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Auditory Brainstem Response (ABR) Testing

Whenever a sound wave is detected by the ear, it triggers a number of neuro-physiological responses along the auditory pathway. An action potential is conducted along the eighth nerve, the brainstem, and finally to the brain. About a third of a second after initial stimulation, the signal evokes a response in the area of the brain where sounds are interpreted. These response signals are so small that they are frequently masked by the "background noise" of electrical activity in the brain. This interference is random with respect to the initial stimulation. If you find an average of this interference signal, it will approach zero. However, since the evoked response is dependent on the stimulus, it should occur at the same time relative to the stimulus when the process is repeated. Therefore, if you repeat this stimulus-response process many times the "background noise" will disappear and what will be left is the neuro-physiological response of principal interest.

This is the basis behind Averaged Brainstem Response testing. It can be used for neurodiagnostic purposes to detect lesions on the eighth nerve and brainstem and can also be used for threshold testing. The purpose of averaging is simply to enhance the target response while minimizing background noise.

There are five general response categories based on when they occur relative to the stimuli. This time lag between stimulus and response is referred to as the **latency**.

- **Fast** responses occur anywhere between 2 and 12 msec after stimulation
- **SWR** responses (slow wave components of the brainstem) occur about 12 msec after stimulation
- **Middle** responses occur 12 to 50 msec after stimulation
- **Slow** responses occur 50 to 300 msec after stimulation
- **Late** responses occur 250 to 600 msec after stimulation

Also, choice of stimulus can change the latency of some responses. Many different types of stimuli can be used, but they can generally be classed into clicks, tones, and white noise.

One of the most important factors in ABR testing is reducing the amount of impedance between the

electrode and the skin's surface. Impedance, also called resistance, is the measure of opposition to the current in a circuit. High impedance can be caused by excess dry skin, long hair, or the presence of scar tissue and has the detrimental effect of hiding or altering the acquired data. Proper skin preparation must take place so that the least amount of impedance is present and optimal skin contact is obtained.

To detect and record your subject's auditory brainstem response with the MP data acquisition system, set all of the hardware and software parameters as stated below. These have proven to be optimal for ABR testing, although many of the settings can be customized to account for individual testing preferences.

Equipment

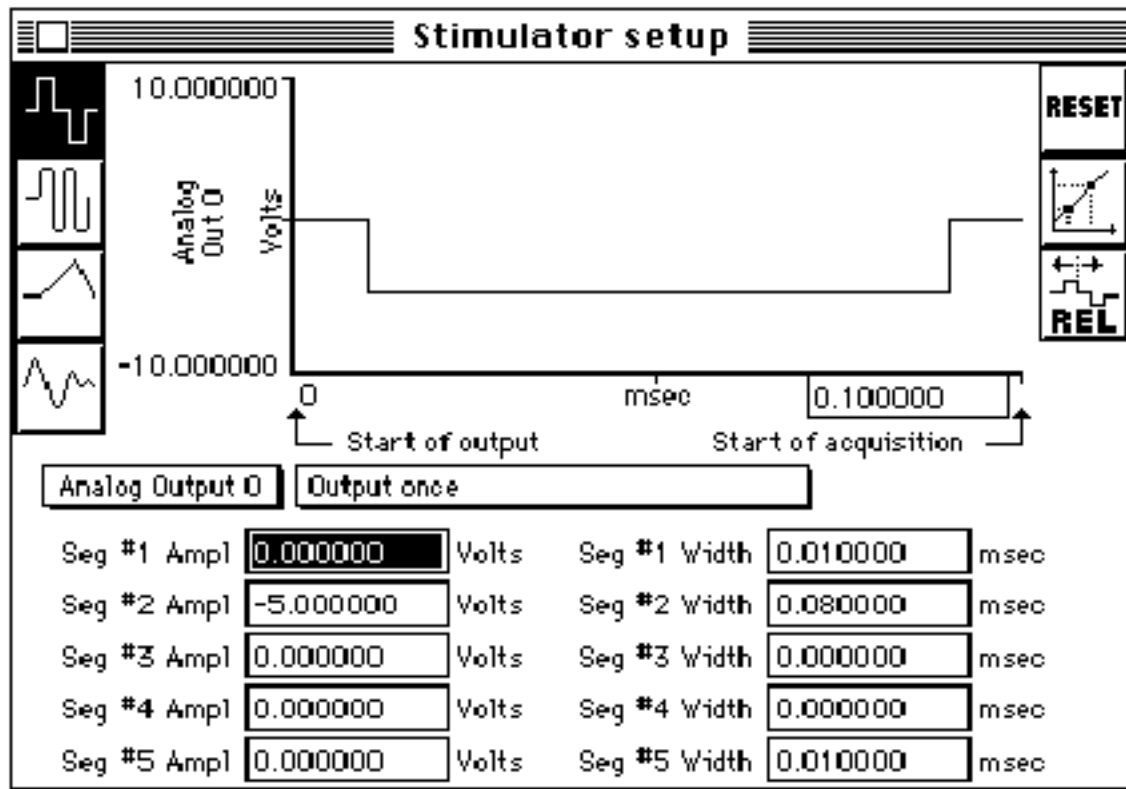
- MP acquisition system (MP100 or MP150)
- Evoked response amplifier module (ERS100A)
- Stimulator module (STM100A)
- Tubephone (OUT101)
- 3 x disposable electrodes (EL503)
- Unshielded lead (LEAD110)
- 2 x Shielded leads (LEAD110S)

Hardware Setup

1. Connect the MP unit to the computer.
2. Connect the STM100C module to the UIM100C and the MP unit.
3. Connect the ERS100C to the free side of the UIM100 (see attached diagram).
4. Power up the MP unit.
5. Set the ERS100C module:
 - a. Channel 1
 - b. Amplifier sensitivity to 5,000
 - c. Filter OFF
 - d. HI PASS filter set to 1Hz
6. Set the STM100C module:
 - a. OUT 0
 - b. AC/DC switch set to DC
 - c. POS/NEG switch set to POS
 - d. Level set to 100%

Software Setup

1. Start *AcqKnowledge*.
2. Under Setup Channels, select channel 1 and scale it to read in "mVolts"
3. Under Setup Acquisition, set storage to Averaging; sample rate to 20,000 samples/second; acquisition length to 50 msec
4. In the Averaging setup dialog box, set the number of averages to 1000 and the latency to 150 msec.
5. Under Setup Stimulator, set parameters as shown in the diagram below.



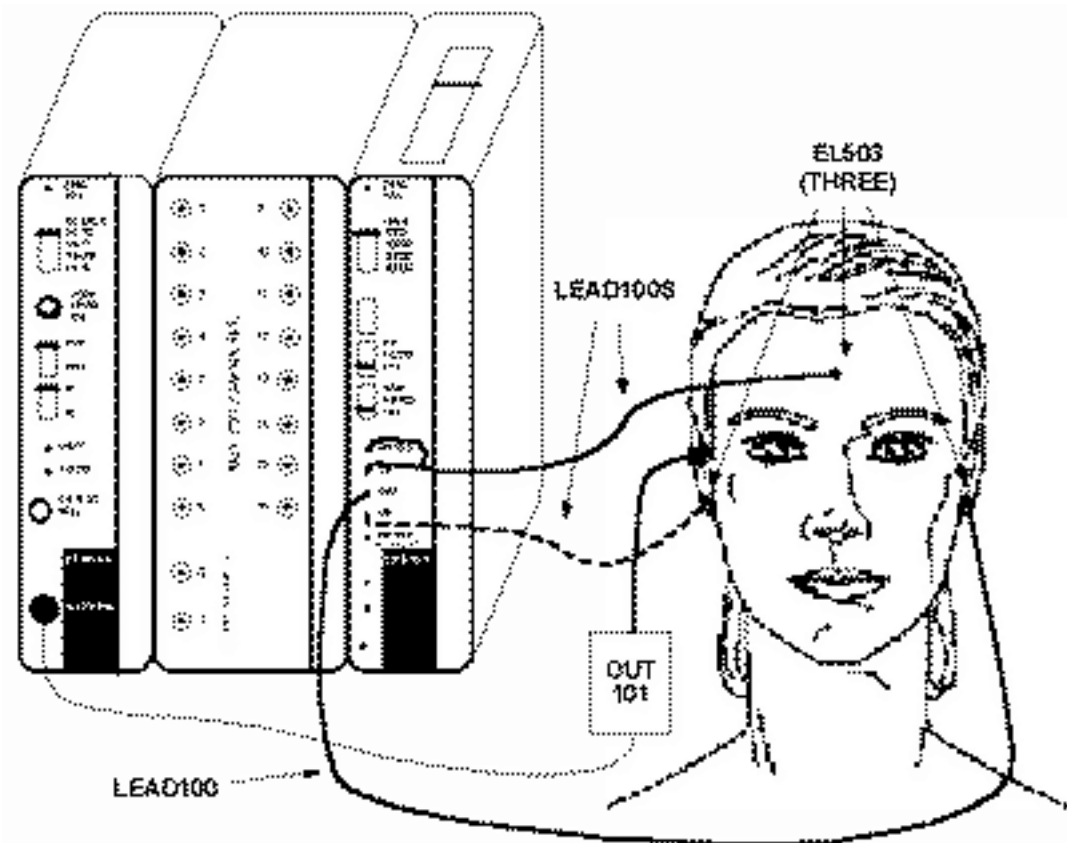
Stimulus output set to output a 0.080 msec pulse prior to acquiring data

Subject Setup

1. Have the subject insert a foam ear tip in his/her ear and connect the OUT101 to the foam plug.
 - Whichever ear the OUT101 is connected to is referred to as the **ipsilateral** ear, and the other ear is referred to as the **contralateral** ear.
2. Prepare the electrode sites to minimize impedance.
 - a. Apply abrasive skin prepping gel and/or rub BIOPAC's ELPAD on the electrode placement areas to lightly abrade the skin in order to increase electrode conductivity. This gently removes dry, non-conductive skin cells which might impede the efficiency of the electrode signal.
 - b. Apply electrode gel to the electrode in order to further increase the conductivity.
3. Place three electrodes as follows:
 - a. Ipsilateral earlobe
 - b. Contralateral earlobe

c. Forehead

- Technically, this electrode should be placed at the vertex in the top center of the subject's head, however forehead placement is generally accepted as a more convenient alternative (see figure below).



Detail of electrode configuration and connections to UIM100

4. Connect the leads from the ERS100C as follows:

- LEAD110S from ipsilateral earlobe electrode to VIN-.
- LEAD110 from contralateral earlobe electrode to the GND.
- LEAD110S from forehead electrode to VIN+.

5. Connect the OUT101 to the EXT STIM jack on the STM100C.

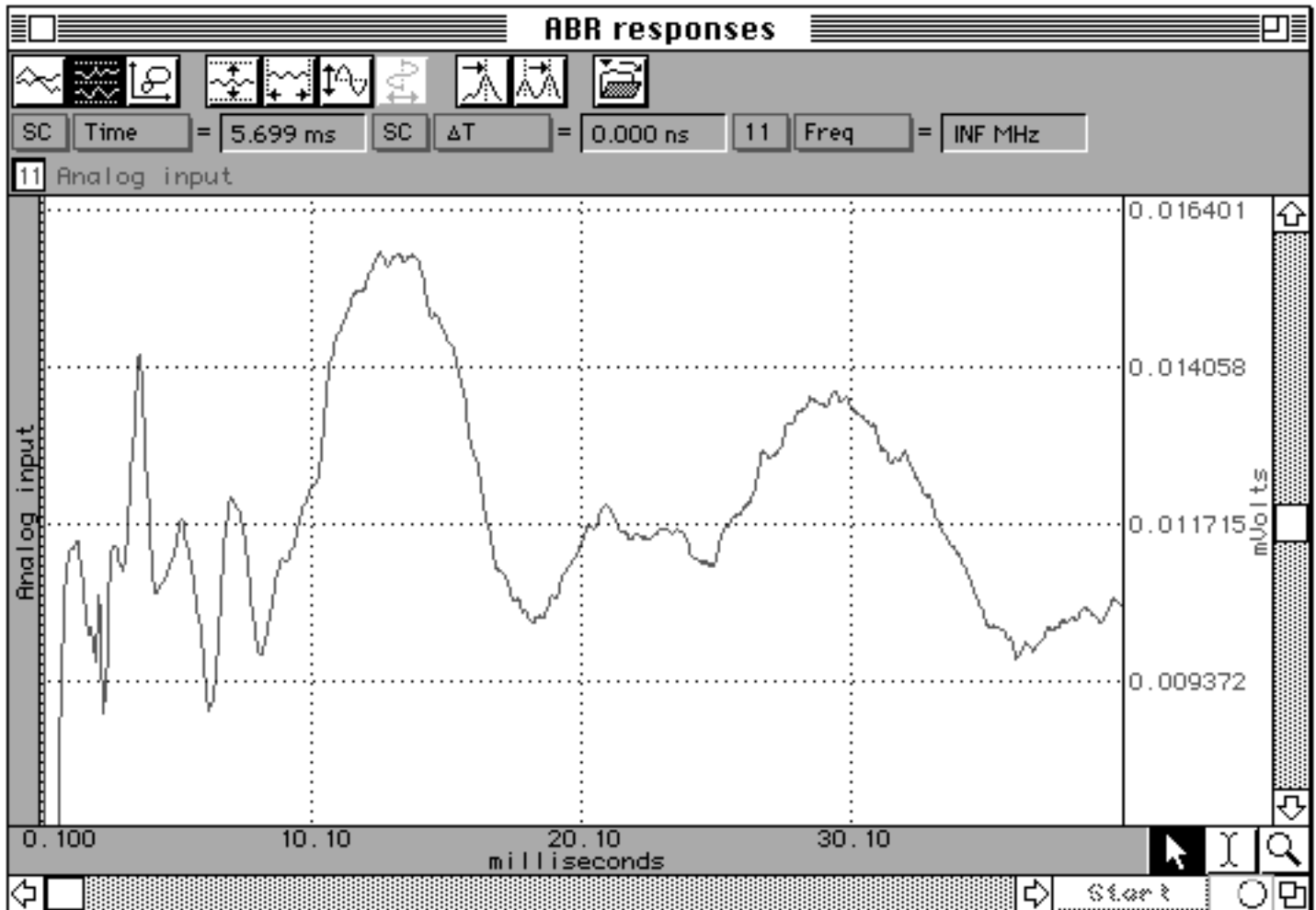
Impedance Check

Once an acceptable electrode set-up is achieved, a check can be made to determine the resistance by hooking up pairs of electrodes to an electrode tester. This will directly determine the resistance between the two selected electrodes.

- Impedance levels as low as 1 or 2 KOhm can be maintained with proper skin preparation, however 5 or 10 KOhm is acceptable.
- The Stimulator will output a 0.080 msec pulse through the STM100C. When the pulse is output through the OUT101, it will sound like a click.

Recording

The first waveform plotted may appear somewhat random, and as each trial is acquired, the waveform will reflect the average of all previous trials. The level of background noise decreases with each trial, making the response waveforms more pronounced. Increasing the number of averages will result in a more robust pattern of responses, although it will take longer to complete the acquisition.



Auditory Brainstem Responses from 0 to 40 msec (smoothed)

Analysis

In order to insure accurate representation of your graphical data, you will need to alter your waveform to account for at least two known discrepancies.

- A. The *AcqKnowledge* software has a built in feature that ignores the first two samples, which are occasionally corrupted. This is done so that remnants of the stimulus signal and its echo are not recorded in the acquisition. The time elapsed during these two samples must be added back onto the beginning of the acquisition.
- B. There may be external hardware delays which require adjusting. Depending on the type of

earphone used, a minor modification may need to be made. Some earphones, such as BIOPAC's OUT101, delay the stimulus signal by 1 msec and others may not delay the signal at all. This will cause the first millisecond of each acquisition to be "lost".

In order to counter both of these circumstances, you will need to change the horizontal axis. By readjusting the horizontal axis, you will counter the effects of both internal and external differences in timing so that responses to the stimuli are correctly measured.

1. Select Display > Horizontal Axis to generate the Horizontal Scaling dialog (shown below).

Horizontal scaling

Time (ss.sss) Frequency
 Time (HH:MM:SS) Arbitrary

sample interval: seconds/sample

first sample: seconds

Horizontal Scaling Dialog

2. Use the formula to determine the "first sample" so that it reflects these two variations. By default, *AcqKnowledge* will automatically correct for the first two samples, however for the sake of simplicity, use the following formula:

$$\text{first sample} = -(\text{delay by external earphone apparatus in msec}) + (2 / \text{sampling rate})$$

3. Enter this number in the "first sample" box.
 - o For example, if you are using a BIOPAC OUT101 and sampling at a rate of 10,000, you would enter "-.0009" seconds.

Option #1 - Focus on Faster Responses

You may want to shorten the duration of the acquisition and decrease the sampling rate in order to focus on the faster responses (such as the Jewett sequence of wavelets) which normally occur between 2 and 10 msec.

- Click here for [Application Note #105B](#), which is an ABR application note that focuses on the Jewett sequence, or contact BIOPAC and ask our Technical Support staff to fax or mail you a

copy.

Option #2 - Control Signal Amplitude (Volume)

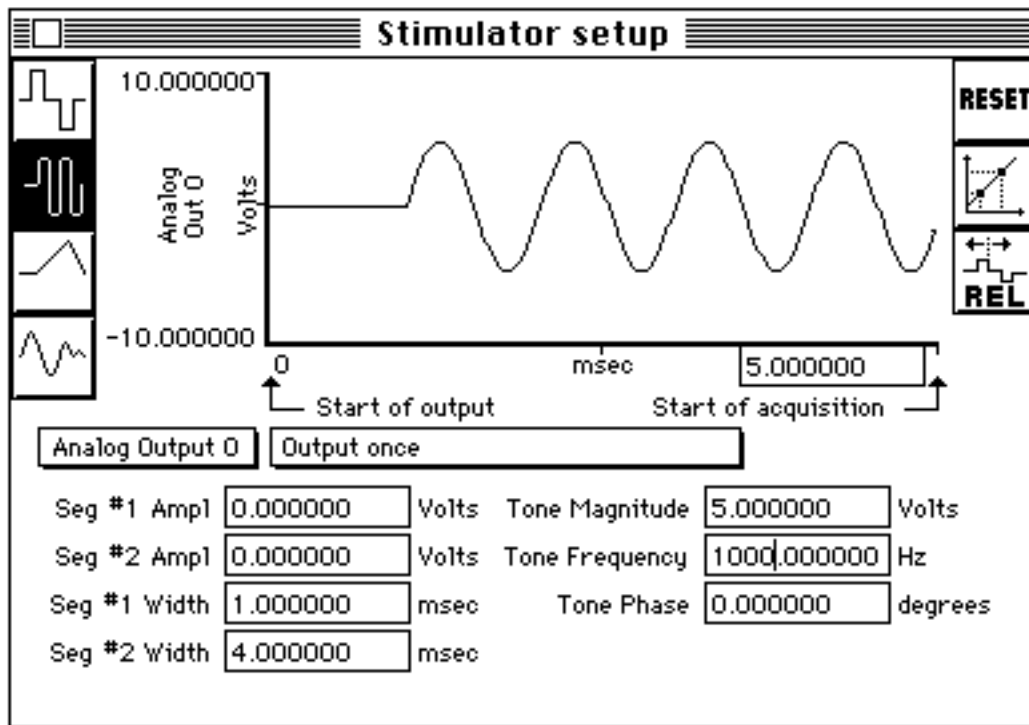
In some cases, the results of the ABR test can be dependent on the amplitude (volume) of the signal. You can control the amplitude of the stimulus signal through the Manual Control dialog options. The Manual Control option attenuates the signal output through the STM100C. To attenuate the signal to a given dB value:

1. Turn the level setting on the STM100C to 100%.
2. Select MP menu > Show Manual Control.
3. Since the signal is being output through the STM100C, check the STM100C box in the upper left corner of the dialog box. This will cause a scroll box and text field to appear, allowing you to change the extent to which the signal from the STM100C is attenuated.
4. Adjust the attenuation level either by moving the scroll bar or entering a value in the STM100C attenuation text box.
 - Since the stimulator module will limit the output signal to 128 dB, attenuating a full scale signal (one scaled to +/- 10 Volts in the scaling window) by 40 dB will result in an 88 dB signal.

Option #3 - Output Variations

In addition to pulse signals, the Stimulator Setup dialog also has options to output pure tones, "tone pips" and other types of waveforms through the Analog Output channels (Out 0 or Out 1).

The Setup Stimulator dialog box changes somewhat when Averaging mode is selected, and the sample dialog below illustrates how a 5 msec tone (at 1000 Hz) would be output.



Settings for 5 msec tone (at 1000 Hz)

When Averaging mode is selected, the time base of the Stimulator Setup window changes so that you can edit the total duration of the stimulus signal. In the example above, the total stimulus signal is 15 msec, even though the actual tone is only 5 msec.

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