrows to respond. Across trials, the Landolt C may appear red, green, or blue (during the color test), white/gray (during the contrast test), or black (during the acuity test). Figure 13 shows an example of the size reticle and Landolt C at a high and a low contrast. Examples of the stimuli used in the color test can be seen in Figure 14. The colors red, green, and blue (r, g, and b) are selected to isolate the three cones for individuals with normal color vision (i.e., test the function of the red, green, and blue, or long, medium, and short wavelength receptors). Additionally, the size is varied across trials for the contrast and acuity Landolt C tests, while remaining constant for the color test. The size of the r, g, and b Landolt C is 50 arc minutes. The white/gray and black Landolt C set has three sizes: 50, 12.5, and 6.25 arc minutes. The size of the Landolt C will scale based on the viewing distance selected in the test options described above. The contrast of the Landolt C is varied according to an adaptive procedure (Kingdom & Prins, 2010). The participant's accuracy in identifying the Landolt C orientation as contrast varies is recorded by the application and stored as a text file. Speakers or headphones should be used to enable auditory feedback. Correct responses are indicated using a positive/pleasant sound ("ding"), while incorrect responses are indicated using a negative/unpleasant sound (buzzer).

The design of this test is based on the current U.S. Air Force standard color test, the Rabin Cone Contrast Test, which has been described in previous publications (Rabin, 1996; Rabin, Gooch, & Ivan, 2011). The new color test, or OBVA cone contrast test, has been updated to use a more sophisticated adaptive procedure and an improved color calibration process. The design of the new test is described in more detail in another report (Gaska, Winterbottom, & van Atta, 2016).

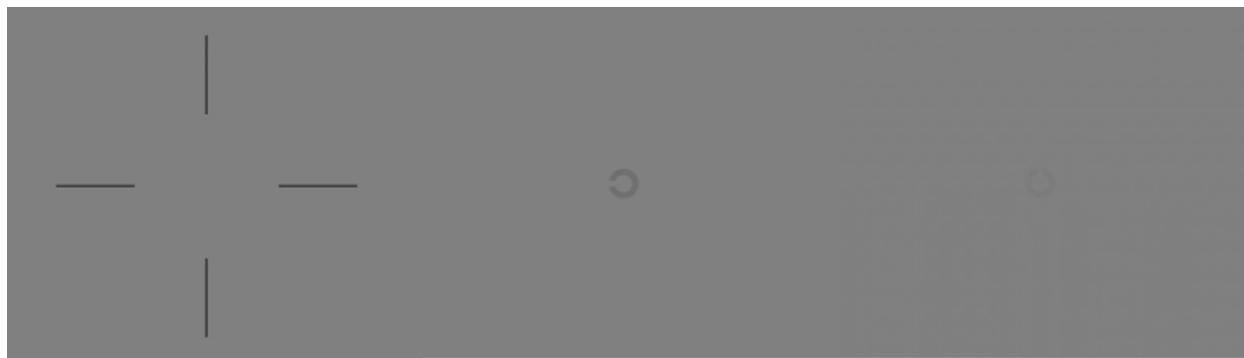


Figure 13. An example of the size reticle (left). Landolt C with the gap positioned on the left and high contrast (center). Landolt C with upward orientation and low contrast (right).

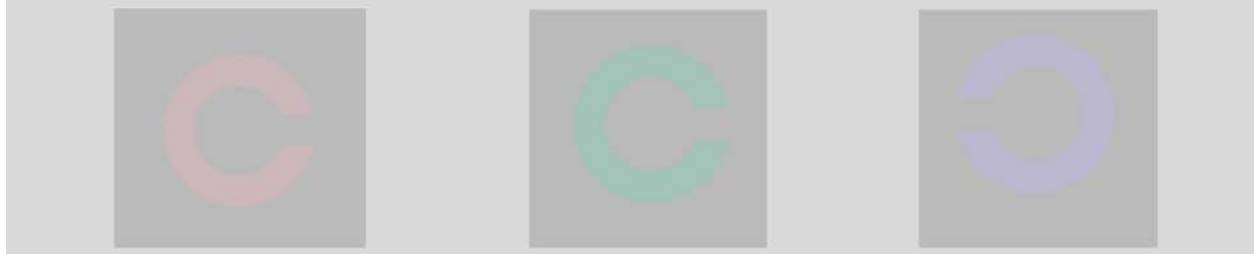


Figure 14. Landolt C stimuli used in the OBVA cone contrast test.

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LIST OF ABBREVIATIONS AND ACRONYMS

2D	two-dimensional
3D	three-dimensional
AVT	automated vision test
GUI	graphical user interface
LCST	Landolt Contrast Sensitivity Test
OBVA	Operational Based Vision Assessment