Late Latency Responses

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 recordings acquired will contain certain peaks and valleys. In an LLR recording, 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. It is recommended that the patient avoid stimulants, or any kind of drug that may affect the nervous system, before testing.

Electrode Placement
Electrodes may be connected using the following configuration:
- **Right Inverting (-)**: right ear mastoid (M2) or ear lobe (A2).
- **Left Inverting (-)**: left ear mastoid (M1) or ear lobe (A1).
- **Non-Inverting (+)**: high forehead (Fpz) or vertex (Cz), use a Y-adapter to join channels.
- **Ground**: low forehead.

When testing using a single channel amplifier, connect the **Red** electrode socket to the Right mastoid or ear lobe, the **Blue** electrode socket to the Left mastoid or ear lobe, and the **Black** electrode socket to the high forehead or vertex. Remember to flip the amplifier switch to the correct position before starting acquisition.

Electrode Usage
Surface electrodes are sufficient for acquiring LLR recordings. Clean and prepare electrode pacing sites in order to reduce the impedance and acquire a clearer recording. 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 \[STIMULUS > MODALITY > AUDITORY > LLR\]. This option will apply the necessary settings and scales to start acquisition.

2. Click on the [EEG AND AMPLIFIER] button from the SmartEP control 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.

3. Click on the [STIM] button on the SmartEP control panel and select the proper stimulus and stimulation options. Click [OK] to set the stimulus.

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.

Make sure to carefully select your filter settings in the EEG and Amplifier dialog box. Lack of filtering may result in excessive artifact, while excessive filtering may result in waveforms that are too smooth to assess. EEG and Amplifier settings may not need to be adjusted more than once.

**Recommended Test Settings**

Use these settings as a guideline for acquisition. It is recommended to run the test 2 to 4 times to assess repeatability of the response.

- **Stimulus**: 40 milliseconds tone burst.
- **Frequency**: 500 – 8000 Hz, as needed.
- **Rate**: 1.1 per second.
- **Polarity**: alternating.
- **Transducers**: insert earphones.
- **Intensity**: 70 dB HL.
- **Filters**: 1-30 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 accurately diagnose a condition, you should first place the applicable labels on the recently acquired recording in one of the following ways. Select the recording 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 recording 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.

![LLR recording with suggested labeling](image)

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.