NHS
Antenatal and Newborn Screening Programmes

NEWBORN HEARING SCREENING AND ASSESSMENT

Provisional guidelines for using Auditory Steady State Responses (ASSR) in babies

Suggested parameter values for recording frequency-specific ASSR using Natus Biologic MASTER / GSI Audera / ICS Chartr EP 200/ Interacoustics Eclipse systems

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Introduction

At present there is no NHSP protocol for ASSR testing. This interim advice is provided by NHSP pending a full protocol. Use of ASSR in assessment following newborn hearing screening is described in the NHSP Early Assessment Guidelines Protocol[1] which should be read in conjunction with this document. In particular it is important to consider how ASSR fits with the overall hearing assessment process in babies.

The advice is based on experience with the Natus Biologic MASTER and GSI Audera systems but also covers the Otometrics ICS Chartr EP 200 and Interacoustics Eclipse systems. The advice is not intended to imply any relative merit of these systems over any others that are commercially available.

Equipment

Transducer:

Air conduction

For air conduction insert earphones or supra-aural headphones can be used. However at high stimulus levels inserts are recommended as they are less likely to produce stimulus artefact.

Muffins (as used in newborn hearing screening) are not recommended as the maximum stimulus level is limited and the authors are not aware of any reference data available for calibration.

Bone conduction

Bone conduction transducers have been shown to produce sufficient stimulus artefact to affect some ASSR results. Technical improvements have been made in equipment to overcome this but any responses should be checked for artefact. This is done by repeating the test with the vibratory stimulus blocked.

To achieve this, the bone conductor should lifted away from the head by a few millimetres to prevent transmission of the BC stimulus and should also be acoustically shielded to prevent stimulation by air conduction. A true bone conduction response should disappear.

Maximum stimulus levels

Care should be exercised when using high levels of stimuli. This is particularly the case for multi-frequency stimuli where the overall intensity will be higher than the level set for each single frequency. Some systems e.g. MASTER system and ECLIPSE warn the user when a single frequency should be used rather than multiple frequencies.

Electrodes:

Two ear testing

Two ear testing has the potential advantage of reducing the test time significantly. Details of this are beyond the scope of these guidelines and the reader is referred to Picton[2]

Positive: High forehead (as high as possible but avoiding the fontanelle)
Negative: Nape
Common: Shoulder or site at least 4cm from other electrodes.

NB for the ECLIPSE (2 channel) - left channel negative electrode to the left mastoid, and right channel negative electrode to the right mastoid.

One ear testing:

Positive: High forehead (as high as possible but avoiding the fontanelle)
Negative: Nape or ipsilateral mastoid
Common: Shoulder or site at least 4cm from other electrodes.

Stimulus parameters

Multi-frequency testing.

This has the potential benefit of reducing the test time when the ASSR threshold to more than one frequency is required. The reader is referred to Picton et al[3]

Modulation parameters- NB in some equipment these are fixed

Amplitude Modulation Depth: 100%

Frequency Modulation Depth: 20% (±10%)

FM to AM Phase: –90° (+270°)

Modulation Type: Enable exponential modulation (if available)
Enable FM modulation

Carrier frequencies: 500, 1000, 2000, 4000Hz

Modulation rates:

MASTER: MASTER version II variable, can be set by user. Recommendations on spread of rates are given in the manufacturer's information. This is particularly important to consider when carrying out multi-frequency testing.

Audera: 74Hz for 500Hz, 81Hz for 1000Hz , 88Hz for 2kHz, 95Hz for 4kHz.

Chartr: Use 'child asleep search protocol default'. Default rates. Right ear :88Hz for 500Hz, 80Hz for 1000Hz, 96Hz for 2000Hz and 92Hz for 4000Hz**.**
Left ear: 90Hz for 500Hz, 82Hz for 1000Hz, 98Hz for 2000Hz and 94Hz for 4000Hz**.** These rates can be modified but the default rates are recommended.

Eclipse Select 90Hz range

Stimulus levels: Normally record responses in 10dB steps.

Initial intensity level: Provisional recommendation is 50dBHL, where expected threshold (e.g. from ABR results) is unknown.

Calibration

Contact Guy Lightfoot (g.lightfoot@liverpool.ac.uk or John Stevens john.stevens@sth.nhs.uk) for further information if required

Headphones

These can be calibrated in dBHL using pure tones as follows. The method is similar to the peak-to-peak calibration of transient tone pip or tone burst stimuli.

1. The transducer is placed on a suitable coupler connected to a sound level meter. The output of the sound level meter is displayed on an oscilloscope.
2. An amplitude-modulated tone from the ASSR system (with no exponential or frequency modulation) is fed to the transducer at a known stimulus level and displayed on the oscilloscope.
3. The peak-to-peak amplitude of the modulated tone is equated (on the oscilloscope) with a pure tone from a suitable source. The frequency of this reference tone is not critical but should be within the recording bandwidth of the sound level meter. A 1kHz pure tone is a suitable choice or the frequency of the ASSR carrier.
4. The pure tone is then calibrated in dBHL using RETSPL data for pure tones (ISO 389-1)
5. This value in dBHL will be the output of the ASSR system at the set stimulus level. The ASSR system should be adjusted until they are the same value.

NB The ECLIPSE uses a chirp based stimuli and requires a slightly different procedure.

Insert earphones

These can be calibrated in dBHL in the same way as earphones using a suitable coupler for the insert and the appropriate reference levels (RETSPL in ISO389-2). However although this will calibrate the equipment for use in adults, allowance needs to be made for smaller ear canal volumes in babies, which will increase the stimulus level. See reference 1 for more details on this.

Bone vibrator

These can be calibrated in dBHL in the same way as for headphones, substituting an artificial mastoid for a coupler in (1), using a pure tone of the ASSR carrier frequency in (3) and using RETFL (ISO 389-3) reference data in place of RETSPL data in (4).

Recording Parameters

Filter settings: Fixed by system except for Chartr. Use default rates for Chartr.

EEG Reject levels: Closest equipment setting to ±10µV. A lower value than this can be used if the baby has very low EEG down to about ±5µV.

Recommended maximum recording time: 4 minutes for each run at one stimulus level.

Stop criteria for presence of a response:

A stop criteria of p<0.02 (98% confidence) is recommended to accept the presence of a response. Times to reach p<0.02 vary between test frequencies: e.g. it can often take longer to reach this criteria for 500Hz. Use clinical judgment to decide whether there is time to wait for all frequencies to reach this target or whether available time is better spent on determining ASSR threshold at a limited number of frequencies

MASTER: Stop when p<0.02. NB the MASTER system may have a default green light at p<0.05. The more stringent criteria is recommended to make determination of threshold more robust. On MASTER II software the value can be changed to p<0.02.

Audera: Fixed at >97% (p<0.03)

Chartr: User settable: Set response confidence to 98%

Eclipse: Set to accuracy option (p<0.01)

Noise floor for good recording condition:

Where this data is available the provisional recommended value is <10nV root mean square to accept that good recording conditions were achieved. Where noise is higher than this a result needs to be considered as inconclusive

Minimum recordings:
Threshold – 10dB
Threshold
Threshold + 10dB
Threshold + 20dB (desirable but not essential)

Definition of Threshold

In the NHSP AC click ABR protocol[4] the definition of ABR threshold is “the lowest level at which a clear response is present, with the absence of a recordable response at a level 5 or 10dB below the threshold, obtained under good recording conditions. The provisional NHSP definition for the ASSR threshold, for each frequency tested, is the equivalent to this, i.e. the lowest level at which the target response criteria value of p<0.02 is obtained, with the absence of a recordable

response at a level 5 or 10dB below this threshold, obtained under good recording conditions (defined as p >0.02 with the noise floor <10nV). There should also be a response meeting the p<0.02 criteria at 5 or 10dB above threshold. If threshold is at the maximum stimulus level there should be a further run at the maximum stimulus level meeting the p<0.02 criteria instead of the run at 5 or 10dB above threshold.

References

1. Stevens JC et al (2007) Guidelines for early assessment and management of babies referred from the Newborn Hearing Screening Programme. Newborn Hearing Screening Programme (England). http://hearing.screening.nhs.uk/protocols_audioassess.

2. Picton TW (2006). Audiometry using ASSR. In Auditory evoked potentials basic principles and clinical application. Burkard RF. Eggermont JJ, Don M (Eds). Lippincott, Williams and Williams, Baltimore.

3. Picton TW, van Roon P, John MS (2009). Multiple Auditory Steady State Responses (80-101Hz): effect of ear , gender, handedness, intensity and modulation rate. Ear Hear 30(1) 100-109.

4. Stevens JC et al (2008). Air conduction Auditory Brainstem Response testing in babies using clicks. A recommended test protocol. Version 2.0. Newborn Hearing Screening Programme (England) http://hearing.screening.nhs.uk/protocols_audioassess.

Further reading

5. Rance G (Editor) (2008) Auditory steady state response. Generation, Recording and Clinical Application. Plural, ISBN-13: 978-1-59756-161-7

6. Picton TW, John MS, Dimitrijevic A, Purcell D (2003).Human steady-state responses. Int J Audiol 42 177-219.