**CogToolbox - version 2.3 (08.22.14)**

MATLAB functions from the Cognitive Division at the University of Illinois.

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**I.** *Introduction*

The CogToolbox is a set of functions for [MATLAB](http://www.mathworks.com/) and [Psychophysics Toolbox 3](http://www.psychtoolbox.org) for cognitive psychology experiments.

The toolbox includes some standard cognitive tasks such as cued and free recall tasks, self-paced reading, visual world eye-tracking, Likert scale questionnaires, and reading span and other working memory tasks. There are also functions for more general tasks such as selecting and verifying participant numbers, taking a screenshot of the experiment, and getting a keyboard or mouse response within a specific window of time.

Most of these functions were just written in the course of assembling our own experiments. So, they might not include particular functionality that you want or need for your own experiments. But, they may help you out, and you can always modify them for your own purposes!

Functions in the CogToolbox were written by Scott Fraundorf, Michael Diaz, [Jason Finley](http://www.jasonfinley.com), [Molly Lewis](http://langcog.stanford.edu/people.html#Molly), [Kristen Tooley](https://webapp.psych.txstate.edu/directory/facultydetails.php?faculty=k_t76), Angie Isaacs, Tuan Lam, [Alison Trude](https://sites.google.com/site/alisontrude/home), [Sarah Brown-Schmidt](http://sarahbrownschmidt.com/), and Laurel Brehm.

**II.** *Installing the Cog Toolbox*

Installation instructions for current versions of MATLAB:

1. Download and install [Psychophysics Toolbox 3](http://www.psychtoolbox.org/PsychtoolboxDownload) for MATLAB if you don’t already have it.
2. Put the toolbox folder somewhere on your computer. (Many of the functions in the toolbox require other functions in the toolbox, so it is important to copy the *entire* folder.)
3. In MATLAB, go to the **Home** tab.
4. In the **Environment** block of that tab, choose **Set Path...**
5. Click **Add with Subfolders** and then select the toolbox folder. This adds all of the subfolders to MATLAB. You should see them all listed in the Set Path window. (If you just click *Add Folder* and not *Add with Subfolders*, MATLAB will not see all the subfolders.)
6. Click **Save** and then **Close**.
7. ???
8. Profit!

If you don’t have a Home tab and an Environment block, you have an older version of MATLAB. Here are slightly different instructions that will work just fine for those versions:

1. Download and install [Psychophysics Toolbox 3](http://www.psychtoolbox.org/PsychtoolboxDownload) for MATLAB if you don’t already have it.
2. Put the toolbox folder somewhere on your computer. (Many of the functions in the toolbox require other functions in the toolbox, so it is important to copy the *entire* folder.)
3. In MATLAB, pull down the **File** menu and choose **Set Path...**
4. Click **Add with Subfolders** and then select the toolbox folder. This adds all of the subfolders to MATLAB. You should see them all listed in the Set Path window. (If you just click *Add Folder* and not *Add with Subfolders*, MATLAB will not see all the subfolders.)
5. Click **Save** and then **Close**.

Many of the functions in the CogToolbox rely on functions in the Psychophysics Toolbox 3 (Brainard, 1997; Kleiner, Brainard, & Pelli, 2007; Pelli, 1997). **The CogToolbox will not work if you don't already have MATLAB and the Psychophysics Toolbox 3**.

**III.** *Contents of the Toolbox*

For an exact description of how to use any of the functions, type **help functionname** in MATLAB, except replace **functionname** with the name of one of the functions. (e.g. **help makeValidPath**)

***Distractor Tasks***

|  |  |  |
| --- | --- | --- |
| AdditionDistractorTask | Presents 2-digit addition problems for a specified duration. | MD |
| DivisionDistractorTask | Presents 2-digit division problems for a specified duration. | MD |
| MathDistractorTask | Presents 2-digit addition *and* subtraction problems (mixed) for a specified duration. | MD |
| Multiplication DistractorTask | Presents 2-digit multiplication problems for a specified duration. | MD |
| Subtraction DistractorTask | Presents 2-digit subtraction problems for a specified duration. | MD |

***File Reading and Saving***

|  |  |  |
| --- | --- | --- |
| BWtoRGB | Converts a black-and-white or grayscale image to RGB format. (This doesn't colorize the image; it just changes the format so you can do color-related operations on it.) | SHF |
| changeFolder | Updates MATLAB’s active directory to the directory where the current script is. | SHF |
| csvToStruct | Opens a comma-separated spreadsheet with a set of named columns and converts it to a struct … slowly | SHF |
| dualfprintf | Prints using fprintf both to the MATLAB Command Window and to a file | SHF |
| getSubjectNumber | Gets a valid subject number from the experimenter and verifies it hasn't already been used. Optionally, can also rotate subjects through a set of lists. | SHF |
| imageToTexture | Loads an image from a file and puts it in a new texture. | SHF |
| loadimage | Loads an image from a file and puts it in a new offscreen window. This window can then be quickly copied to another using PTB's Screen(“CopyWindow”) function | SHF |
| makeValidPath | Ensures that a path is a properly formatted folder name, and creates that folder if needed. | SHF |
| openValidFile | Repeatedly prompts the user for a filename until a valid file is opened | SHF |
| picturetester | Displays a folder of pictures one at a time to make sure they look good in your experiment. | SHF |
| save\_triang | Saves the upper- or lower-triangular part of a matrix | SHF |
| Screenshot | Takes a screenshot of the current experiment display and save it in a file that you can use to demonstrate your experiment. | SHF |
| textFileToCellArray | Reads a text file into a cell array, with each line as one entry in the cell array. Optionally, can read just a limited # of lines. | SHF |

***Keyboard and Mouse***

|  |  |  |
| --- | --- | --- |
| allKbNames | Display the numerical code corresponding to each keyboard key. For use in programming only. | MD |
| getKeys | Waits for the user to press a key and determines what key was pressed. Unlike PTB functions, this ignores keys already been held down. Optionally, can end after a maximum time has elapsed with no keypress. | MD,  SHF |
| Wait4Key | Waits for the user to press one of a *particular* set of a keys and returns the RT and key pressed. | MD |
| Wait4KeyTimed | Same as Wait4Key, but can force the user to respond with a particular time limit. | SHF |
| Wait4Mouse | Waits for the user to click one of a particular set of regions on the screen. Returns RT and area clicked. | MD |
| Wait4MouseTimed | Same as Wait4Mouse but with a time limit. | SHF |

***List Creation***

|  |  |  |
| --- | --- | --- |
| listmaker | Creates sets of experimental lists using Latin Square designs. Can include multiple factors and filler trials. | SHF |
| makeLagList | Creates a presentation list for an experiment in which the stimuli vary in lag between 1st and 2nd presentation. Can also include non-repeated stimuli. | MD,  SHF |

***Math and Matrices***

|  |  |  |
| --- | --- | --- |
| containsDuplicates | Tests if any value is repeated more than one in a matrix. | SHF |
| countValue | Counts how many times a specified value appears in a matrix. | TQL, SHF |
| fitROC | Fits an ROC curve to some data. | MD |
| horizshift | Shifts elements horizontally within each row of a matrix. | SHF |
| hourmin | Returns a nicely formatted version of the current time (optionally, with seconds) | SHF |
| InscribeCircle | Finds the x, y coordinates for a point inscribed in a given circle. | MD |
| iseven | Determines whether a given number is an even integer | SHF |
| IsInBounds | Determines whether a particular point would be within the bounds of a N-dimensional matrix. | SHF |
| isodd | Determines whether a given number is an odd integer. | SHF |
| modrz | Performs modular division (remainder of X divided by Y), but replaces outputsof 0 with Y. | SHF |
| nth | Performs a given function, and returns the Nth element of the result of that function | SHF |
| RaggedCellArrayToMatrix | Converts a cell array of vectors, which may be of uneven length, into a matrix. | SHF |
| randorder | Puts the elements of a vector in random order. | SHF |
| repelem | Creates a vector with each element repeated a certain number of times. | SHF |
| reversescore | Reverse score a Likert scale response. | SHF |
| reversevector | Puts the elements of a vector in reverse order | SHF |

***Matlab Demos***

|  |  |  |
| --- | --- | --- |
| CenterOnScreen | Demo of how to make your own functions in Matlab. | SHF, ML, KT |
| graphicsdemo | Demo of how to do graphics in Psychophysics Toolbox. | SHF, ML, KT |
| InstructionsScreenDemo | Demo of how to use the InstructionsScreen function. | SHF |
| matlabbasics | Demo of how to do basic operations and run an experiment in Matlab. | SHF, ML, KT |
| RSVP | Demo of stimulus display, in the context of a simple rapid serial visual presentation task. | SHF, ML, KT |
| selfpaced | Demo of stimulus display and user response, in the context of a simple self-paced reading task. | SHF, ML, KT |
| sounddemo | Demo of how to play & record sound in Psychophysics Toolbox. | SHF, ML, KT |
| visualworld | Skeleton of a visual world eye-tracking experiment that provides accurate timing measurements and flicker-free picture display and movement. It has to be filled in with the details of your experiment … it does not run on its own. | SHF, SBS, AT, AMI |

***Memory Tests and Scoring***

|  |  |  |
| --- | --- | --- |
| freerecall | Performs a free recall test. Allows for a particular minimum and maximum number of responses. Can return the words recalled and RTs, or save them to a file. | JRF,  SHF |
| FreeRecallScore | Scores the data from a free recall test against a list of targets. Allows the user to decide how to score particular intrusions, misspellings, etc. | SHF |
| GetEchoStringCuedT4 | Prompts the subject to enter a word and returns the word & time taken. Optionally, a cue may be specified for cued recall. | JRF,  SHF |
| lenientcompare | Calculates a score from 0-100 of how similar two strings are; can be used to score recall data that might contain misspellings, etc. | JRF |
| lenientcompareset | Uses lenientcompare to compare one string to a SET of possible matches and find the best match. | SHF |

***Perceptual Speed Tests***

|  |  |  |
| --- | --- | --- |
| LetterComparison | Task in which participant must make speeded judgments as to whether sets of consonants are identical or not. | SHF |
| LetterSetCreate | Used internally by LetterComparison only. | SHF |
| PatternComparison | Task in which participant must make speeded judgments as to whether line patterns are identical or not. | SHF |
| PatternCreate | Used internally by PatternComparison only. | SHF |

***Prefab Screens & Tests***

|  |  |  |
| --- | --- | --- |
| AdjustVolume | Screen to allow users to adjust the volume before an experiment. | SHF |
| antisaccade | Antisaccade task in which participants must saccade in the opposite direction of a peripheral cue. | SHF |
| colordemo | Demo what various colors look like on this monitor. | SHF |
| doIndividualDifferences | Used internally by IndividualDifferences.m only | SHF |
| flanker | Classic flanker task. | SHF |
| IndividualDifferences | Runs a battery of individual differences measures. | SHF |
| InitExperiment | Start an experiment by defining colors and pixel size, and seeding random number generator. | MD |
| InstructionsScreen | Displays an instruction screen with the specified text. Forces the subject to spend time reading the instructions before they can advance. | SHF |
| shipleyvocab | 40 item forced-choice vocab test. Auto-scored. | SHF |
| Stroop | Short Stroop test with 2 blocked conditions: reading words, and then color naming. Automatically paced. | SBS, AT, SHF |
| StroopRT | Long Stroop test with 2 blocked conditions: naming colors of patches and words. Paced by participants, collects RT. | SBS, AT, SHF |
| vocab | Administers a multiple-choice vocabulary test. Test items not included. | SHF |

***Pseudowords***

|  |  |  |
| --- | --- | --- |
| gupta | Pseudoword repetition task from Gupta (2003) | LB, SHF |

***Questionnaires***

|  |  |  |
| --- | --- | --- |
| BinaryQuestion | Asks a question with 2 choices. | AMI |
| Likert | Asks a Likert scale question with a varying number of response options. | AMI, ML, SF |
| OpenResponseQuestion | Asks a question with free response by participant. | AMI |
| Questionnaire | Asks 2 basic demographics question: hometown & languages spoken. | AMI |
| YesNoQuestion | Asks a yes/no question. | AMI |

***Reading***

|  |  |  |
| --- | --- | --- |
| compQ | Asks a reading comprehension question. | SHF |
| movingwindow | Performs a self-paced moving window reading task on a sentence. | SHF, KT |
| movingwindowQ | Do a moving window item followed by a comprehension question. | SHF |
| movingwindowTester | Tests the screen layout of moving window items by displaying the entire item on the screen at once. | SHF |
| ResidReading | Calculate residual reading times from the output of movingwindow. | SHF |

***Shape Drawing***

|  |  |  |
| --- | --- | --- |
| CenterInRect | Returns the coordinates that would center a shape within a given region. | SHF |
| DrawArrow | Draws an arrow from one point to another. | SHF |
| DrawLineAnimated | Draw a line incrementally. | SHF |
| FilledPoly | Draws a polygon filled with a color. | SHF |
| FilledRect | Draws a rectangle filled with a color. | MD |
| FilledRectWText | Draws a colored rectangle and writes text in it. | MD |
| FramedRect | Draws the outline of a rectangle. | MD |
| FramedRectWText | Draws the outline of a rectangle and writes text in it. | MD |
| makeRadialGrid | Draws circles evenly arranged radially around the center of the screen. | TQL |
| snapToBorder | Snaps an image to the border of a larger region. | SHF |

***String and Text Processing***

|  |  |  |
| --- | --- | --- |
| analyzeMarkupCode | Reads an HTML-style markup code and determines what code it is. | SHF |
| asPercent | Converts a proportion to a percent. | SHF |
| divideSentenceInTwo | Splits a string in half so that each half has an equal number of *words*. | SHF |
| doubleToSingleSpacing | Converts double- and triple-spacing to single-spacing. | SHF |
| extractNumbers | Extracts all the numbers from a string of text. | SHF |
| extractTextFromLines | Given a cell array of lines of text, can extract a string that may span multiple lines. | SHF |
| findInCellMatrix | Searches a cell array for a particular string, and returns a matrix indicating the location of all the matches. | SHF |
| findUtteranceStart | Within a block of text, finds where a particular sentence started. | SHF |
| getClosingTag | Determines the closing tag for a markup tag. | SHF |
| getNextComplete Sentence | Reads the next complete sentence from an open file. | SHF |
| initialsCapsOnly | Capitalizes the first letter of every word in a string, and puts everything else in lowercase. | SHF |
| makeTextWidth | Adds space or truncates a string to make it fit a particular width. | SHF |
| matchesInStringSet | Compares a string (or set of strings) to a cell array of strings and determines where a match is. | SHF |
| num2strLZ | Converts a number to a string and adds leading zeros to force it to be a particular length. | SHF |
| parseNumberList | Allows you to create a vector by describing it in a string, e.g. "1-3,5" -> [1 2 3 5] | SHF |
| randTokens | Takes in a string that contains tokens separated by spaces and returns string that randomizes the order of the tokens (e.g., “This is a sentence” could return “is This sentence a”) | TQL |
| stripLeadingCharacter | Removes any instances of a particular character at the start of a string. | SHF |
| stripManyStrings | Removes several different substrings from a given string. | SHF |
| stripPunctuation | Removes all punctuation from a string. | SHF |
| stripString | Removes all cases of a substring from a string. | SHF |
| stripStringNum | Removes a portion of a string defined by its numerical starting and ending point. | SHF |
| strrepMany | Within a string, makes multiple replacements of different substrings with other substrings. | SHF |
| strrepNum | Replaces part of a string with something different, defined (unlike strtok) by numerical position. | SHF |
| strtokMultiple | Completely divides a string into multiple tokens, based on a delimiter. | SHF |
| wordCount | Counts the number of words in a string. | SHF |

***Text Display***

|  |  |  |
| --- | --- | --- |
| File2Screen | Prints the contents of a text file to the screen. | MD |
| optimalTextSize | For a moving window experiment, finds the largest text size that allows every sentence in the experiment to fit on one line. | SHF |
| WriteCentered | Writes text on the screen, centered at a particular point. Now runs onto multiple lines if needed. | MD,  SHF |
| WriteLeft | Write left-aligned text on the screen. | MD |
| WriteLine | Write text on the screen, with word wrap. Includes options for paragraph breaks, double-spacing, and various font effects (e.g. boldface, italics, highlighting certain words in color). | MD,  SHF |
| WriteRight | Write right-aligned text on the screen. | MD |

***Text Input***

|  |  |  |
| --- | --- | --- |
| GetEchoStringDisplay | Get text from the user, and display it as they're typing. Unlike PTB-3's GetEchoString, this can preserve what's *already* on the screen when you call the function. | SHF |
| GetEchoStringFreeResponse | Asks a free response question to the participant | SHF |
| inputnumber | Has the Matlab user enter a number within a particular minimum and maximum. | SHF |
| inputstring | Forces the Matlab user to enter a non-empty string. | SHF |
| inputyn | Gets an answer to a yes/no question from the Matlab user. | SHF |

***Window and Monitor Management***

|  |  |  |
| --- | --- | --- |
| CreateOffWin | Open a new offscreen window and set its font and color properties. | MD |
| GetRefresh | Returns your monitor's refresh rate. | SHF |
| monitorsize | Calculates the physical dimensions of your monitor. | SHF |
| pixels2visangle | Converts a measure of pixels from center to visual angle. | SHF |
| visangle2pixels | Converts a measure of visual angle to pixels from center. | SHF |
| visangle2width | Converts a measure of visual angle to physical distance. | SHF |
| width2visangle | Converts a measure of physical distance to visual angle | SHF |

***Working Memory Tasks***

|  |  |  |
| --- | --- | --- |
| alphabetspan | Subject must recall words in alphabetical order. | SHF |
| listeningspan | Listen to sentences, make true/false judgments, and recall the last word from each sentence. | SHF |
| lspan | Listen to sentences, make true/false judgments, and recall intervening letters. | SHF |
| minus2span | Recall a set of numbers in order while subtracting 2 from each | SHF |
| ospan | Judge the answers to arithmetic equations and recall intervening letters. | SHF |
| readingspan | Read sentences aloud, make judgments, and recall the last word from each sentence. | SHF |
| rspan | Read sentences aloud, make judgments, and recall intervening letters. | SHF |
| wmbattery | Administers the alphabetspan, listeningspan, minus2span, and readingspan tasks. Automated scoring. | SHF |

**IV.** *What’s New in This Version (Changelog)*

Version 2.3—08.22.14

Updated functions:

* selfpaced.m: Fixed a bug that could prevent this demo from running.

Version 2.2—02.22.14

New functions:

* makeRadialGrid
* randTokens
* Added license information
* Added troubleshooting

Version 2.1—08.25.12

New functions:

* None in this update.

Updated functions:

* BWtoRGB, loadImage: Improved handling of grayscale images.

Version 2.0—08.25.12

New functions:

* None in this update.

Updated functions:

* AdditionDistractorTask: Properly clear the screen during the interstimulus interval. Function now detects the existing screen and font size if not specified. Fixed an error in the help text about how to set the ISI. Improved stimulus timing.
* alphabetspan: Clarified instructions on how to enter the DONE response. Improved stimulus timing.
* antisaccade: Improved stimulus timing.
* compQ: Updated exit key to F3, which doesn’t conflict with any of the audio controls on a Mac. Improved stimulus timing.
* DivisionDistractorTask: Properly clear the screen during the interstimulus interval. Function now detects the existing screen and font size if not specified. Fixed an error in the help text about how to set the ISI. Improved stimulus timing.
* emailResults: Display a warning message if the email fails to send.
* ERVT: Improved stimulus timing.
* flanker: Improved stimulus timing.
* GetEchoStringDisplay: Corrected a problem where a changed text size or font wasn't reflected in the initial display. Made the function more efficient.
* graphicsdemo: Added some demonstrations of TIMING the screen flips and using font manipulations in WriteLine, as well as some additional comments to further explain things
* Gupta: Improved stimulus timing.
* initialCapsOnly: Fixed a crash that occurred if the string was just one letter long.
* LetterComparison: Improved stimulus timing.
* lenientcompare: Improved efficiency.
* Likert: Added an option to restrict the display to just part of the screen.
* listeningspan: Clarified instructions on how to enter the DONE response. Improved stimulus timing.
* lspan: Fixed a bug where not all TOO SLOW trials were counted as incorrect. Improved stimulus timing.
* MathDistractorTask: Properly clear the screen during the interstimulus interval. Function now detects the existing screen and font size if not specified. Fixed an error in the help text about how to set the ISI. Improved stimulus timing.
* matlabbasics: Added demos of keyboard responses, test for inequality, and some other things. Added more comments with further explanation.
* minus2span: Clarified instructions on how to enter the DONE response. Improved stimulus timing.
* movingwindow: Added options to keep the text on the screen after the end of the trial and/or to return the ending position of the last word. Improved stimulus timing.
* movingwindowQ: Updated exit key to F3, which doesn’t conflict with any of the audio controls on a Mac. Properly handle trials where the exit key was pressed.
* MultiplicationDistractorTask: Properly clear the screen during the interstimulus interval. Function now detects the existing screen and font size if not specified. Fixed an error in the help text about how to set the ISI. Improved stimulus timing.
* openValidFile: Made the more function efficient, and more compatible with newer version of MATLAB.
* ospan: Fixed a bug where not all TOO SLOW trials were counted as incorrect. Improved stimulus timing.
* PatternComparison: Improved stimulus timing.
* picturetester: Improved efficiency.
* Questionnaire: Improved efficiency.
* readingspan: Fixed a bug that kept the nag message from appearing if the participant pressed the same key too many times in a row. Clarified instructions on how to enter the DONE response. Improved stimulus timing
* rspan: Fixed a bug where not all TOO SLOW trials were counted as incorrect. Improved stimulus timing.
* rsvp: Demonstrated getting the timing information directly from Screen('Flip') for more accurate timing.
* selfpaced: Demonstrated how to more accurately measure RTs by getting the time from Screen('Flip'). Updated exit key to F3, which doesn’t conflict with any of the audio controls on a Mac. Added additional explanatory comments.
* shipleyvocab: Improved stimulus timing.
* sounddemo: Added some demonstrations of how to start a sound at a particular future time point.
* Stroop: Allowed more time to record the participant’s response to the last item in a block. Improved stimulus timing.
* StroopRT: Allowed more time to record the participant’s response to the last item in a block. Improved stimulus timing.
* SubtractionDistractorTask: Properly clear the screen during the interstimulus interval. Function now detects the existing screen and font size if not specified. Fixed an error in the help text about how to set the ISI. Improved stimulus timing.
* textFileToCellArray: Improved error handling.
* WriteLine: Added the ability to list a set of words to highlight in color (as per the old WriteLineHighlight). Always returns the ending position on the screen of the text, even if there was no text to display.

Older updates not listed here.

**V.** *License*

The CogToolbox is made available under the [MIT license](http://opensource.org/licenses/MIT):

Copyright (c) 2014 Scott Fraundorf, Michael Diaz, Jason Finley, Molly Lewis, Kristen Tooley, Tuan Lam, Angie Isaacs, Alison Trude, Sarah Brown-Schmidt, and Laurel Brehm

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**VI.** *Troubleshooting*

**Q. It doesn't work / The computer crashes when I get to a particular part of my experiment / MATLAB says a particular function isn't found.**

**A.** My experience is that the vast majority of errors with the CogToolbox stem from not having everything fully installed. First, make sure you've installed the [Psychophysics Toolbox 3](http://www.psychtoolbox.org/PsychtoolboxDownload); it's required to use the CogToolbox! Then, make sure you've set up the entire CogToolbox following the instructions above. Trying to copy and use a single function from the CogToolbox on its own probably won't work; many of those individual functions rely on other functions in the CogToolbox and won't work in isolation.

**VII.** *Citing the Toolbox*

If you use the CogToolbox in your research, a citation is always appreciated! You can cite the CogToolbox instruction manual:

* Fraundorf, S. H., Diaz, M. I., Finley, J. R., Lewis, M. L., Tooley, K. M., Isaacs, A. M., Lam, T. Q., Trude, A. M., Brown-Schmidt, S., & Brehm, L. (2014). CogToolbox for MATLAB [computer software]. Retrieved from http://www.scottfraundorf.com/cogtoolbox.html

The CogToolbox relies on Psychophysics Toolbox 3, so *please also cite your use of the Psychophysics Toolbox*. As of this writing, the [instructions for citing the Psychophysics Toolbox](http://www.psychtoolbox.org/PsychtoolboxCredits) include the following citations:

* Brainard, D. H. (1997). The Psychophysics Toolbox. Spatial Vision, 10, 433-436.
* Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. Spatial Vision, 10, 437-442.
* Kleiner, M., Brainard, D., & Pelli, D., (2007). What's new in Psychtoolbox-3? Perception 36 ECVP Abstract Supplement.