Steady State Responses
using SmartEP-ASSR

What is ASSR?

Auditory Steady State Responses are potential differences generated when a person's ear is stimulated with a series of repeating stimuli. The potential difference originates in the VIII cranial nerve and the auditory brainstem system. These potential differences can be evoked using controlled repeated stimulation, allowing acquisition of these differences by averaging the acquired signal over a specified period of time. As the following graphic shows, the sequential stimulus train generates an equivalent sequence of Auditory Evoked Potential responses that overlap due to the high repetition rate; these overlapping responses add up to a steady state response.
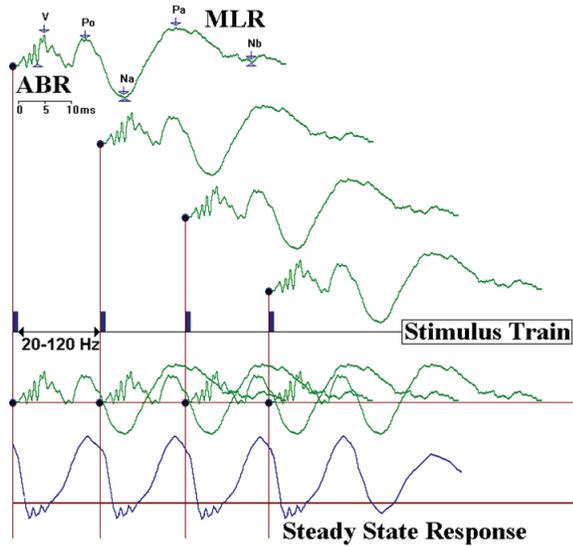

Fig.1 - Steady State Responses

The recordings acquired will contain a particular frequency spectrum based on the repetition of the stimulus used, usually 70 to 110 Hz. Stimulation may be provided either as a series of repeated pure tones or as AM and/or FM modulated tones. The amplitudes of those responses, when analyzed using the frequency domain and polar plots, can be used to determine hearing thresholds using signal detection algorithms and statistical analysis. The use of specific repetition rates for each audiometric frequency and the analysis using the frequency domain allow the use of multiple frequencies per ear to be tested simultaneously. These techniques help to eliminate the guesswork from threshold determination.

Why Acquire ASSR?

ASSR can be used for screening and frequency-specific hearing assessment in infants and children. Statistical analysis techniques can be used on ASSR responses to provide an objective response determination where no peak identification is required. ASSR can be recorded for multiple stimuli and both ears simultaneously. This makes them potentially much faster than tone burst ABRs. Normal hearing or sensorineural hearing loss data suggests ASSR thresholds are comparable with tone-evoked ABR thresholds.

Patient Preparation

The patient must be placed in a comfortable and quiet environment, preferably a sound booth where the patient lies down on a comfortable bed. The patient should be instructed to relax and, preferably, try to sleep during testing to reduce noise. It is recommended that the patient avoid stimulants, such as caffeine, before this procedure. Electrodes may be placed in the following configuration for a dual channel system:

- **Inverting (-):** Corresponding right and left mastoids, or earlobes.
- **Non-Inverting (+):** High forehead, joined with a Y-adapter.
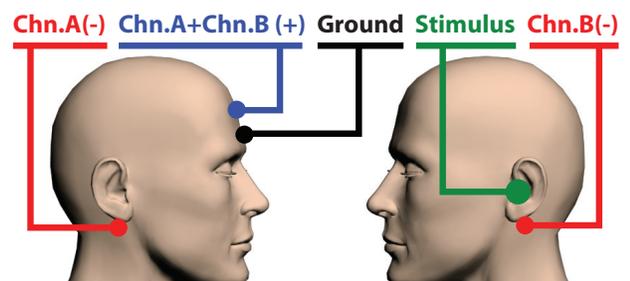- **Ground:** Low Forehead

Fig.2 - Recommended Electrode Placement

It is recommended to test both ears, in a dual channel system. Using a dual channel setting

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will allow you to record ipsilateral and contralateral recordings, decreasing test time by doubling the chances to obtain response. For a single channel unit: connect the **RED** electrode position (-) to the right mastoid, connect the **BLUE** electrode position (+) to the left mastoid and connect the **Black** electrode position (ground) to the high forehead. Make sure to set the switch on the Opti-Amp to the test ear position. Consult the SmartEP-ASSR manual for additional electrode placement options.

Electrode Usage

Surface electrodes are sufficient for acquiring ASSR recordings. Clean and prepare electrode placement sites in order to reduce impedance and acquire a clearer recording.

Special Considerations

- Make sure that electrode cables are away from insert earphone cables or other devices that may cause interference.
- Braid electrode cables when possible to reduce noise.
- For infants, keep in mind that insertion gains in small ear canals will cause higher output intensities (+10-20 dB).
- Do not stimulate at very high intensities unless you suspect a severe hearing loss.
- When stimulating at very high intensities (>90 dB SPL), minimize the stimulation time. After 3 minutes, stop and evaluate the results. Prolonged exposure to very high intensities WILL damage hearing!

Setting up SmartEP-ASSR

Complete the following steps in the order outlined, use the test setting that best fit your requirements or use the recommended settings shown on the next section:

- If testing other than the four standard frequencies, change the stimulus by selecting the desired check boxes from the stimulation panel and then clicking on "Activate Stimuli", or select the files directly from the **[STIMULUS]** menu.
- Select the desired number of sweeps from the **[STIMULUS]** menu, as needed.
- Click on the **[EEG AND AMPLIFIER]** button on the control panel to ensure that the artifact rejection level is appropriate for each channel and that the incoming EEG is acceptable.

- Press the **[LEFT]**, **[RIGHT]** or **[BOTH]** buttons to start acquisition.

SmartEP-ASSR allows automation of the acquisition process. To start an Intensity Sweep series in 10dB increments, select one of the options from the **[PROTOCOL > INTENSITY SWEEP]** menu. It is also possible to create a custom protocol, consult your user's manual to learn how to create your own testing protocol or how to save your settings for future use.

Automatic Stopping Rules

The software will stop acquisition automatically when one or more of the following options are selected from the protocol menu:

- **Residual Noise (Auto-Stop Level):** Measured in the time domain as the peak-to-peak amplitude of A-B; where A and B are the two internal recording buffers. The stop level is user selectable (typically 0.7 uV).
- **Response Detection (Auto-Stop All Response):** When a response is detected for all of the carrier frequencies being tested.

Acquisition will always stop once the Maximum Sweep Count has been reached. This maximum can be found in the **[STIMULUS]** menu.

Strategies for Shorter Test Time

To determine thresholds, the software analyzes the response in the frequency domain and looking at the locations where the response is expected. For faster testing you may observe the incoming data and use your best clinical judgment to determine if it is acceptable to stop acquisition based on the system scoring criteria.

You can observe all the values used for scoring a response by activating the "Show Table" check mark at the bottom left of the Analysis window. Signal and Noise amplitude can be observed directly from the FFT graph as shown below.

- **Signal Amplitude:** > 0.0125 uV
- **SNR of the signal:** > 6.13dB
- **Noise Amplitude:** < 0.05 uV
- **SNR of Side Bins:** > 6.13 dB
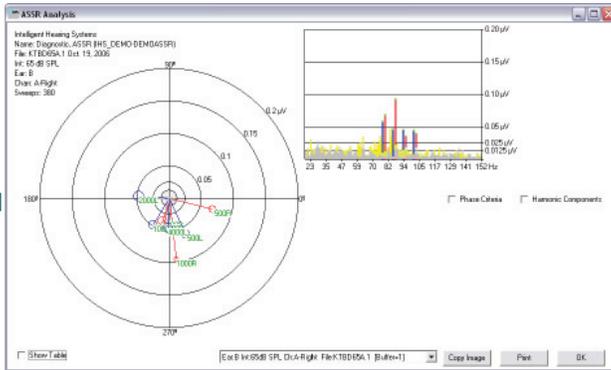
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Fig.3 - SmartEP-ASSR Analysis window

In order to speed up testing, you can refer to the following guidelines:

- If all responses are well defined, have been showing green colored labels for multiple blocks and are high above the noise floor, the recording may be stopped and you may move to the next intensity level.
- When acquiring well defined responses you may consider using a 20 to 30 dB lower intensity for the next set.
- If a response is not present at a particular frequency at a high intensity, do not expect it at a lower intensity; remove it from the next stimulus set. You may test that frequency by itself later.
- A recording with non-improving high noise floor may be stopped, and may require that some noise reduction measures be taken, or that the patient be given further instructions.
- Recordings may be stopped if there are very small changes in the response amplitude while the noise remains low.
- A single frequency run should be attempted when a response is not found at one of the four frequencies, or it is taking too long to be detected.
- Single frequency recordings should also be attempted for confirmation of the hearing threshold at each of the tested frequencies.

Recommended Test Settings

This table shows the recommended settings for ABR acquisition:

- **Stimulus:** 500 Hz, 1 kHz, 2 kHz, and 4 kHz tones; binaural stimulus at repetition rates of 70 Hz to 110 Hz.
- **Transducers:** Insert Earphones.
- **Intensity:** 70dB SPL for starting point, then up or down for threshold search.
- **Filters and Gain:** fixed by software.

- **Notch Filter:** OFF, Only ON if there is excessive power line noise present.
- **Analysis Time Window:** 1 second.
- **Sweeps:** 400 maximum.
- **Electrode Montage:** Ipsilateral array.

Audiogram

The software can generate an audiogram automatically based on the responses located on a report page from the SmartEP-ASSR program. Recordings from multiple sessions an be used to build the audiogram as long as they are placed on the same report page.

To show only the threshold, uncheck the **[PLOT INDIVIDUAL TRIALS]** box. To show all passing frequency-intensity combinations that passed, have it checked. To show all combinations, wether a response was found or not, uncheck the **[RESPONSES ONLY]** box.

Corrections may be applied to view the response in the HL scale.
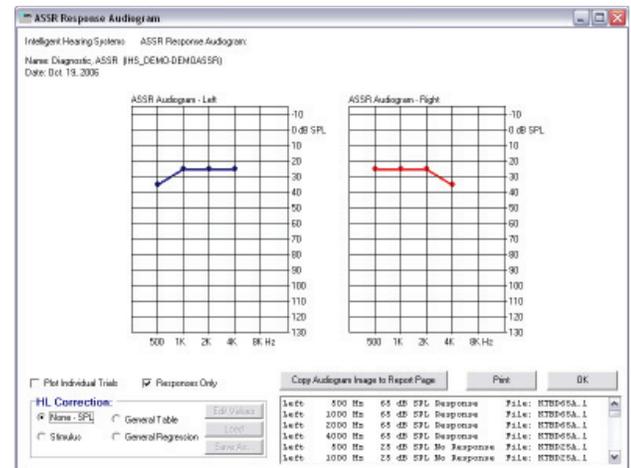

Fig.4 - SmartEP-ASSR Audiogram window

The HL scale shown can come from many sources. To avoid confusion, the source is indicated by two small letters after the HL label.

- **HLcg:** General Table Correction
- **HLcs:** Stimulus Table Correction
- **HLcr:** Regression Table Correction