Visual Acuity: Lesson 1

This **step-by-step** tutorial teaches you how to build and run your first experimental design for measuring visual acuity. More specifically, you will learn how to:

1) create the hierarchical structure of a basic experiment using the Method/Procedure/Stimulus design paradigm,
2) customize the events,
3) use variables to connect procedural and stimulus events,
4) run the experiment,
5) and inspect & visualize the results.

After this lesson, you will be able to create many real psychophysical experiments that relies on the staircase method and a discrimination procedure.

Difficulty: 3/5
Duration: 30 mn to 1 h.

BASIC TASK

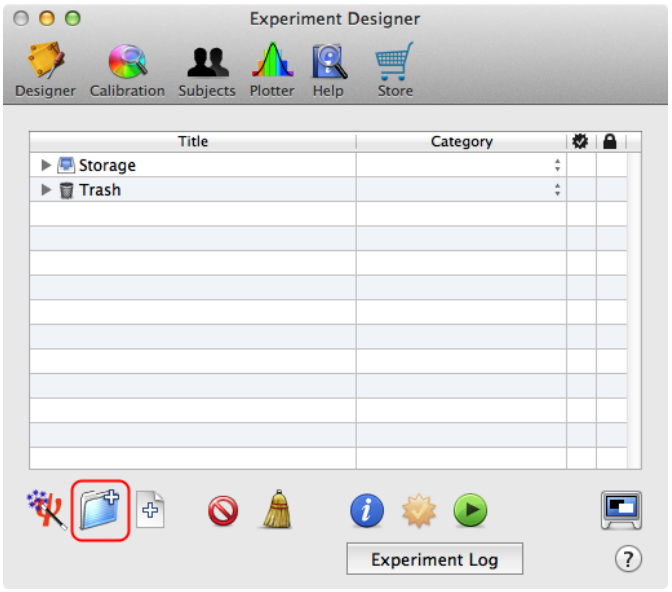
The aim of this experiment is to measure visual acuity using Sloan optotypes. While one could use bitmap images of these optotypes, one could also use a Sloan font. Such a font is available from Denis Pelli's software web page (http://psych.nyu.edu/pelli/software.html). To install it on your Mac, download version 2 of the font (Sloan.otf at http://psych.nyu.edu/pelli/docs/Sloan.otf.zip), unzip it, double-click on the **otf** file to open it using the Mac OS X **Font Book** application, and click on the ***Install Font*** button. The font will then be available to every application running on your system (Psykinematix included).

Step 1: Opening the "Designer" Panel

Launch Psykinematix, and select the **Designer** panel by clicking on its icon in the toolbar.

Step 2: Adding an Experiment Event

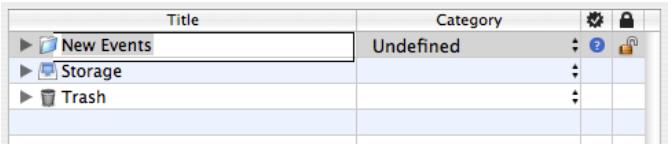
The **Experiment Designer** panel presents a hierarchical view of the experiments. Before going further, make sure to deselect any event by clicking on an empty row or ⌘-clicking on the selected event to deselect it.



Now, create a new **group** event by clicking on the folder icon with the '**+**' symbol in the bottom toolbar.

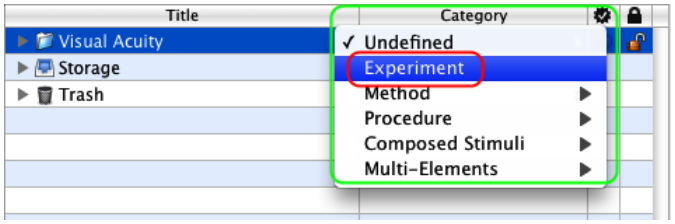
***Tip**: A group event embeds one or several other events. This allows to create the hierarchy of the design structure.*

The new event appears at the top in the table with a default title (***New Events***). Change its title to ***Visual Acuity*** to reflect the experiment purpose (double-click on the title to edit it).



Note the two last columns of the designer table: the right-most one indicates the lock status of the event (either unlocked or locked to protect it from changes) and the 2nd right-most column shows the event status (for example, a question mark or a warning sign would indicate that the event function and properties are still undefined, while a check mark would indicate the event is fully specified).

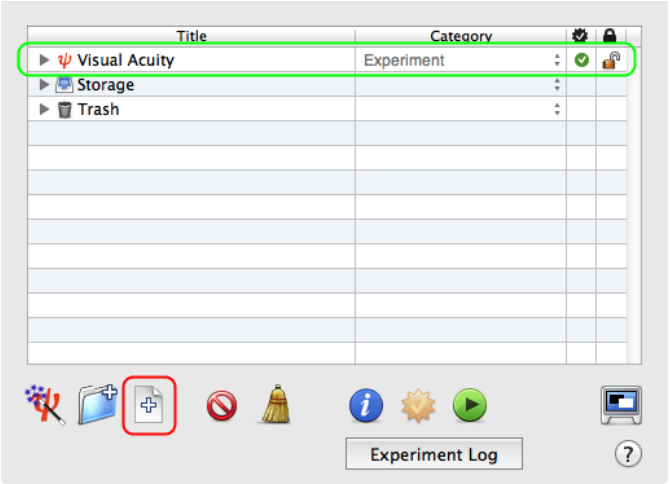
Each event is characterized by a category that defines its function inside your experimental design. To change the default category (**Undefined**), use the pop-up menu to select the **Experiment** entry. Note how the small icon in front of the event changed from a small folder to a small red **psi** icon specific to the **Experiment** event.



***Tips**:*
Each category of events has its own small icon to depict its function.
The Undefined category with the folder icon can be used to group several experiments under one roof (eg: all experiments related to the same study).

Step 3: Adding the Optotype Stimuli

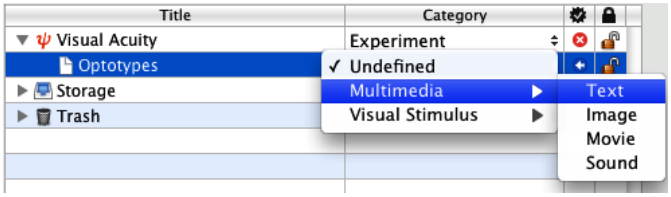
Select the **Experiment** event you just created (***Visual Acuity***), and add a new **leaf** event by clicking on the file icon with the '**+**' symbol in the bottom toolbar.



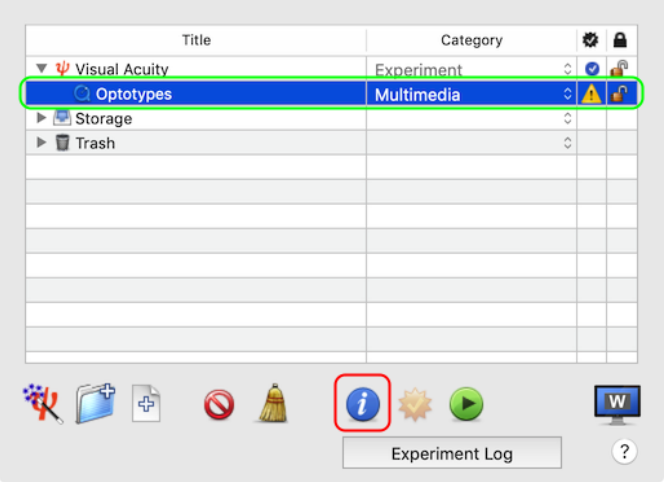
***Tip**: As atomic events, leaf events do not embed other events hence the absence of the small arrow in front of their descriptive mini-icon.*

Change its title to ***Optotypes***.

Change its category to **Multimedia** with the **Text** sub-category as illustrated.



Note the warning sign in its status column: this indicates the event properties are still unspecified. To change this, click on the ***Optotypes*** event to select it and then on the **Inspector** button (or press the ⌘**-i** keystroke) to access the properties of this **Multimedia Text** event.



Step 4: Customizing the Visual Stimulus

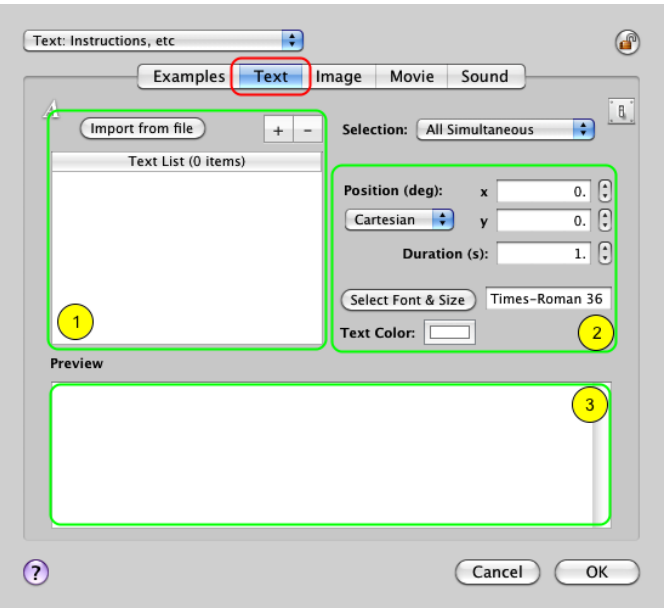
In the properties panel, control-click on the **Text** tab to select the Text Stimulus if it is not yet selected.

The properties panel for the **Multimedia Text** event consists of three sections:

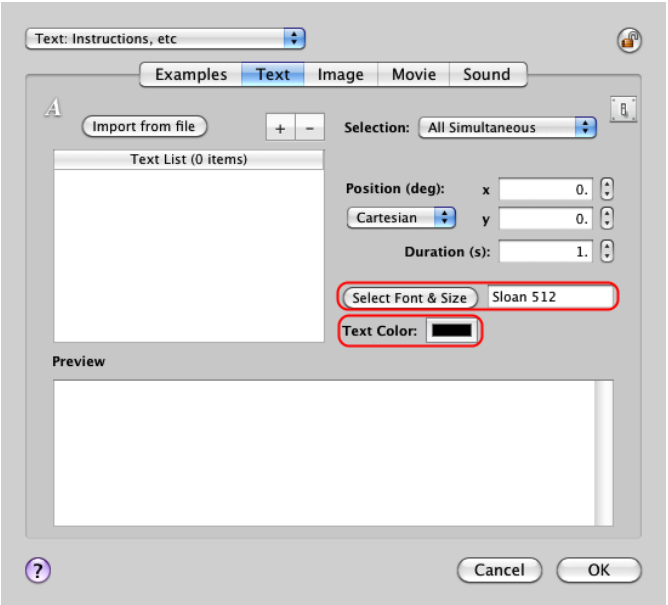
1) a top left section that specifies the content of each line of text,

2) a top right section that specifies the position, duration, and appearance of each line of text,

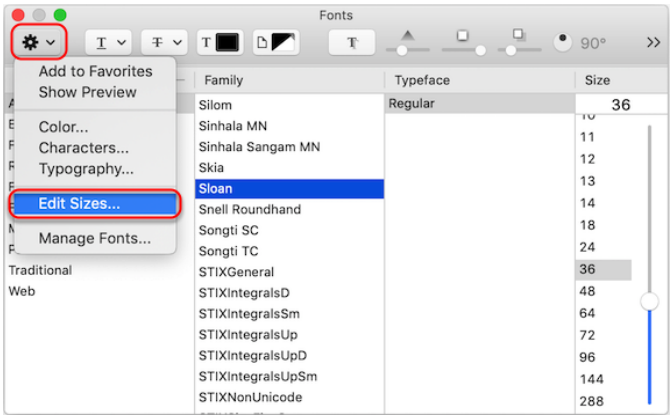
3) a preview in the bottom section of the currently selected line of text.



Change the default color to be applied to each line of text to black as well as the default font type and size to "Sloan 512".

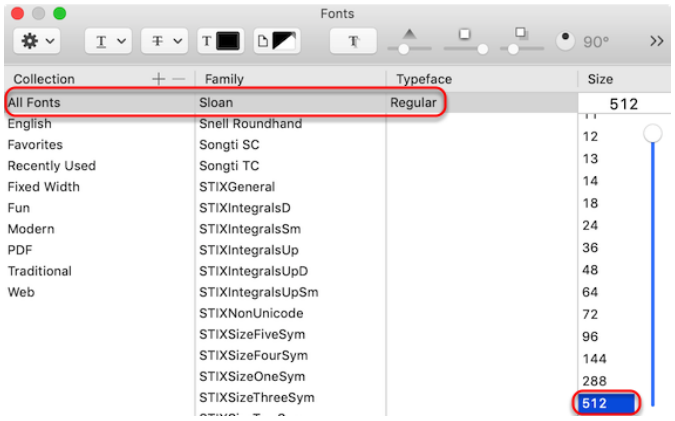


If the size of 512 pixels is not available, click on the dented wheel button to access the font menu and select **Edit Sizes...**



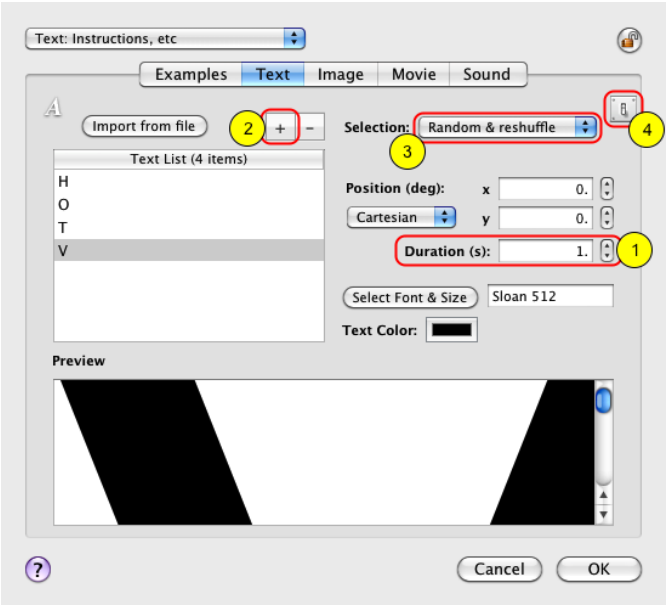
Add the new size of 512 pixels so it appears in the list and click on the **Done** button to validate.

Select the Sloan font and the 512 pixels size before closing the Fonts palette. ***Sloan 512*** should appear in the font & size text field when returning to the properties panel.



1) set the presentation duration to a value you feel appropriate,

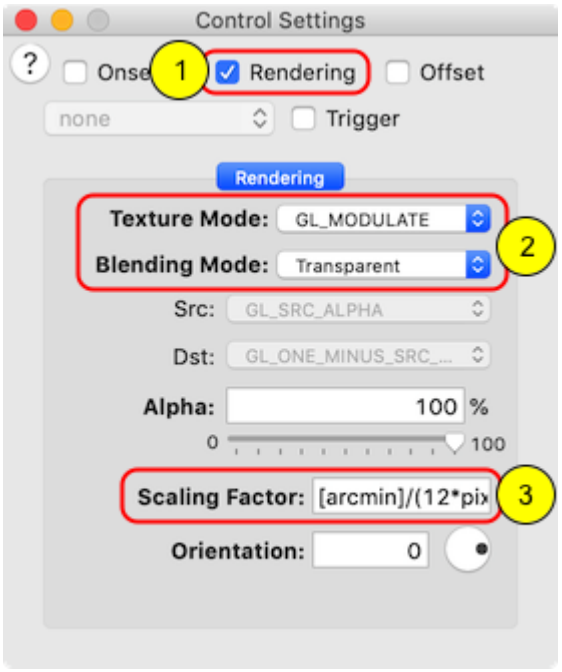
2) now that we have defined the default properties of the text, we can enter each optotype: click on the '**+**' button for each letter and edit the text entry in the table. In this example, the 4 Sloan letters HOTV will be used to measure visual acuity. The default properties previously set would apply to each new added text entry.



3) change the **Selection** mode from ***All simultaneous*** to ***Random & reshuffle***: this indicates that a single randomly selected text entry will be displayed in each trial, each letter being equiprobable in each selection block. The value of the system-defined variable **[SELECTION]** will be automatically updated with the selection (here 'H', 'O', 'T' or 'V' string values). This special variable will be used to associate the subject's response input and the correct decision in the Procedure event (see Step 8 below).

4) click on the switch button to access the control settings palette.

In the **Control Settings** palette:



1) check the **Rendering** box to access the Rendering options,

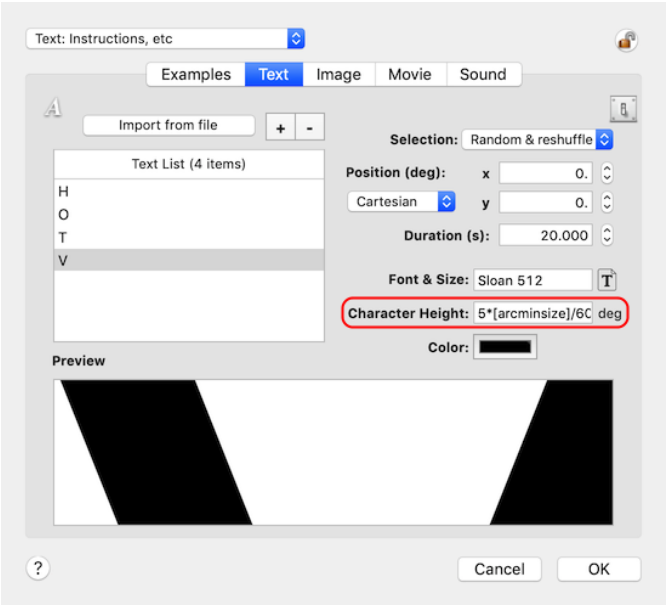
2) set the **Texture Mode** to ***GL_MODULATE*** and the **Blending Mode** to ***Transparent***: this is necessary because all texts are rendered as OpenGL masking textures,

3) specify the **Scaling Factor** to apply on the optotypes so they appear at the size specified by the ***arcminsize*** variable (acuity expressed in arc minute unit, 1 arcmin corresponding to 20/20 visual acuity):

```
[arcminsize]/(12*pixtodeg(512))
```

The denominator "12*pixtodeg(512)" is a normalizing factor so 512 pixels (the font size we specified) correspond to 5*1 arcmin (i.e. 5 / 60 = 1 / 12 deg). The *pixtodeg*() function allows to perform this conversion irrespective of the chosen viewing distance. If you decide to use a different size of the font to obtain higher quality optotypes, e.g. 1024, then make sure to update that expression as well, e.g. with [arcminsize]/(12*pixtodeg(1024)) .

Note that the more recent versions of Psykinematix include a size field which automatically shows the **Character Height** expressed in degrees of visual angle. You can use it to specify the letter size directly in degrees rather than in pixels: if provided as a scalar value, the name of the selected font will change accordingly to reflect the new size in pixels.



For the purpose of this tutorial, you could use it to directly indicate the optotype size as a function of the ***arcminsize*** variable with the expression:

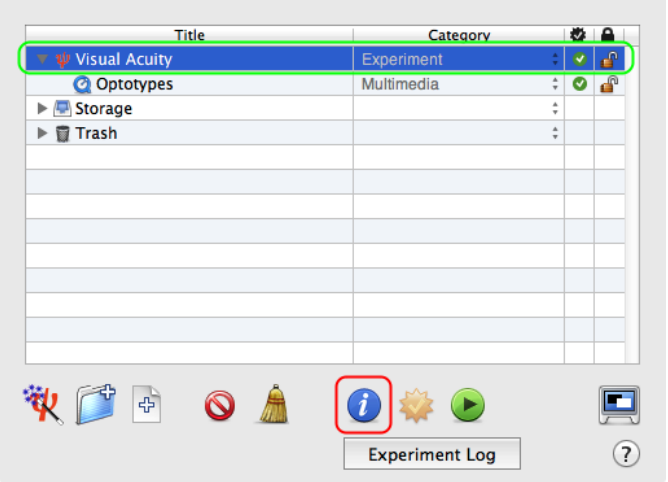
```
5*[arcminsize]/60
```

In that case, make sure that the same custom character height is set for all optotypes specified in the text list and that the **Scaling Factor** in the rendering section of the **Control Settings** palette is left to its pre-defined value (1, i.e. no scaling performed).

We have now finished with the stimuli design so click on the **OK** button in the properties panel to validate the changes and return to the **Designer** panel. Now we are going to customize the experiment properties and specify the value of the ***arcminsize*** variable.

Step 5: Customizing the Experiment

From the **Designer** panel, select the ***Acuity Experiment*** event, and click on the **Inspector** button to inspect its properties.

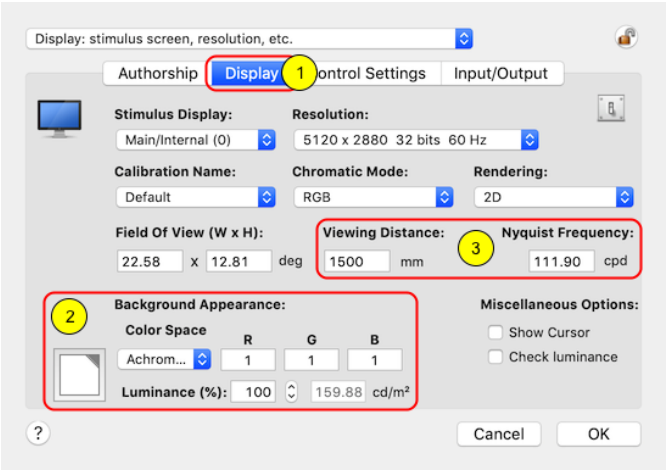


First let's customize the **Display** settings of the experiment:

1) click on the **Display** tab to view/edit the display settings, ie. those settings that affect the stimuli rendering on the experimental display,

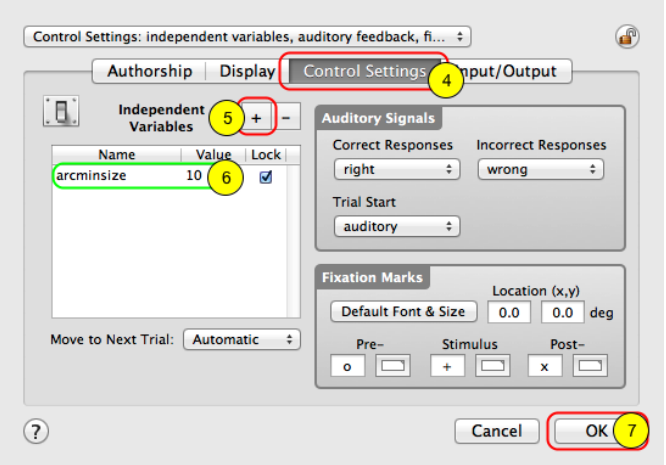
2) change the **Background Appearance** to white by selecting the **Achromatic Color Space** and setting the **luminance** to 100%,

3) set the **Viewing Distance** to whatever value you intend to measure visual acuity from.



***Note**: you should select a high enough distance so the pixelization of the display does not interfere with the acuity measurement, meaning individual pixels should not be resolvable. Because the best achievable visual acuity (~ 20/10) corresponds to about 60 cpd, the selected viewing distance should provide a Nyquist Frequency of about twice as much, i.e. ~ 120 cpd). Alternately, you can specify the expected **Nyquist Frequency** to find the associated viewing distance. Psykinematix automatically takes into account the display resolution and physical size to perform this conversion (assuming you correctly calibrated the geometry of your display, if not refer to the **Calibration Tutorial**).*

Then let's customize the **Control Settings** of the experiment:



4) click now on the **Control Settings** tab to view/edit the control settings, ie. those settings that affect the experimental protocol,

5) click on the '**+**' button to add an entry in the **Independent Variables** table,

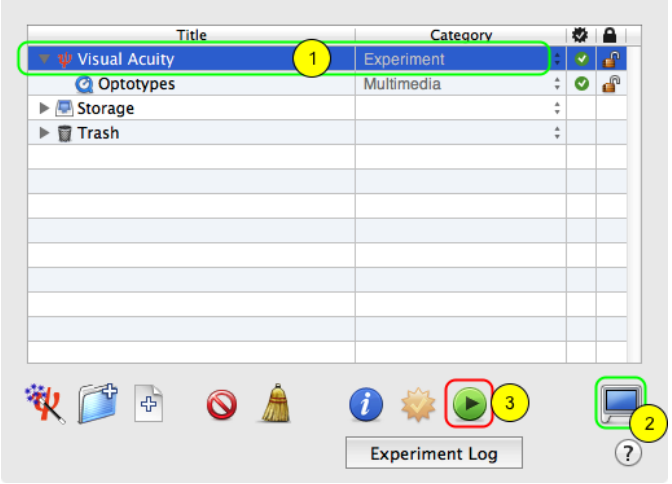
6) edit this entry and name it ***arcminsize*** and specify its value (10 arcmin in this example, corresponding to 1 LogMAR unit, 20/200 in foot unit or 6/60 in meter unit),

7) click on the **OK** button to validate these changes and return to the **Designer** panel.

We have declared ***arcminsize*** as an independent variable here only for demonstration purpose. Later, in step 7, we will change it to a dependent variable since this is the stimulus parameter that will vary across the trials when measuring visual acuity. In that step, you will be asked to remove this ***arcminsize*** variable from the **Independent Variables** table above by selecting it and clicking on the '**–**' button.

Step 6: Testing the Stimulus Presentation

Though we have only defined a stimulus in this experimental design, one can already run it and verify that the optotype is properly displayed:



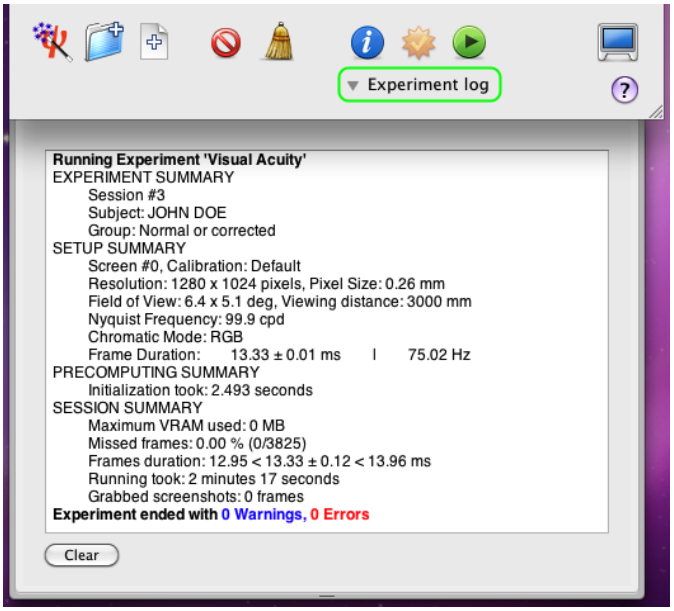
1) select the ***Visual Acuity*** **Experiment** event,

2) toggle the experimental session to full-screen mode (note that this option is disabled when running Psykinematix in demo mode which is limited to a windowed stimulus presentation),

3) click on the **Run** button to run this experiment (see Step 10 below for more details): a single optotype randomly selected should be presented at the size specified by the ***arcminsize*** variable.

4) Once the running of the experiment (aka session) has completed normally, you will be asked to press **ESC** to return to the **Designer** panel.

If an error occurred during the session, a logging panel will automatically show up with relevant error and warning messages. This panel also includes a summary of the experimental conditions in terms of subject, display setup, and various other diagnostic information. If no error occurred, you can still reveal this panel by clicking the **Experiment log** button at the bottom on the **Designer** panel.

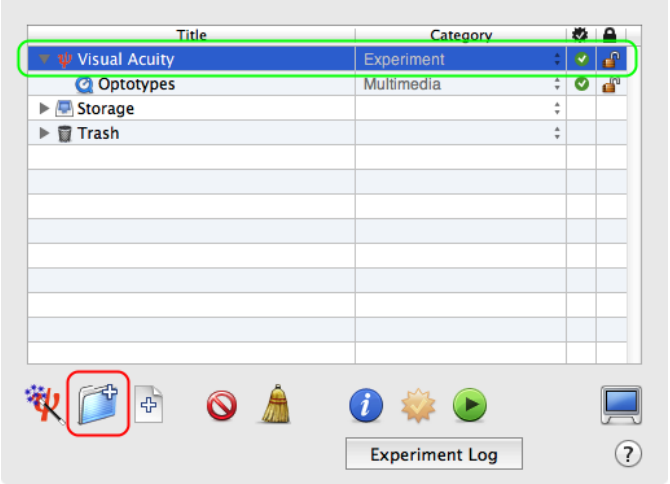


Now we are going to implement the staircase method and the discrimination procedure necessary to measure the visual acuity threshold. Before going ahead make sure to remove the ***arcminsize*** independent variable from the **Control Settings** of the Experiment event (See Step 5 above and use the '**–**' button to remove the variable entry). This is required because ***arcminsize*** will be declared as a dependent variable instead as an independent one.

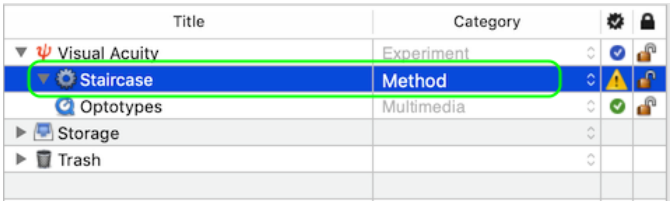
Warning: *Declaring the same variable in different events of the experimental design will trigger run-time warnings and possibly critical errors. Once declared, a variable is made global and is available for use to all events.*

Step 7: Adding a Staircase Method

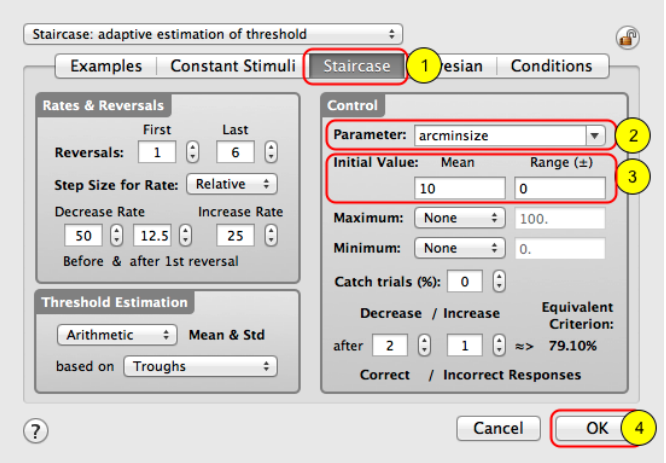
Select the **Experiment** event and add a new **group** event by clicking on the '**+**' folder icon again.



Set the category of the new event to **Method** with the **Staircase** sub-category and rename it simply ***Staircase***. Then make sure the ***Staircase*** event is selected and click on the **Inspector** button to access its properties panel.



In this properties panel, the default settings are suitable for a standard staircase method but they can be customized to better fit your experimental requirements. The mandatory changes are those associated with the stimulus parameter that drives the threshold estimation during the experiment and its initial value:



1) control-click on the **Staircase** tab to select the Staircase Method if it is not yet selected,

2) enter ***arcminsize*** in the **Parameter** text field: this is the **dependent variable** of this experimental design,

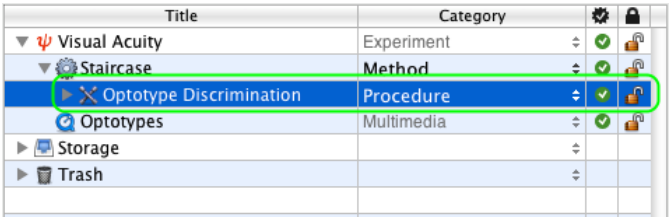
3) set the **Initial Value** of the staircase parameter (randomly selected in the range specified by a uniform distribution, mean ± deviation): here the staircase method will always start with the same size (10 arcmin),

4) click on the **OK** button to validate these changes and return to the **Designer** panel.

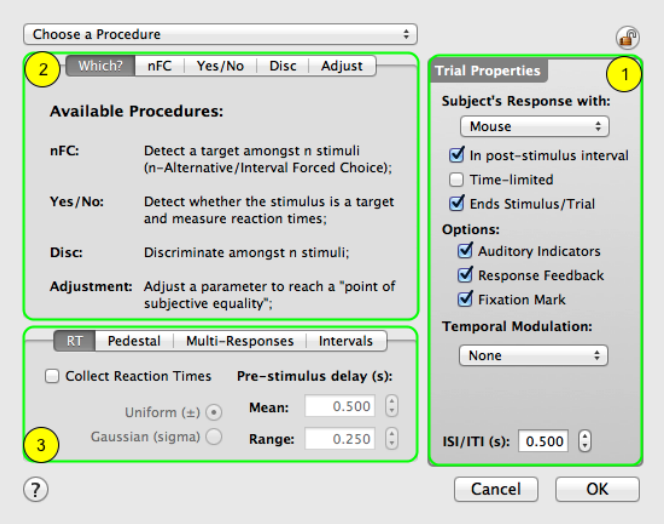
Important*: Since we have now declared the* ***arcminsize*** *variable as a dependent variable, make sure to return to step 5.5 above and delete it from the* ***Independent Variables*** *table in the Control Settings of the experiment by selecting it and clicking on the '–' button.*

Step 8: Adding a Discrimination Procedure

Similarly to the previous step, select the **Method/Staircase** event, add a new **group** event, set its category to **Procedure** with the **Discrimination** sub-category and change its title to ***Optotype Discrimination***. Then make sure this new ***Optotype Discrimination*** event is selected and click on the **Inspector** button to access its properties panel.



The properties page for the **Procedure** event consists of three sections:



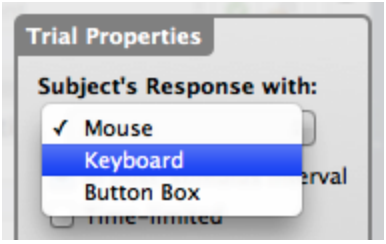
1) a right side common to all procedures that specifies the properties to be applied to each trial,

2) a top-left section that specifies the properties of the selected procedure,

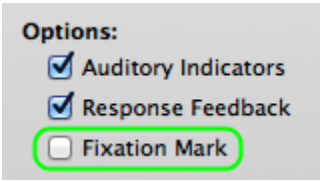
3) a bottom-left section that provides more customization for some of the procedures (eg, reaction times and pedestal),

You should customize each of these sections to fit your experimental requirements, for example as following:

First, in **Trial Properties:**

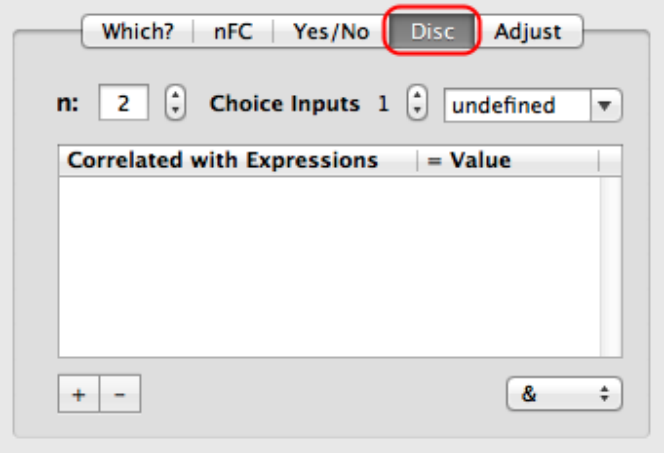


- change the type of inputs used by the subject to provide his/her responses: select the **Keyboard** device instead of the default (**Mouse**). Here the h,o,t and v keys will be used by the subject to indicate the recognized letter (see below).



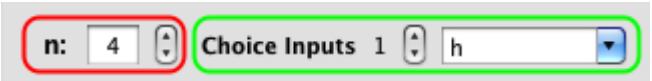
- uncheck the **Fixation Mark** option, so no fixation is displayed during the optotype presentation (pre- and post-stimulus fixations may be still present).

Second in the procedure-specific section of the panel:



- control-click on the **Disc** tab to select the Discrimination Procedure to view/edit its settings if it is not yet selected,

- specify a 4FC discrimination task by setting **n** to ***4*** which corresponds to the number of response choices (4 letters).

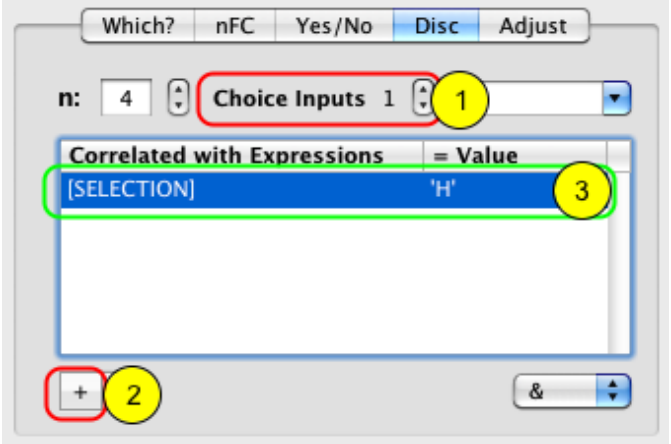


- enter the subject response associated with each alternative decision: select the first choice index with the stepper (1 in the above figure) and enter the keyboard key (***h*** in the figure) provided by the subject for the H letter decision. Similarly, set the response keys (o, t and v) for the other choice indices (2, 3 and 4) corresponding to the O, T and V letter decisions.

***Tip**: Several inputs, separated by a comma, can be specified for the same decision.*

- finally indicate explicitly the correct decision for each choice input using the appropriate stimulus variables and their expected values:

1) select the choice input,
2) click on the '**+**' button to add an expression entry in the table,
3) under the "**Correlated with Expression**"



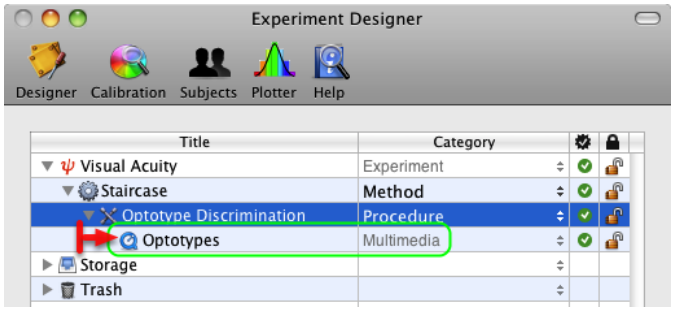
column enter the stimulus dependent expression and its expected value under the "**= Value**" column.

As emphasized in Step 4, the value of the system-defined variable **[SELECTION]** specifies the optotype presented in the current trial. So here we simply have to indicate that the correct response for each choice input (h,o,t,v) is provided when the value of the [SELECTION] variable corresponds to the associated letter ('H','O','T','V' respectively).

Click on the **OK** button to validate the changes and return to the **Designer** panel.

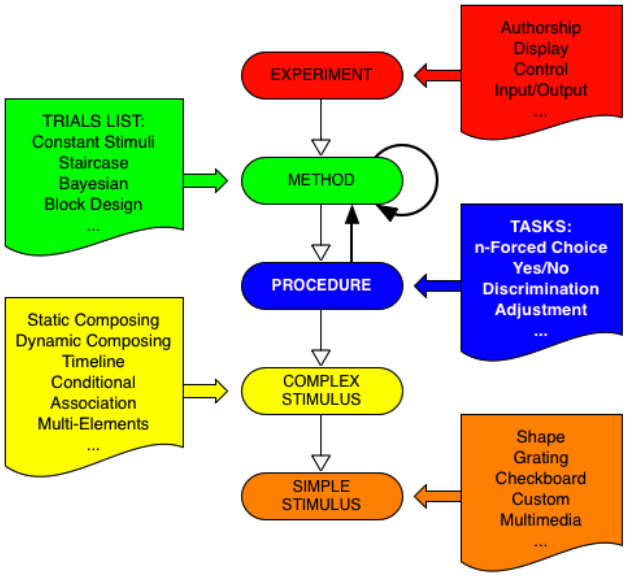
Step 9: Finalizing the Design

To finalize the hierarchical structure of the experimental design, drag the ***Optotypes*** stimulus **INTO** the ***Optotype Discrimination*** procedure so it is indented to the right as illustrated. This is a critical step to ensure that the experiment will correctly work since stimuli events are typically the deepest events in the hierarchy structure of an experimental design (and because their properties depend on the independent and dependent variables declared in their parent events).



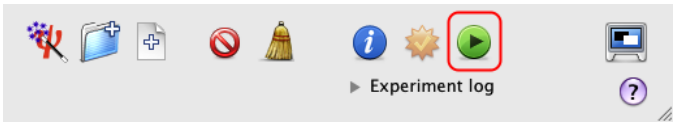
The Method/Procedure/Stimulus Experimental Paradigm

As you can see, the design now follows the Method/Procedure/Stimulus paradigm depicted here which is the basis of many behavioral experiments, not just the psychophysical ones. This experimental paradigm is both conceptually simple, intuitive, and powerful enough, and constitutes a well-proved template for most experimental needs.



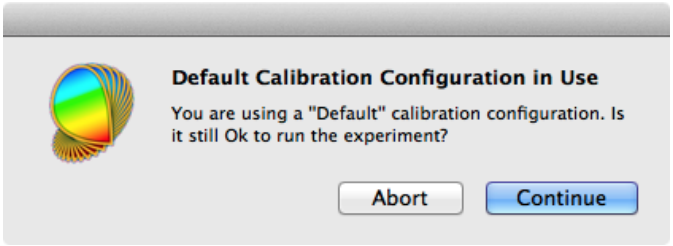
***Tip**: This hierarchical description describes the logic of the experiment both in terms of its conceptual semantics and operational execution. Most of the experiments created by Psykinematix should follow the above **Method/Procedure/Stimulus** hierarchical template as experimental paradigm.*

Now we have completed the hierarchical structure of the experiment, we are ready to run this experimental design: select the ***Visual Acuity* Experiment** event and click on the **Run** button to start the experiment and measure visual acuity using the specified staircase method and discrimination procedure.

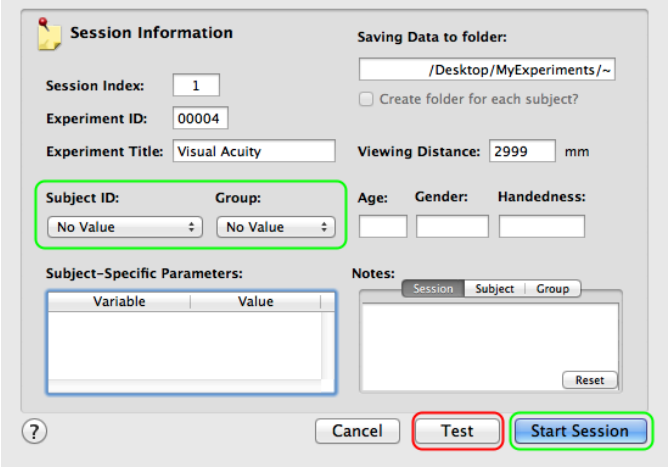


Step 10: Running the Experiment

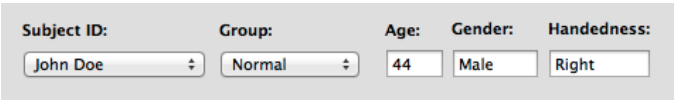
This warning message is displayed when no calibration configuration has been explictely specified for the experiment running (see the end of the ***Calibration Tutorial*** to learn how to specify a calibration configuration); however, you can still run the experiment using a default calibration by clicking on the **Continue** button.



Before the session starts in full-screen mode, a panel summarizing the **Session Information** is displayed. You can either run the session in testing mode (***Test*** button), which does not require the specification of the subject and group, or in real mode (***Start Session*** button) if you specify them. ***In testing mode, the session data will only appear as temporary data*** under the **Plotter** panel ***and will not be actually saved in the results database*** (shown under the **Subjects** panel).



If you have already entered subjects and groups in the **Subjects** panel (see the ***Subjects Tutorial***), you can select them using the two pop-up menus provided. Their age, gender, and handedness are then shown.



Click on the **Test** or **Start Session** button.

Press **ESC** (escape keyboard key) to stop the session at any time.

If the experiment aborts by itself because some critical error occurred during the session, the logging panel will automatically show up with the relevant error messages. In that case, carefully review the different steps provided above using the indications provided by these error messages.

Important note: *To save the session results in the Psykinematix database for future retrieval, always make sure to:*

*- run the experiment in full-screen mode by toggling the display icon in the **Designer** bottom toolbar,*
*- select the subject and group in the **Session Information** panel,*
*- click on the **Run Session** button in the **Session Information** panel.*

Step 11: Visualizing the Results

Upon termination of an experimental session, the results data can be visualized immediately from the **Plotter** panel:

1) Click on the **Plotter** icon in the toolbar to access the panel. The results for the last session appear at the top of the table.

2) Option-click on the small arrow in front of the session entry to expand the whole hierarchy of the results data.

3) Select one of the entries in the final level of the hierarchy to plot its attached dataset (each entry contains a different dataset).

4) You can customize the appearance of the graph by clicking the "Graph Settings" button to access the **Graph Properties** palette (6) or the "Data Settings" button to access the **Data Analysis** palette.

5) Some data analysis options specific to the selected dataset are available from the tabs available in the **Data Analysis** palette on the right side of the results table: for staircase data for example, it is possible to select whether an arithmetic or geometric mean is used, or whether troughts or/and peaks of the reversal data points are considered to estimate the displayed threshold.

6) Numerous aspects of the graph appearance can be customized using the **Graph Properties** palette: here for example, a log scale and a minimum of 0 were selected for the y-axis and the legend showing the acuity estimate was repositioned.

7) Control-click inside the graph to either print, copy, or save it to a file.

8) Click on the **Data Table** button to reveal the spreadsheet containing the selected data (3) used to plot the graph. Control-click inside the spreadsheet to print or export the data. The data

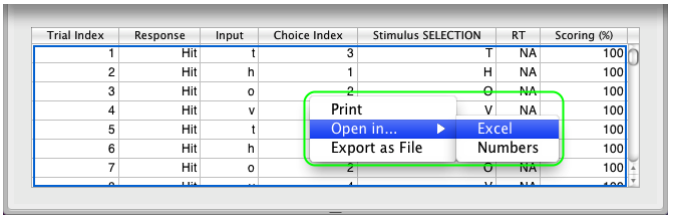
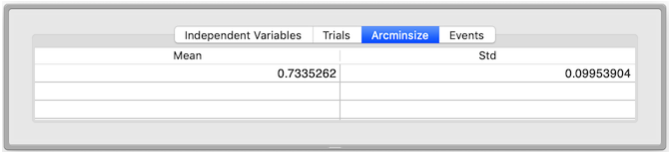


table shown above is the one associated with the "Optotype Discrimination" section of the results table.

When selecting the root object of the session entry (entitled in this example ***00001 - Visual Acuity***), the data table will present a summary of the measurements, in this example the threshold estimate (mean ± std) under the ***Arcminsize*** tab also shown on the graph above.



See the ***Subjects Tutorial*** and the ***Plotter Tutorial*** to learn how to select, import, and plot data collected during previous Psykinematix sessions.

Conclusion

In this lesson, you learned the Psykinematix basics: how to create the hierarchical structure of an experiment, how to customize the events, how to use variables to connect procedural and stimulus events, and how to run a session and inspect the results.

In the next lesson, you will learn how to add crowding bars around the optotypes (**Lesson 2**). You may also consider the following lessons to learn how to:

- interleave several staircases to investigate the effect of another parameter (**Lesson 2 on Contrast Sensitivity**),
- implement a sandwich paradigm with forward and feedback masking noise (**Lesson 3 of Orientation Discrimination**),
- add a spatial and temporal context (**Lesson 4 of Orientation Discrimination**).