Bio-logic SYSTEMS CORP

MASTER - Suggestions for Optimal Test Procedure
August 1, 2005

Patient State
Patient state is critical to ASSR testing, perhaps to a greater extent than with standard ABR testing. The frequencies of the measured response are between 80-100 Hz for ASSR so the amplifier filters are set to 30-150 Hz. In ABR, these frequencies are often filtered out since they do not always contribute significantly to the ABR. Also the ASSR response is measured in nanovolts (small) and an ABR response is measured in microvolts (larger). A relaxed, quiet, preferably sleeping patient, reclining or lying in a comfortable chair or bed, will facilitate data collection.

Electrode Montage
The standard electrode montage for MASTER, when testing both ears simultaneously, is Vertex (or high forehead) to Nape, with one of the Mastoids as ground. There is some literature that suggests that for babies using a Vertex (or high forehead) to Mastoid, with contra-lateral Mastoid as ground while testing one ear at a time may result in larger amplitude responses and cleaner recordings. Sometimes it is easier to keep the transducers in one ear at a time. Also, the binaural stimulus can be unsettling for babies in natural sleep. Therefore, more efficient test times may result from testing one ear at a time. This is also more consistent with a traditional single-channel ABR montage if you are recording both types of data and want to apply the minimum number of electrodes. A third option is to use vertex (or high forehead) to linked mastoids (a dangling jumper cable plugged into input 2 channel 1, with each mastoid plugged into one side of the jumper), with low forehead as ground. (See images of the various montage options at the end of this document.)

Modifying the Default Test Parameters
Modulation
Begin the test using the default protocol (exponential and FM enabled). Exponential amplitude modulation has been shown to increase the response amplitudes in the lowest and highest frequencies, notably at 500 and 4000 Hz. Mixed Modulation is the combination of amplitude modulation [AM] (either with or without exponential modulation) and frequency modulation [FM]. This enhances responses across all frequencies and helps reduce the test time required to reach a significant response.

Initial Intensity Level
The default in the protocol is 60 dB HL. Choose your desired beginning level based on the click ABR threshold, if it is available (e.g. if click threshold is 70, start at 80 for MASTER). For patients in natural sleep this can be critical. If the click ABR threshold is 25 dB nHL, start at 40 or 50 dB HL on MASTER. Starting at 60 dB HL can be unsettling for normal hearing patients in natural sleep. High physiological noise levels may result, which will prolong the test and perhaps make it difficult for a significant response to emerge from the noise. Another option, if you suspect relatively normal hearing (based on click threshold of <25 dB), is to consider starting at 30 dB HL and ascending, if needed. This way if you get responses at 30 you are finished!

Ending Intensity Level
The default MASTER protocol sets the intensity range to begin at 60 dB HL and to end at 30 dB HL. Since a patient's MASTER threshold is typically 10 dB higher than the behavioral threshold (15 dB at 500 Hz), terminating with a significant response on MASTER at 30 dB HL means that the behavioral threshold is approximately 20 dB HL or better. If you feel that the management of the patient would be the same whether their true behavioral response is 20 dB HL or a lower threshold, then it is not necessary to continue testing below 30 dB HL. Of course, if more precise threshold prediction is required, you can change the ending intensity level to a lower value when you begin the test. Or during data collection, you can choose the "Change Intensity" button to set a lower intensity value.

Number of Sweeps

The default maximum number of sweeps is set to collect more sweeps at lower intensities and fewer sweeps at higher intensities. However, it is not necessary to collect the maximum sweeps in all cases. For example, if significant responses emerge and continue for two or more consecutive sweeps at targeted frequencies, you can "Accept Results" or "Change Intensity" and move on to evaluate responses at a lower intensity even before the default number of sweeps has been performed.
The default maximum number of sweeps is set to fewer sweeps at the high intensities for two reasons. First, responses generally emerge more quickly at higher intensities, either because the intensity is significantly above threshold and the response amplitude is larger, or because the presence of hearing loss with recruitment causes the response to emerge with fewer sweeps even at low sensation levels. Secondly, it is not advisable to continue averaging to 32 sweeps for high intensities due to the possibility of causing Temporary Threshold Shift, and/or Tinnitus, or possible permanent damage due to prolonged high-level stimulation.

Data Collection

Deciding When to Continue Averaging and When to Change Intensity

Below are some suggestions for things to watch for during data collection that can help you predict whether a significant response may eventually occur so that you can make decisions about when to move along in the test process. All of these suggestions presume that you have low and balanced impedances (preferably 5 kOhm or lower), you have done all you can to minimize electrical artifact in your test environment, your patient is resting in a relaxed state with eyes closed, preferably sleeping, and that the transducers are adequately coupled to the patient's ear. These are core prerequisites to the collection of good quality data.

- Are the noise levels decreasing and the F-value decreasing from sweep to sweep? Continue to average until noise floor is below 10 nV (consider averaging to 5nV in infants because of smaller response amplitudes).
- Is the noise floor starting out extremely high (e.g. 125 nV) or staying high? Remember you are trying to detect a small response buried in EEG "noise". You have to reduce the noise by managing the state of the patient, improving electrode impedance or investigating sources of noise in your environment (i.e. other equipment).
- Is the noise level low (10 nV, 5 nV for infants) and F-value is high (e.g. >0.400)? The purpose of averaging is to reduce to the noise so that you can see the response. If the noise level is low and there is still no response, you are below the patient's threshold. You need to move on.
- It is useful to monitor actual response amplitude relative to the residual noise amplitude (e.g. If response amplitude is fairly stable and is less than 10 nV, the response is not likely to reach significance, even when residual noise is low – so you can move on to save some time). As a general rule, the response amplitude must be approximately two times the amplitude of the noise in order to achieve a 0.050 F-value. Monitor actual numerical response amplitudes (third row of data) and noise amplitudes (bottom row of data) in the stimulus tables rather than watching the spikes in the Amplitude Spectrum (it auto scales to make the smallest spike on the screen visible).
- Test time will only be as fast as your slowest frequency to become significant. 500 Hz will very often take longer to achieve significance than the other frequencies. You can choose to move on to pursue thresholds for those frequencies and then run 500 Hz by itself.

In general, if the noise level and the F-value are decreasing from sweep to sweep or if the response amplitude is increasing, there may be a chance that a response will eventually emerge as significant with continued averaging. However, if you have averaged a high number of sweeps and the F-value is still far from the 0.050 value or if the noise level is <10 nV (5 nV in infants), it is probably unlikely that a significant response will emerge despite continued averaging - move on. If the noise is still high after a high number of sweeps, you might be able to achieve a response by taking the time to make

your patient more comfortable or by re-prepping your electrode sites to achieve better impedance values.

True Response
Are all of the F-values at or below 0.050 and have they been "green" for at least 2-3 consecutive sweeps? If so, Accept Results to begin collection at the next lower intensity level. (At moderate intensities for a quiet patient this can occur in as few as 3-4 sweeps.)

Modifying dB Step Control
If the F-values for all frequencies are highly significant (0.000) and have been significant for at least 2 consecutive sweeps:

- You may want to consider changing the dB Step control on the collection window to 20 before selecting the Accept Results button to decrease intensity by more that the default 10 dB step. In other words, you might want to jump from 60 dB HL to 40 dB HL and skip 50 dB HL.
- Also consider a bracketing technique. Drop immediately to 30 dB HL. If significant values occur, no further testing is needed. If not, go up in 10 dB steps (or 5 dB steps if this level of precision is needed for patient management) until you reach threshold.

Waiting for a Single Frequency
Are the F-values consistently at or below 0.050 at 3 out of 4 frequencies in each ear but one frequency in one or both ears has not reached significance? Use your clinical judgment. Rather than continuing to collect data at that intensity for many more sweeps, your time may be better used to move on to the next lower intensity and collect more sweeps at that intensity. In general, as the stimulus level gets closer to threshold, you will have to average longer to achieve a significant response (because response amplitudes at or near threshold tend to be smaller). Also consider pursuing threshold for the three frequencies, then going back and running the "hold-out" frequency alone. Example- 500 isn't significant. Try running 500 by itself, using AM^2/FM. Consider varying your stimulus parameters. Sometimes a patient's ear may be more optimally tuned to different modulation parameters for different carrier frequencies. If you don't see a response for a given carrier frequency using AM^2/FM, try using AM/FM, or AM^2 alone. If you have access to the Research version of MASTER, try using a different modulation rate.

Response at Lower Intensity; No Response at Higher Intensity
The presence of a significant response can occur at a lower intensity when it did not occur 10 dB higher if you averaged significantly longer at the lower intensity or if the noise level went down. This phenomenon often occurs as the patient relaxes or begins to fall asleep during the test. However, if you get a response at one level without seeing a significant response at 10 dB **and** 20 dB above this intensity, then you should be suspicious of the result at the lower intensity and not count it as reliable. Monitor the F-value in these cases. The closer to 0.000, the more confident you can feel that you have a true response. If you are concerned about the validity of a response, repeat that frequency at that intensity. If the response is present when you repeat (particularly if the F-Value is very low) you can trust it is a true response.

Collecting Data for Sloping, Rising Configuration
It is probably most efficient to pursue threshold for those frequencies where a significant response occurs and proceed with testing lower intensities in sequence (down to no response) for those frequencies. This means you will continue stimulating some frequencies at intensities where a response is not expected. For example, if a significant response was not achieved at 60 dB HL for 4000 Hz despite sufficient averaging, you should not expect, or wait for, a response to appear at 40 dB for that frequency.

Once you have tested down to threshold for the best frequencies, begin to search for responses at frequencies where no response was achieved at 60 dB HL. You have two options.

- Immediately change the protocol and turn off frequencies for which you have achieved significant responses and threshold. Set the intensity higher as required for the targeted test frequency in each ear. This way you run less of a risk of waking the patient and introducing noise by stimulating at high sensation levels. This may make test time more efficient. Pursue threshold as you did with the other frequencies, restricting testing to a single frequency per ear above 80 dB HL.

- Selecting the Change Intensity button before the last sweep is collected at your lowest test intensity (yes, your results will be saved). Change the intensity to 80 dB HL, which is the highest intensity at which you can present multiple stimuli in an ear. In general, if the patient is quiet, significant responses should appear within 8-10 sweeps at these high intensities if the intensity is above the person's threshold.

  If no response is achieved at 80 dB HL for targeted frequencies, you will need to stop the current protocol and start a new test setting up for testing a single frequency per ear at the desired intensity. The program will not permit use of multiple stimuli in an ear with intensities above 80 dB HL due to the risks associated with high-level stimulation. But, when testing above 80 dB HL, you can still test both ears simultaneously, using the same or different carrier frequencies for each ear.

Testing above 80 dB HL

Prolonged presentation of very high intensity stimuli for which you received a "high intensity warning" message can damage hearing. Limit exposure to these loud stimuli. Because many cochlear hearing losses are accompanied by recruitment, the response amplitudes at threshold are larger and often become significant quickly without prolonged data collection. If you choose to collect more sweeps than specified in the default, consider using the High-Intensity Timeout feature to stimulate short durations with brief periods of silence to allow the ear recovery time.

Data Access

Anytime you change the protocol (e.g. air and bone data, or high intensity, individual frequency files), a new file is created. File names are created based on patient name, date, and time of test.

- To combine these files into one audiogram you need to use the Multiple File Access.
- You may wish to use MASTER Playback to replay raw EEG after test session. This is useful for verifying results, troubleshooting your system, and for training.
- One trick for keeping track of which file is which is to change the patient's "first name" to reflect the frequencies you are testing. For example, when testing .5, 1, 2, and 4 kHz simultaneously the patient's name is George Jetson. If you have to test 500 Hz by itself change the name to G500 Jetson. That way, when you use multiple file access or MASTER Playback you can quickly identify the test you want to access by the file name.

Recommendations from a Colleague who uses MASTER Successfully

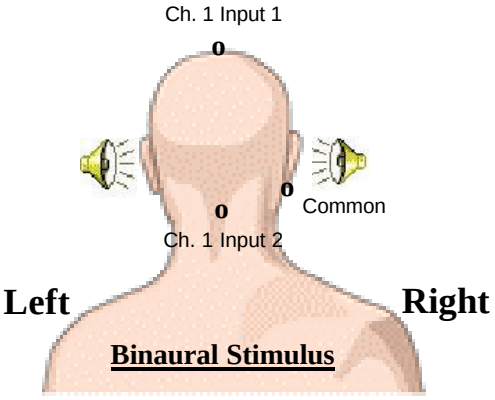
"I start with binaural click ABR stimulation and zip down to a minimal response level (never less than 20 dB nHL) and then do each ear 20dB above that level. At that point I have a general idea about hearing level and if the ears are symmetric. I then go to ASSR, concentrating on 2k and 4k starting at a level slightly above (20 to 30dB) the click. I do not wait until I get all 8 responses green. This is especially true for 500 Hz and if the baby is only 2-4 weeks old. Even a one week growth period can make a big difference in yielding better ASSR thresholds as the baby gets older. We really stress sleep deprivation. No naps in car on the way to see me. We send an instruction letter and call them the day before. We warn them that it might take two sessions. 90% of the time we are done in one. I rarely hit 30 sweeps unless I am at threshold in a 2-4 week old and even then 20 to 25 sweeps are usually

enough. I try to start with noise levels no greater than 50 nV preferably 25 nV to 30 nV. Let them settle down, restart the test at the same level, this clears the sweeps and you should have a lower noise level to start. Remember you need to drive the noise levels down to see the response. Do not wait for 8 green (significant responses) before switching levels. Get the key frequencies you need in order to answer the question of whether there is a loss and if the baby needs hearing aids etc. Getting the child to sleep usually takes longer than performing the test itself. I can get all I need in less than 2 hours (click and ASSR). Be active in your observation of response and noise levels. Plan ahead what level you want to do next, etc... Do not just be a green light watcher!!! 40 to 50 sweeps is not needed if you start with low noise levels. Always plan that the baby will wake, get as much as you can as quickly as you can. If the baby is still sleeping get the rest but start by getting what you need! Most of my testing is non-sedated. Hope this helps."

Richard Sauer MS CCC-A, Audiologist, UW-Health Hearing Services, Madison, WI.

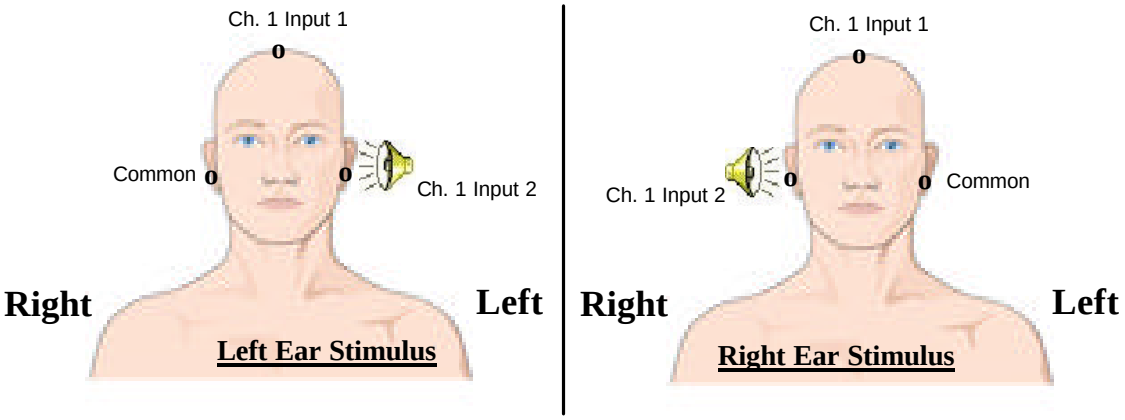
Montage Images

1-Channel MASTER-Nape Placement



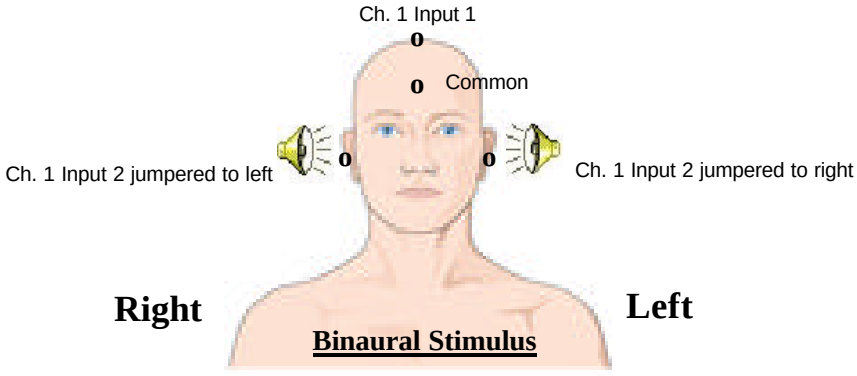
Either Mastoid can be used as Common with this montage (this example shows RE as Common). Either binaural or monaural stimulation can be performed with this montage.

1-Channel MASTER – Mastoid Placement



This montage requires manual switching of electrodes between ears. Binaural stimulation is not appropriate with this montage.

1-Channel MASTER – Linked Mastoid Placement



Place one end of the jumper cable into channel 1 input 2 (one end is dangling). Plug each mastoid into one side of the jumper. Data collection is the same as for Nape reference and binaural or monaural stimulation can be performed with this montage.