MABR Toolbox - v0.1

Matlab Auditory Brainstem Response Toolbox

Software and Documentation written by Daniel Stolzberg, PhD - Copyright 2019

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1. Introduction

The Matlab Auditory Brainstem Response (***MABR***) Toolbox was designed for the specific purpose of acquiring and organizing auditory stimulus-locked brain responses using a standard personal computer running on the Windows operating system and high quality sound cards. The highest frequency of your auditory stimulus is determined by your sound card's maximum sampling rate. Using a high quality sound card (see recommendations below) provide up to 192 kHz sampling rate which can produce frequencies up to 96 kHz (theoretically, but in practice).

2. Getting Started

2.1. Requirements

2.1.1. Hardware

- Personal computer with quad-core processor or better and at least 8 GB memory (more processors and ram is always better).
- High-quality sound card with at least 2 input and 2 output channels; Recommended:
  - RME Fireface UCX (http://www.rme-audio.de/en/products/fireface_ucx.php)
- Differential Bioamplifier and headstage; Recommended:
  - A-M Systems Model 3000 AC/DC Differential Amplifier (https://www.a-msystems.com/p-254-model-3000-acdc-differential-amplifier.aspx)
  - A-M Systems Model 3000 Headstage (https://www.a-msystems.com/p-271-model-3000-headstage.aspx)
- Appropriate electrodes for your application and connections to your headstage.

2.1.2. Software

- Windows 10 operating system
- Matlab 2018b (v9.5) or newer including the following toolboxes and versions (or newer):
  - Signal Processing Toolbox, v8.1
  - Audio System Toolbox, v1.5
  - DSP System Toolbox, v9.7

2.2. Software Setup

- *First time installation only*
  - Install Matlab and required toolboxes (see section Software).
  - Copy the ***MABR*** folder to a known location on your computer. It is recommended to copy the folder to `C:\MABR` for the sake of simplicity.
  - Start Matlab.
  - In Matlab's command window, type `addpath('C:\MABR')` replacing `C:\MABR` with the directory where you copied the software, and hit Enter on your keyboard.
- To run the ***MABR*** Control Panel, type `MABR` in Matlab's command window and hit Enter on your keyboard. You should see a message in Matlab's command window and the Control Panel should appear momentarily.

2.3. Hardware Setup

- Connect the sound card output channel 1 to an audio amplifier and speaker.
- Connect bioamplifier output to input channel 1 on your sound card.
- Create a “loop-back” connection to ensure precise stimulus/acquisition timing by connecting the sound card’s output channel 2 to input channel 2.
- Note that this channel configuration can be customized in the ***MABR*** Control Panel by selecting “Define Audio Channels” under the “Options” menu.

3. ***MABR*** Terminology

3.1. Sweep - Refers to a recorded data in response to a single stimulus presentation. The duration of a sweep is typically 10 ms for ABRs.

3.2. Block - Refers to a group of sweeps in response to the same stimulus parameters.

3.3. Trace - Refers to a waveform created by averaging a block and is displayed in the Trace Organizer utility.

3.4. Schedule - A table that permits the selection of which stimuli will be presented during an ABR session. Each activated row of the table will generate its on block. A schedule is created using the Schedule Design utility.

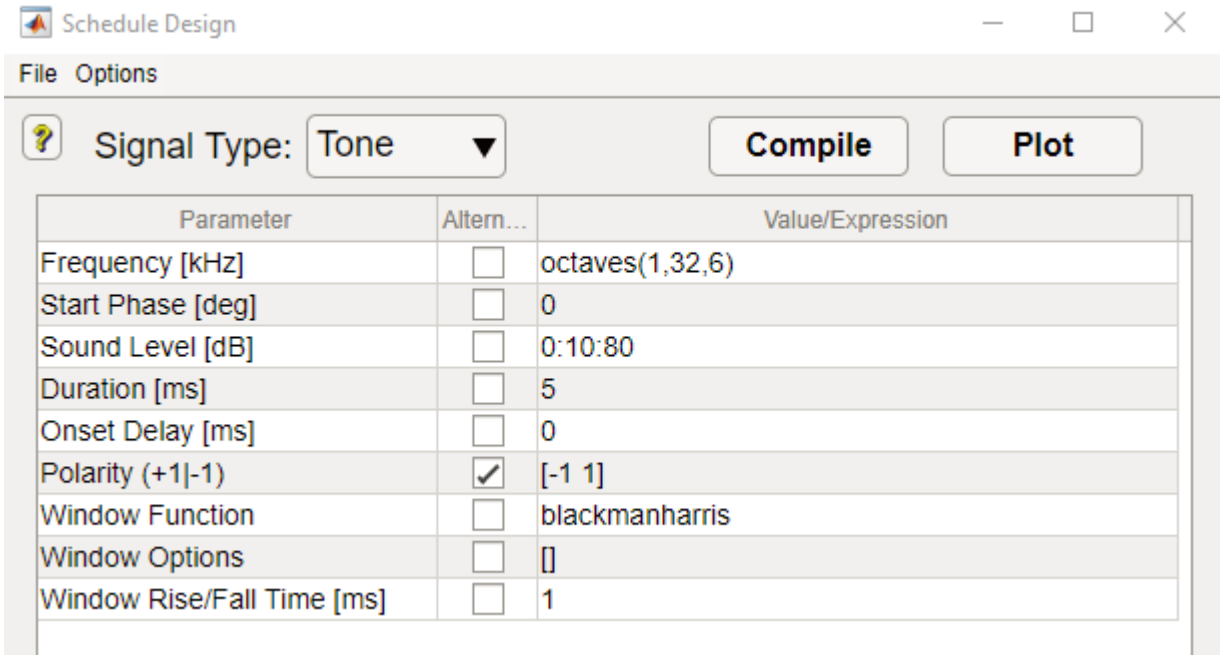
4. The Parametric Stimulus Schedule

The ABR is used to determine how the auditory brainstem responds to sounds varying across one or multiple stimulus dimensions, typically sound level and frequency. The ***MABR*** toolbox includes a "Schedule Design" utility which will help you to setup a stimulus that varys its parameters along one or more dimensions. The result of this process is a "Schedule" that will be used to select the stimulus parameters during an ABR acquisition.

4.1. Creating parametric sounds

The Schedule Design utility can be accessed in two ways:

1. In Matlab's command window, type: `abr.ScheduleDesign`
2. Click the "Schedule Design" button on the Utilities tab located on the ***MABR*** Control Panel.



Setting the Sampling Rate

The first step when creating a new schedule is to set the sampling rate. Select "Stimulus Sampling Rate" under the "Options" menu. Select the sampling rate you would like to use to generate the stimulus. Typically, this is the highest sampling rate supported by your hardware. Note that the ***MABR*** software does not know what sampling rates your sound card supports. Please select a sampling rate your sound card supports.

Signal Type

You will then need to select what kind of sound stimulus you would like to generate. Select from “Tone”, “Noise”, “Click”, “File” in the dropdown box next to “Signal Type”. Selecting a new signal type will update the property table with signal-specific values.

Modifying Signal Properties

The table on the Schedule Design utility contains signal parameters in the leftmost column. The idea is to define one or more values for each property. You can enter a scalar value for a parameter if it is constant for all stimuli. For example, the `Duration [ms]` is given a value of `5`. Note that the units for parameters are indicated in brackets. Entered values must use these units.

Parameters that vary, such as frequency and sound level in the figure above, can be given multiple explicit values. For example, the `Frequency [kHz]` parameter can be given values `[1, 3, 5, 7, 9, 11, 13, 16, 17, 19, 21]`. Alternatively, any Matlab expression that yields a row vector can be entered. For example, the `Frequency [kHz]` parameter can be given the equivalent expression `1:2:21` or `linspace(1,21,11)`.

More examples:

Parameter	Expression	Result
`Frequency [kHz]`	`[1 2 4 8 16 32]`	`[1 2 4 8 16 32]`
`Frequency [kHz]`	`2.^[0:5]`	`[1 2 4 8 16 32]`
`Frequency [kHz]`	`octaves(1,32,6)`	`[1 2 4 8 16 32]`

The “Alternate” column contains only a checkbox. Currently, this is only enabled for the `Polarity (+1|-1)` parameter. This will enable/disable a flag to alternate the polarity of the signal on each stimulus sweep.

Compile

Once you have all parameters defined for your needs, click the Compile button. This will launch a new Schedule utility window containing the generated schedule. Make sure to save the generated schedule in the Schedule utility as this is what will be used by the ***MABR*** Control Panel during an ABR session. For more details, see the section on modifying the parameter schedule.

Save/Load

You can save or load a Schedule Design file using the “File” menu.

4.2. Calibrating parametric sounds

The Calibration utility can be accessed in two ways:

1. In Matlab's command window, type: `abr.CalibrationUtility`
2. Click the "Sound Calibration" button on the Utilities tab located on the ***MABR*** Control Panel.

* Note that startup may take a few moments while a second instance of Matlab is loaded in the background.

The calibration procedure

4.3. Modifying the parameter schedule

5. Acquiring Auditory Brainstem Response

5.1. MABR Control Panel

5.2. Live ABR Display

5.3. Trace Organizer

5.4.