

What is LLR?

Late Latency Responses, also known as ALR, are components of the auditory evoked potential response. The LLR response is found between 50 and 250 milliseconds from the time of stimulation, after the ABR and MLR.

LLRs appear to reflect the response of the auditory cortex. As with ABRs, LLRs can be acquired with the use of pure tone stimulation with an applied envelope (tone-bursts). The LLR response is of very low frequency (under 30Hz) and has a common voltage range between three and ten microvolts.

The waveforms acquired will contain certain peaks and valleys. In an LLR waveform, the peaks are given by a positive potential difference, which are labeled with a P; the valleys are given by negative potential difference, which are labeled with an N. The first peak, P1, is commonly found at 50 to 80 milliseconds from stimulation. The next peak, P2, may be found 150 to 200 milliseconds from stimulation. The first negative voltage, N1, is found between 100 and 150 milliseconds. The second negative voltage, N2, is commonly found between 180 and 250 milliseconds. LLR responses are most commonly acquired using surface electrodes in Fz-A1-A2 or Fz-A2-A1 configurations for right and left acquisition respectively.

Why acquire LLR?

Late Latency Responses may be used to diagnose certain auditory conditions. This type of testing can provide very useful information about hearing loss in a patient.

LLR testing can help determine the amount and type of hearing loss at specific frequencies, (i.e. hearing threshold), in children and adults, depending on the cause of hearing impairment. LLR testing can also provide information about the presence of nervous system abnormalities, particularly referring to levels above the auditory brainstem.

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 must be instructed to relax during testing. If possible, patients should avoid stimulants, or any kind of drug that may affect the nervous system.

Electrode Placement

Electrodes may be connected using the following configurations as shown below. Inverting electrodes may be placed at the mastoid or ear lobe. See SmartEP manual for additional placement options.

- **Right Inverting (-):** right ear (M2) or (A2).
- **Left Inverting (-):** left ear (M1) or (A1).
- **Non-Inverting (+):** joined channels to high forehead (Fpz) or vertex (Cz).
- **Ground:** low forehead.

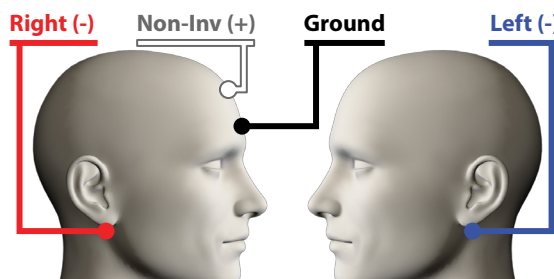


Fig.1 - Dual channel setup for Duet.

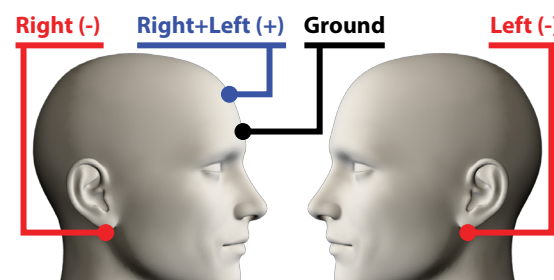


Fig.2 - Dual channel setup for USB and USBjr.

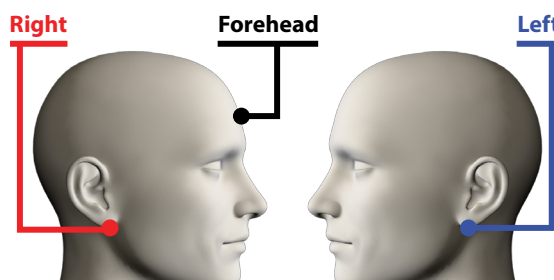


Fig.3 - Single channel setup for USB and USBjr.

Electrode Usage

Surface electrodes are sufficient for acquiring LLR waveforms. Clean and prepare electrode pacing sites in order to reduce the impedance and acquire a clearer waveform. You must use pediatric electrodes with infants.

Acquiring LLRs with SmartEP

LLR acquisition is a built-in function of SmartEP. A few clicks of the mouse will allow you to start LLR acquisition. Complete the following steps in the order outlined, use the test settings that fit your testing requirements or use the recommended settings shown on the next section:

1. From the SmartEP main menu, select **[PROTOCOL > MODALITY > AUDITORY > LLR]**. This option will apply the necessary settings and scales to start acquisition.
2. Click on the **[AMPLIFIER]** button from the SmartEP right side panel and set the filters, notch filter, desired amplification and artifact rejection ratio and region for each channel, as necessary. Click **[OK]** to set the parameters and close the window.
3. Click on the **[STIM]** button on the SmartEP control panel and select the proper stimulus and stimulation options. Click **[OK]** to set the parameters and close the window.
4. On the control panel, set the rate, phase, mode and sweeps as needed.
5. Click on the **[ACQUIRE]** button on the control panel to start acquiring for the selected ear.

You may save this setup by clicking on the **[SAVE SETTINGS]** button from the control panel. These parameters can be loaded using the **[LOAD SETTINGS]** button in future sessions.

Suggested Parameters

This is a general guideline for acquisition of LLR responses. It is recommended to acquire 2 to 4 waveforms to properly assess repeatability of the response.

- **Stimulus:** 40 milliseconds tone burst.
- **Frequency:** 500 – 8000 Hz, as needed.
- **Transducers:** insert earphones.
- **Rate:** 1.1 per second.
- **Polarity:** alternating.
- **Intensity:** 70 dB HL.
- **Low Pass Filter:** 0.1 or 1 Hz
- **High Pass Filter:** 30 Hz.
- **Notch Filter:** OFF, only turn ON if excessive power line noise is present.
- **Amplification:** 50K.

- **Analysis Time Window:** from 0 to 500 milliseconds.
- **Sweeps:** 250.
- **Electrode Montage:** Ipsilateral or Contralateral Array.

Marking Peaks

To help you diagnose a condition accurately, you should first place the applicable labels on the recently acquired waveform in one of the following ways. Select the waveform and then, either:

- Click on the button corresponding to the label you wish to place from the SmartEP tool bar. The label button will turn red. Click again on the general area where the label is to be placed.
- Right click at the point of the waveform where the label is to be placed. From the pop-up menu, mouse over the **[MARK PEAK]** option. Then, select label to be placed (P1, N1, P2, N2, P3, N3).

Once the label is on the waveform, drag the top marker of the labels to the appropriate place if needed. To obtain an amplitude, move the bottom marker to its appropriate location, usually the next peak or valley. Label markers may also be moved using keyboard shortcuts (see the SmartEP user manual for details)

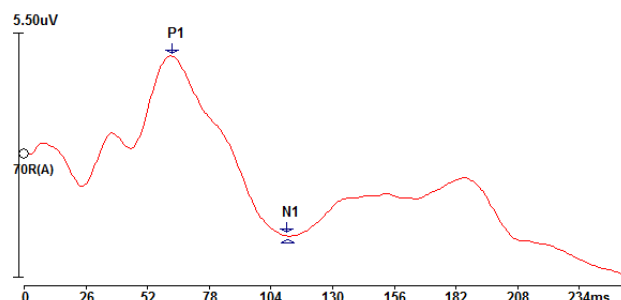


Fig.4 - LLR waveform with suggested labeling.

The graph shows suggested label placing for an acquired LLR. Since label placement is subjective, all results must be evaluated by an audiologist, or other medical professional, trained in LLR techniques.

Printing

Select Print Pages or Print Page from the SmartEP main Menu to print a report of the currently displayed signals. The report pages may also be saved to an electronic record (PDF files) using the corresponding menu options. See the SmartEP manual for other report generation options.