# HULTI-GEN v2.0.5
# User Guide

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# Contents

# 1. Introduction

HULTI-GEN is an acronym for 'Huddersfield Universal Listening Test Interface Generator'. HULTI-GEN was originally developed by in 2015 by Chris Gribben, and has now been updated to version 2.0 in 2020 by Dale Johnson, both at the Applied Psychoacoustics Laboratory at The University Of Huddersfield. Its aim is to simplify the design and execution of listening test experiments, and to allow users to modify and customise test interfaces to suit their experimental needs. It is a completely free, standalone, Max-based tool, and *does not* require a Max license in order to function.

Version 2.0 introduces an overhauled test setup assistant, and a suite of psychophysical test methods such as Two-Alternative Forced-Choice (2AFC), ABX, and Adaptive Staircase. This version is now open-source under the MIT license, which means that the HULTI-GEN program and its built-in tests can be modified within Max, although this does require a Max license in order to save modified patcher files.

Before using HULTI-GEN, the user must have a clear idea of their testing format with consideration toward the number stimuli, the number of sessions that subjects will undertake, and what attributes are being tested. It is therefore recommended that a testing plan is documented before configuring and running an experiment.

**Software requirements**

HULTI-GEN requires Max 8 or higher available from https://cycling74.com/downloads. It will **NOT** run on earlier versions due to the use of the Multi-Channel (MC) audio features only available since Max 8. A Max license is only required to save any modifications to the source patcher file.

**Important information**

**Before running HULTI-GEN**, ensure that the *Overdrive* feature of Max is disabled, and that any stimuli files imported that should accompany the test configuration file should be included in the same folder as the HULTI-GEN project file (HULTI-GENv2.maxproj).

The authors do not assume liability for the correctness of the content in this document, and does not take responsibility for any harm or damage resulting from the use of its application. For further information, or would like to give comments or report bugs in HULTI-GEN, do not hesitate and get in touch with us via email on:

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# 2. Test configuration

When you first open HULTI-GEN, you will be greeted by the main screen shown in Figure 2.1 below. You have two options: 'Create' or 'Open a test. Clicking 'Create' will begin the setup assistant that will guide you through the test creation process, whilst 'Open' will allow to load an existing test, and will then take you straight to the 'Test Menu' (see page 10).
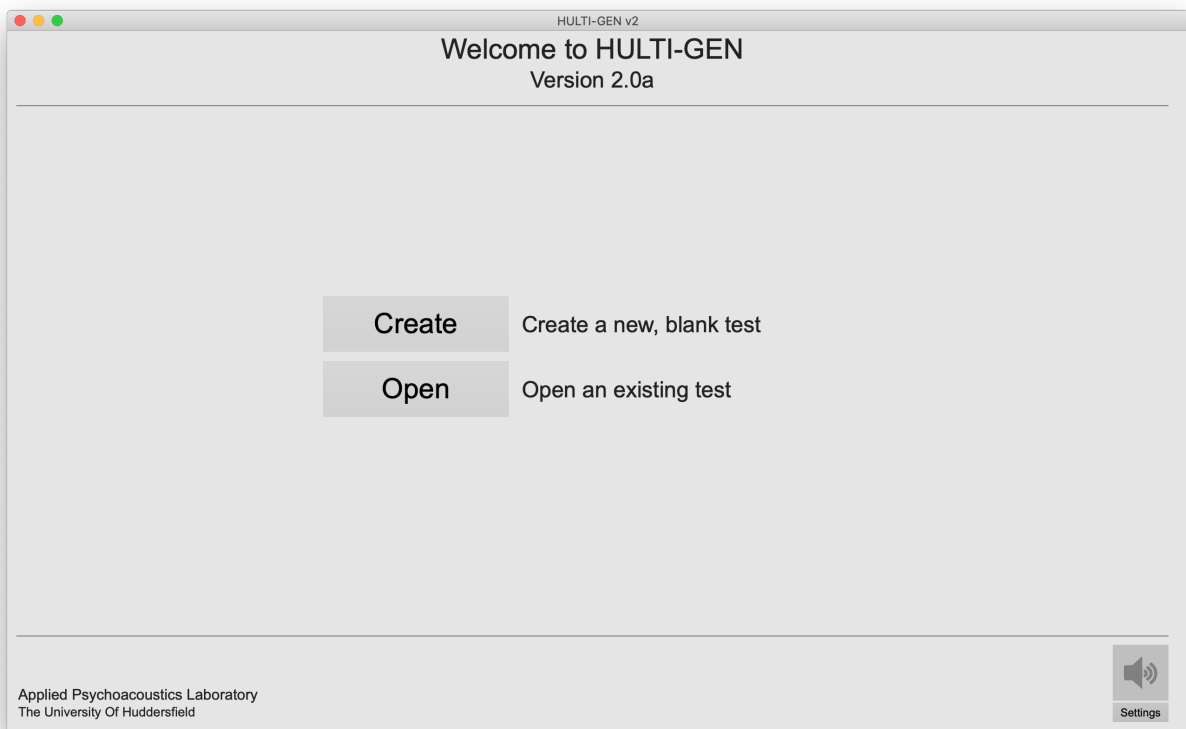


Figure 2.1: Click on the 'Create' button to begin the test setup assistant.

## 2.1 Creating a new test

HULTI-GEN provides a step-by-step, test creation setup assistant. This assistant guides you through selecting a test method appropriate for your experiment, setting the parameters for your chosen method, customising the interface[1], adding stimuli, and assigning the stimuli into sessions and groups.

From the main menu, click the 'Create' button to create a new test and begin the setup assistant. In each step of the setup process, you will be greeted by settings or options for that step. Once you have completed a step, click on the 'Next' button to move onto the next step.

### 2.1.1 Step 1 - Choose a test method

When you begin creating a new test, you will be asked what kind of test method, or task, you want subjects to perform, see Figure 2.2.
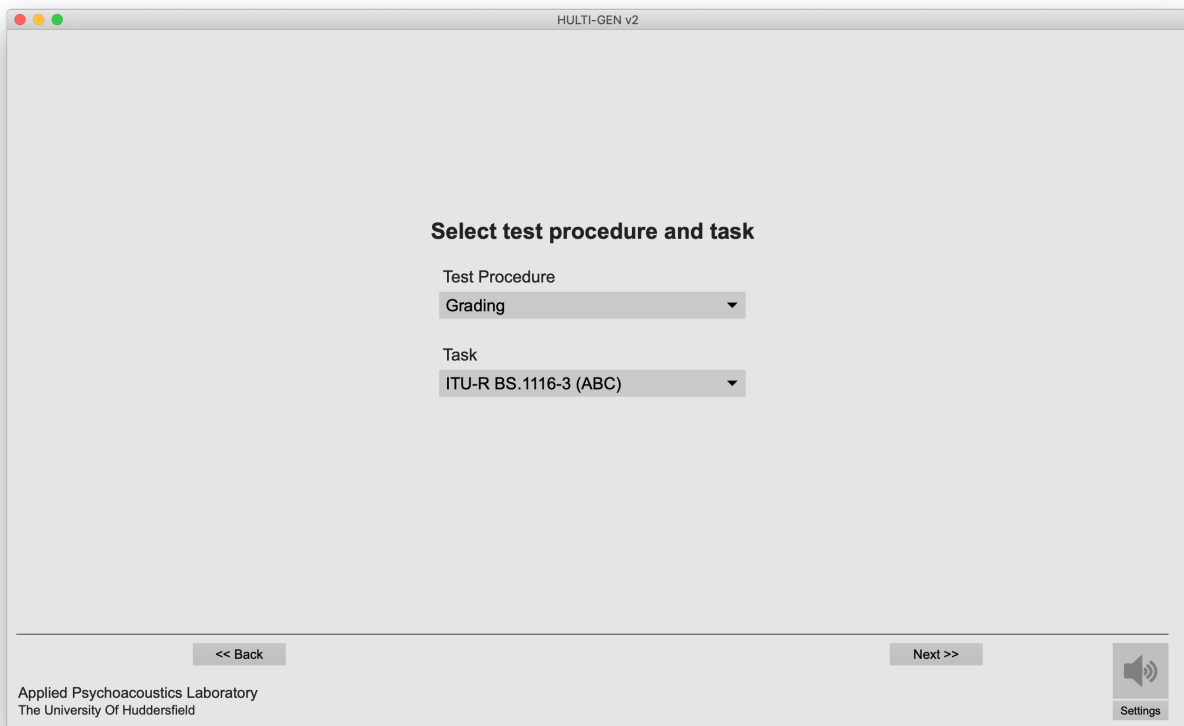


Figure 2.2: Choose what type of procedure and task from the on-screen drop-down menus.

Each test method available in HULTI-GEN is grouped by *Procedure* and *Task*. Procedure groups each task by its testing process. Task is specific task the subjects will carry out during the experiment, e.g. MUSHRA. The following table lists all available tasks grouped by their corresponding procedures. Once you have selected a task, click 'Next'.

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[1]Currently only available for grading tests

| Procedure | Task |
|---|---|
| Grading | ITU-R BS.1116-3 (ABC)<br>ITU-R BS.1534-3 (MUSHRA)<br>Bipolar ±50 with reference<br>ITU-T P.910 Absolute Category Rating (ACR)<br>ITU-T P.800 Degradation Category Rating (DCR)<br>ITU-T P.800 Comparison Category Rating (CCR)<br>9-Point Hedonic Scale |
| Non-Adaptive Psychophysical | Two-Alternative Forced-Choice (2AFC)<br>ABX<br>Yes-No<br>Signal Detection Theory 2AFC<br>Signal Detection Theory ABX<br>Signal Detection Theory Yes-No |
| Adaptive Psychophysical | Staircase 2AFC<br>Staircase ABX<br>Staircase Yes-No |

### 2.1.2 Step 2 - Input test parameters

On this screen you can set the number of sessions, or sittings, and groups of stimuli for the entire test.



Figure 2.3: Example test parameters screen.

The type settings that you will see are contextual, whereby they depend on the type of

procedure that you are configuring. The following list of descriptions explain the settings common to all procedures.

**Sessions** The number of sittings a subject will undertake for the entire test

**Number of groups of stimuli** Sets the number of stimulus groups per session. In grading tests, this also sets the base number of trials.

**Objective** The instructions that the subject will be shown on screen during the test.

*Warning:* *If at any point in setup process the number of sessions / groups are changed after being set, assignment of stimuli to any now non-existent sessions / groups will be destroyed.*

### 2.1.3 Step 3 - Customise the test interface

In this step you are able to customise various aspects of the test interface[2]. You can edit and resize the labels, change the scale minimum / maximum points and resolution, and (if enabled) position the high and low anchor buttons.
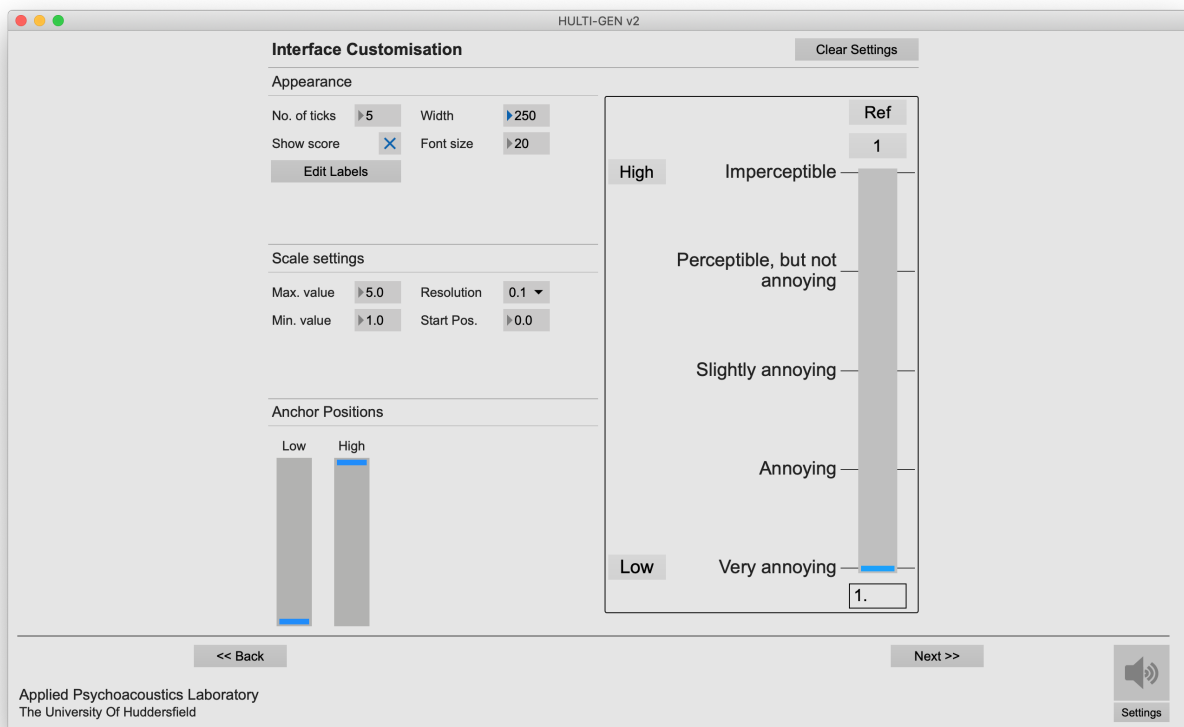


Figure 2.4: Customise the test interface to suit the needs of your experiment.

By default the interface is set to follow the recommendations for the chosen task. Therefore, customising the testing interface means you are working outside of the recommendation. This is not a discouragement, but a reminder that you should justify the design of your test interface where required. After all, the aim of HULTI-GEN is allow experimenters to invent and try new ideas.

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[2]*Note: The customisation step is currently only available for grading tasks. Customisation will be made possible for all built-in procedures and tasks in future updates to HULTI-GEN*

### 2.1.4 Step 4 - Load stimuli

Now that the test parameters have been set, it is now time load stimuli. First, the stimuli need to be loaded into a *pool*, which is collection of all the stimuli used throughout the entire test.

***Warning:*** *Due to the method of how Max locates files and dependencies, stimulus files* **must** *be placed in the HULTI-GEN folder or next to the application file (HULTI-GENv2.maxproj)* ***before running HULTI-GEN****, otherwise Max will not be able to find and load your stimuli files.*
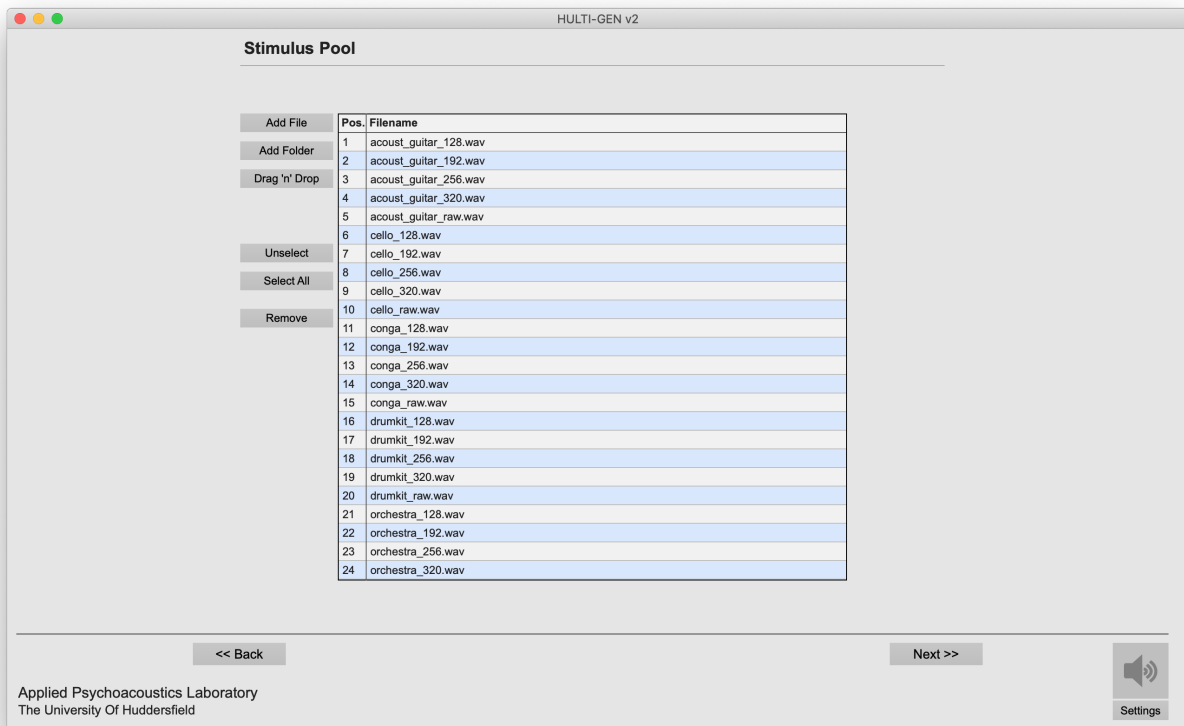


Figure 2.5: Stimuli for the entire test are loaded into a *pool* using this interface.

There are three main ways to add stimuli to the pool.

**Add File** Browse for and add individual files.

**Add Folder** Browse for and an entire folder of files.

**Drag 'n' Drop** Enable the drag and drop feature of the file-list. When enabled, you can drag files directly onto the file-list, where they are then appended to the list.

As you load stimuli into the pool, their filenames are displayed in the file-list in the middle of the screen. Stimuli can be remove by first selecting items in the list, then click 'Remove'. You can select multiple items in the list by holding down 'Cmd' / 'Ctrl' (Operating System dependent) or 'Shift', much like the file browser built into your Operating System.

### 2.1.5 Step 5 - Assign stimuli

The final step of the setup assistant is assigning stimuli to each session and group. This screen is divided into three main parts: Session and group menu, stimulus pool, and group sub-pool. Once all groups have been assigned stimuli, clicking 'Finish' will complete the process and take you to the 'Test menu'.
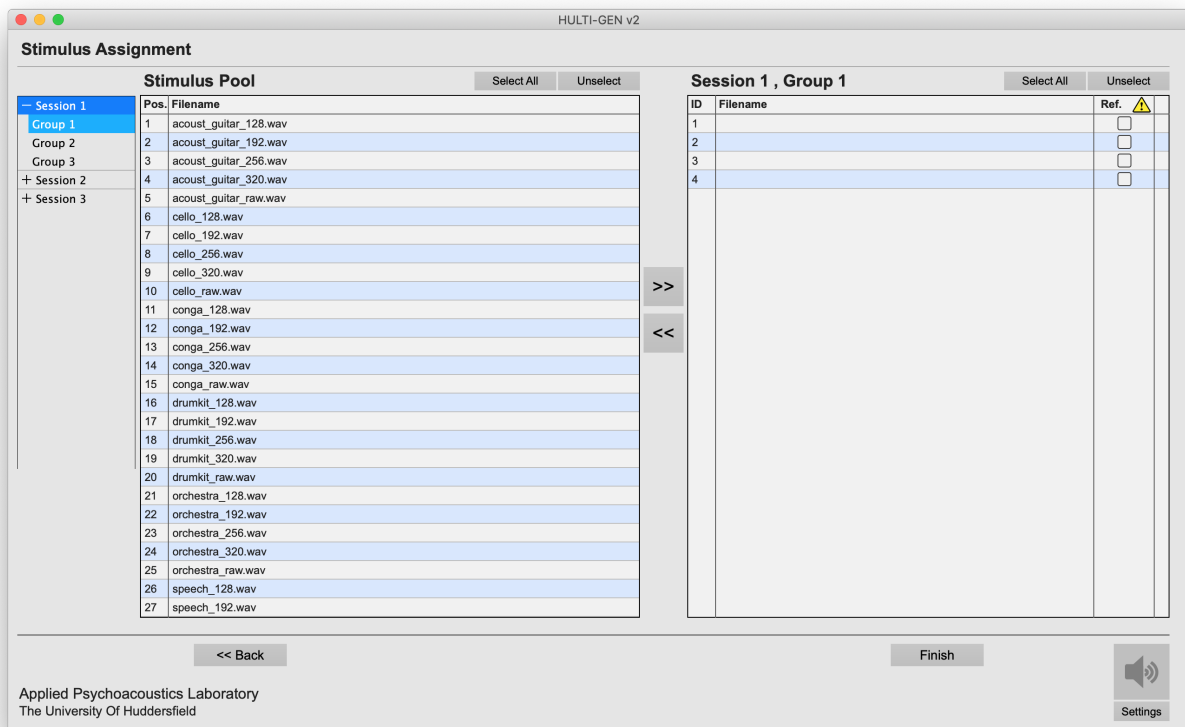


Figure 2.6: The stimulus assignment screen. Stimuli in the pool on the left can be assigned to a group on the right.

#### Assigning to a group

To assign stimuli to a group:

1. Select a session and a group in the left-hand menu.

2. Highlight your desired stimuli in the *Stimulus Pool*

3. Press the '>>' button to assign the stimuli to that group. They will then appear in the group sub-pool list on the right.

#### Removing from a group

To remove stimuli from a group:

1. Highlight the stimuli to remove in the group sub-pool list.

2. Press the '<<' button to remove the highlighted stimuli from that group.

## Grading test reference and anchor assignment

Certain grading tests in HULTI-GEN require a reference stimulus, and if specified, also require 'Low' and 'High' anchors. A stimulus is set as a reference or anchor by checking the relevant checkbox in right most columns.



Figure 2.7: A stimulus is set as a reference or anchor by checking the relevant checkbox.

## Staircase step definition

If you are configuring a staircase test, the position of the stimulus in the list determines which step of the staircase it is assigned to. By default the staircase tests begin at the highest level, which is the highest *numbered* positions of the list, which is marked *Maximum difference*, see Figure 2.8. This is may seem little confusing at first, but essesntially the list represents the staircase upside-down. The general rule is to assign the reference stimulus at position 1, or the *Reference* position, and work down the list with increasing stimulus levels until you reach the stimulus that has the *Maximum difference* compared to the reference.



Figure 2.8: Stimuli are arranged from the *bottom*, reference step to the *top*, maximum difference step.

# 3. Running a test

Once a test has been configured or opened from an existing file, you will be taken to the 'Test Menu', and you can begin running it. On the screen shown below in Figure 3.1, you can begin the test with new subject by clicking *New Subject*, or continue with an existing one that has not yet completed all sessions by clicking *Continue*.
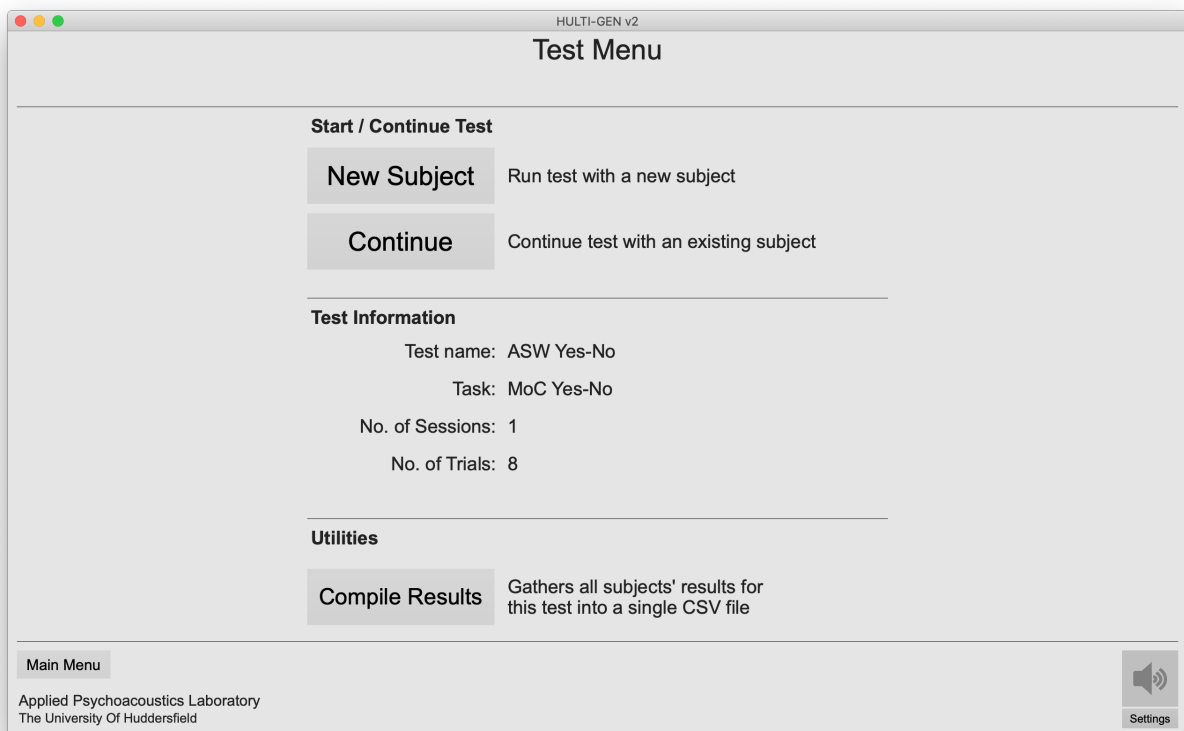


Figure 3.1: The Test Menu, where you can choose to run the test with a new subject or continue with an existing subject.

## 3.1   Starting with a new subject

When you start the test with a new subject, you will be prompted to enter an identifier for this subject, and then where to save their data file. You will then be prompted to begin the test. This displays what sitting and group they are about to begin, and will give the subject a moment to compose themselves. When the subject is ready, they can press 'Begin'.

**Note:** *Don't forget to turn on the audio processing, otherwise your subject will not hear anything.*
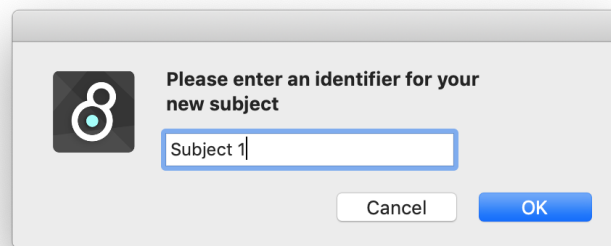


Figure 3.2: Subject identifier prompt.



Figure 3.3: The subject is informed of their progress before beginning the test.

## 3.2   Test completion and results output

The subject will carry out the test for as many trials and groups outlined by the test parameters. When they have completed all groups in a session, their data file is automatically saved, and they may leave the session. Once a subject has finished all sessions in a test, the experiment data is automatically exported as a Comma Separated Values (CSV) file, by which you will be prompted on where to save this file.

# 4. Audio settings

Version 2.0 of HULTI-GEN features a multi-channel audio playback engine featuring real-time binauralisation and headphone filtering. This engine takes advantage of the MC, or Multi-Channel, processing that was introduced in Max 8, and supports up to 64-channels of multi-channel audio playback[1]. The settings for the audio engine are accessed by clicking on 'Settings' under the speaker icon at the bottom-right corner of HULTI-GEN.



Figure 4.1: Audio settings screen.

The audio settings screen is split into four main parts: 'Playback Format', 'Headphone EQ', 'Binauralisation', and the channel list.

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[1] Whilst it is possible to process up to 1024 channels of audio in Max 8, for technical reasons in HULTI-GEN it has been limited to 64 channels.

## 4.1 Playback format

The 'Playback Format' section allows you to define the number of output channels you will be using in you test, and is linked to the channel list. Here is a summary of the controls in this section:

**Preset** Set the channel list and 'Binauralistion' virtual speaker layout to one of the built-in configurations, e.g. 2.0, 5.0, 9.0 etc.

**Channels** Sets the number of channels that will be used in the audio stream.

**Force mono to stereo** Copies channel 1 to channel 2 for when you are using a mono stimuli but wish to use 2 a channel stereo loudspeaker setup or headphones.

## 4.2 Headphone equalisation

If you are using headphones for your test, it is sometimes desirable to reduce or *cancel out* the effect of the headphone's own frequency response. The 'Headphone EQ' section allows you to apply headphone equalisation, either by using a matching, built-in, EQ filter, or by loading your own filter. The following is a summary of the controls in this section:

**Model** Selects which of the built-in headphone equalisation filter you want to use.

**Load Custom** Allows you to load your own measured, headphone EQ, inverse filter.

**Custom** This text box displays the filename of your custom filter.

The equalisation is enabled by toggling the top 'On' switch, whilst the custom filter is used in place of the built-in filter by toggling the 'On' switch next to the 'Custom' filename box.

***Warning:*** *The current version of HULTI-GEN does not feature any form of resampling of headphone EQ filters. Therefore, it is crucial that you the sample-rate of your chosen filter matches the sample-rate of Max or vice-versa.*

## 4.3 Binauralisation

Finally, the 'Binauralisation' section allows you to convert each audio channel into a virtual loudspeaker. The position of this virtual loudspeaker is set by the 'Azimuth' and 'Elevation' number boxes in the channel list. This process requires a Head Related Impulse Response (HRIR) database in the form of a SOFA file. These files are available from the internet. The following list describes the controls for this section:

**Load SOFA** Opens a dialog that lets you browse for and load a SOFA file. Binauralisation is only possible once a SOFA file has been loaded.

**Name** Displays the filename of the currently loaded SOFA file.

**S. Rate** Abbreviation of sample-rate, displays the sample-rate of the SOFA file.

***Warning:*** *The current version of HULTI-GEN does not feature any form of resampling of HRIRs. Therefore, it is crucial that you the sample-rate of your chosen SOFA file matches the sample-rate of Max or vice-versa.*

# A. CSV results file format

## A.1 Individual subject CSV files

Once a subject has completed all sessions in a test, HULTI-GENv2 will prompt the user to save a 'Comma Separated Values' (.CSV) file. This file is saved in conjuction with the subject's .JSON file, and is supported by most statistical analysis and speadsheet applications. The data in each column of a CSV file is formatted in hierarchical fashion, depending on the procedure. For grading and non-adaptive psychophysical tests, e.g. 1534-2 MUSHRA, MoC 2AFC etc, the hierarchy is:

**Session → Group → Stimulus → Repetition → Response / Grading Value**

Whilst for adaptive methods, e.g. Staircase 2AFC, the hierarchy is:

**Session → Group → Trial → Step / Stimulus → Response**

The following table is an example of a subject's CSV file for a 1534-2 MUSHRA, grading test arranged as 2 Sessions, 2 Groups, 3 Stimuli per Group repeated 2 times:

| Session ID | Group ID | Stimulus | Repetition | Response |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 100. |
| 0 | 0 | 0 | 1 | 100. |
| 0 | 0 | 1 | 0 | 97. |
| 0 | 0 | 1 | 1 | 98. |
| 0 | 0 | 2 | 0 | 50. |
| 0 | 0 | 2 | 1 | 45. |
| 0 | 1 | 0 | 0 | 100. |
| 0 | 1 | 0 | 1 | 100. |
| 0 | 1 | 1 | 0 | 86. |
| 0 | 1 | 1 | 1 | 90. |
| 0 | 1 | 2 | 0 | 31. |
| 0 | 1 | 2 | 1 | 38. |
| 1 | 0 | 0 | 0 | 100. |
| 1 | 0 | 0 | 1 | 100. |
| 1 | 0 | 1 | 0 | 90. |
| 1 | 0 | 1 | 1 | 89. |
| 1 | 0 | 2 | 0 | 44. |
| 1 | 0 | 2 | 1 | 40. |
| 1 | 1 | 0 | 0 | 100. |
| 1 | 1 | 0 | 1 | 100. |
| 1 | 1 | 1 | 0 | 75. |
| 1 | 1 | 1 | 1 | 78. |
| 1 | 1 | 2 | 0 | 20. |
| 1 | 1 | 2 | 1 | 25. |

The following table is an example of a subject's CSV file for an Adaptive Staircase 2AFC test arranged as 2 Sessions and 2 Groups per session (***Note:*** *For clarity, the table has been truncated*):

| Session ID | Group ID | Trial | Step | Response |
|---|---|---|---|---|
| 0 | 0 | 0 | 10 | 1 |
| 0 | 0 | 1 | 10 | 1 |
| 0 | 0 | 2 | 9 | 1 |
| 0 | 0 | 3 | 9 | 1 |
| 0 | 0 | 4 | 8 | 1 |
| 0 | 0 | 5 | 8 | 1 |
| 0 | 0 | 6 | 7 | 1 |
| 0 | 0 | 7 | 7 | 1 |
| 0 | 0 | 8 | 6 | 1 |
| 0 | 0 | 9 | 6 | 1 |
| 0 | 0 | 10 | 5 | 1 |
| 0 | 0 | 11 | 5 | 0 |
| 0 | 0 | 12 | 6 | 0 |
| 0 | 0 | 13 | 7 | 1 |
| 0 | 0 | 14 | 7 | 1 |
| 0 | 0 | 15 | 6 | 1 |
| 0 | 0 | 16 | 6 | 1 |
| 0 | 0 | 17 | 5 | 1 |
| 0 | 0 | 18 | 5 | 1 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 0 | 1 | 0 | 10 | 1 |
| 0 | 1 | 1 | 10 | 1 |
| 0 | 1 | 2 | 9 | 1 |
| 0 | 1 | 3 | 9 | 1 |
| 0 | 1 | 4 | 8 | 1 |
| 0 | 1 | 5 | 8 | 1 |
| 0 | 1 | 6 | 7 | 1 |
| 0 | 1 | 7 | 7 | 1 |
| 0 | 1 | 8 | 6 | 1 |
| 0 | 1 | 9 | 6 | 1 |
| 0 | 1 | 10 | 5 | 1 |
| 0 | 1 | 11 | 5 | 0 |
| 0 | 1 | 12 | 6 | 1 |
| 0 | 1 | 13 | 6 | 1 |
| 0 | 1 | 14 | 5 | 1 |
| 0 | 1 | 15 | 5 | 1 |
| 0 | 1 | 16 | 4 | 1 |
| 0 | 1 | 17 | 4 | 1 |
| 0 | 1 | 18 | 3 | 1 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |