ABR Advanced Questions & Answers

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Warning: Although the following answers are based upon current BSA guidance, some personal opinions are given which may not always adhere to the guidance to the letter. Readers should make their own minds up on such issues and agree on policy with their peer reviewers. Guy Lightfoot

Q1. The residual noise criterion for RA is 25nV "average gap" or 15nV objectively reported by the NavPro or Eclipse. For the objective version, I see from appendix E of the ABR guidance that for RA, just a single run is acceptable. However, if I do two RA runs, do both need to be ≤15nV? Surely not, because if I do a weighted addition, the residual noise would be much less than 15nV.

A1. (Updated) You're right. If you do two runs, each needs to be ≤21nV because they combine to ≤15nV. You may not want to hear this, but there is a complication: the value of 15nV is suggested for caution but actually, 18nV is the best correlate to the 25nV average gap value and personally, I would argue that of the two methods, the objectively computed noise is likely to be more robust and reliable. If you go with 18nV rather than 15nV, then two runs of 25nV (to be strict, it's 25.5nV; it is pure coincidence that it is almost identical to the 25nV average gap value) combine to be 18nV. The value of 15nV was suggested because there is some spread of values in the relationship between "average gap" and the objective equivalent. The equation to calculate the residual noise of two waveforms with residual noises x & y is:

$$\text{Noise} = 1/\sqrt{\frac{1}{x^2}+\frac{1}{y^2}}$$

Don't forget that any RA also needs to be "appropriately flat, with no evidence of a response".
The next question is related, and may be of interest.

Q2. I use an Eclipse and if I mark wave V and SN10, the system reports the signal-to-noise ratio, based on the size of the response and the noise, as measured by the Eclipse. This is great; if I mark the waveform whilst averaging and keep an eye on the SNR, I can stop averaging when the SNR rises above 3. However, the Eclipse noise is not the same as the "average gap between replications" figure on which the 3:1 rule is based – there is a fiddle-factor of 25nV (RA criterion) to 15nV (Eclipse RA criterion) so is it valid to go by the SNR that the Eclipse reports? Should we be aiming at a different SNR criterion?

A2. (updated) I don't know whether you should be praised for your scientific rigour or be told to get out more! You are correct and the ABR guidance should really have covered this. Let's do that now. The ABR guidance (Appendix E, section E2.2) tells us that 25nV "average gap" noise is equal to 18nV as reported by the Eclipse. I am aware that the BSA guidance tells us to use a value of 15nV "as a caution" but 18nV is the best correlate to the 25nV average gap value and personally, I think it is likely to be more reliable then the eyeballed average gap method. That suggests that for the Eclipse we need an SNR of at least 3 x 25/18 = 4.2. However, that would be for a single waveform but at threshold, we need to replicate. If we look at the answer to Q1 above, then it isn't 18nV that we should use in the equation, we should use two lots of 25nV. So, the SNR we should aim for in each of two waveforms is a minimum of 3 x 25/25 = 3 Well, that's easy to

remember! When SNR is measured by the Eclipse, two waveforms each with an SNR of 3 combine to an SNR of 4.2, which is the same as an SNR of 3 when measured using the "average gap between replicates" method. Those numbers are equally applicable to the NavPro though on that system, the ratio is not calculated for you.
If you found Q1 & Q2 interesting, you may be interested in the presentation covering objective ABR measurements available at https://eratraining.co.uk/resources.html (Presentations column).

Q3. In a unilateral case (one ear is fine), where the AC threshold of the poorer ear is, say, 60dB I want to test the poorer ear BC, to find out if it is conductive or sensorineural. I start the BC test at 25dBeHL (on the basis that if I get a CR at 25 and 15 then I don't need to mask and I've got my answer – it is a conductive loss). If I don't see a BC response at 25 and intend going up to 35, is it worth masking the better ear from that point onwards? After all, if I do get a response then I'm going to have to mask anyway.

A3. You could do that. However, an alternative approach is not to mask and instead look at the contralateral channel to tell you whether any response is crossed. Mask only if the BC response is possibly crossed. When you do apply masking, assume the better cochlea (BC) has a 0dB threshold. If you've got tymp results then if the tymp of the better ear is not peaked (or if you haven't got tymp results) it will be worth selecting a non-test ear air-bone gap value of 20-30dB in the masking noise calculator. In fact, that may be worth doing if you didn't test below 30dBeHL by AC since a minor conductive may be present in the non-test ear. You can get a rough idea of any non-test ear conductive element from the size of the AC response. You say the better ear is fine so I presume a CR was obtained at the discharge level but if it was small then there may be a 10-20dB conductive on that side, which should be taken into account when masking.

Q4. I sometimes obtain ABRs with a sloping baseline. If it is downwards (from left to right) then the slope will make the measured response bigger than it really is and if the slope is upwards then it will make the measured response smaller. That affects the estimation of SNR (3:1). How can I get round that and what causes the slope?

A4. We now think that those slopes are a side-effect of the baby's ECG being picked up by the ABR electrodes. If so, changing the artefact rejection level often alters the slope (for better or worse!) so a quick change of AR level might be worth a try, to see if that reduces the slope. If that doesn't remove or reduce the slope, select a high-pass display filter of 50Hz if you have that facility; it will remove much of the slope. However, doing that will also reduce the size of the response slightly too, especially for low-frequency tests, so use the filter only when you need to.

Q5. A case of mine recently came back from peer review with a suggestion I think is wrong. My ABR system (I use a NavPro) doesn't quote % rejections, it gives the number of accepted and rejected sweeps. The ABR guidance suggests relaxing the artefact rejection (AR) level if rejections exceed 30% and increasing the number of sweeps to compensate. I used ±5µV throughout and the baby's state was fairly consistent – settled but sucking a dummy. Typical sweeps were 3000 accepted and 1000 rejected which the reviewer said is over 30% and that I should have changed the AR level whereas I think it is under 30%. Who's right?

A5. This is a common misunderstanding but you're right. The reviewer probably thought that the % rejections was 1000/3000 i.e. 33% but in fact it is 1000/(3000+1000) i.e. 25%. The percentage rejections is the number of rejections divided by the number of sweeps presented (in this case, 4000). All rather

academic – near that 30% value there is not a lot to choose either way. Another way of looking at the 30% rule is: if there are more than 420 rejected sweeps for every 1000 accepted then it is over 30%.

Q6. One of the CR criteria is a minimum response size of 40nV. In a recent case, at threshold, the response was 0.45nV on one run and 0.38nV on the other. Both met the 3:1 signal-to-noise criterion and there was a good CR at 10dB above. Does this combination allow me to rate this as CR?

A6. Yes. Residual noise can do that, adding to the measured response on one occasion and subtracting it on another – it depends where the bumps of noise happen to be on the waveform. In this case the average response is 41.5nV. Simple averaging of the two response amplitudes is scientifically valid.

Q7. I use the NavPro, which has a "show flat line" option for the blocking period. Why shouldn't I have that on all the time?

A7. It doesn't really matter for 4kHz tests because the blocking period is short (1.25ms) but at 1kHz and 500Hz the flat line obscures quite a lot of the waveform and that can compromise interpretation. In CM tests we want to see the stimulus artefact in order to distinguish it from any genuine CM so never use the flat line option in a CM test. The most appropriate circumstance for using the flat line option is in high level BC tests, where the stimulus artefact can be so large as to cause the waveform to span several pages on the printout.

Q8. I have a 3 week old baby and I do tymps prior to the ABR and I record flat tymps bilaterally. My expectation is that this is going to be a bilateral conductive. How will that affect my test strategy and what value should I put into the masking calculator for the air-bone gaps?

A8. Follow your normal routine, without masking, until you have obtained the AC and BC 4kHz thresholds in both ears. Then sit back and think it through. Look at the BC thresholds – if they are no more than 10dB apart then neither will not be crossed and masking will not be needed for the BC tests. If they are >10dB apart the better one will be valid but there is a risk the poorer one may be crossed, with the real threshold being higher. In cases like this, 2-channel ABR is very helpful and may be sufficient to confirm that the responses are not crossed. If you do need to mask the better ear when testing the worse ear, then go by the air-bone gap you have recorded by ABR. An alternative is to enter 30dB into the noise calculator for the air-bone gap but note that this is only playing the percentages game and may be incorrect. Just as in conventional pure tone audiometry, there are some audiometric configurations that present a "masking dilemma" that has no satisfactory solution.

Q9. My equipment is getting very old. When we get a new device apart from Trust documentation and safety processes are there any checks I should make locally to the device?

A9. New equipment should come calibrated but a thorough stage A check and a couple of tests on normal subjects should be sufficient. Spending a session in an ABR clinic of a trusted and experienced colleague with the same equipment would be a very efficient and valuable way to get up to speed and learn of the shortcuts, foibles and issue of your new system.

Q10. The guidance suggests doing 4 runs and averaging if there is any doubt, and also suggests if you have only been able to obtain three runs to average 1 and 3 and compare to 2. Say I complete two runs that I

suspect are a CR but just a little too noisy, and I run a third. By averaging 1 and 3 with 2 I now get a CR with much lower noise. Can I stop there even if the baby is sleeping and I could in theory run a fourth? Or is it reasonable to move on with testing at other levels?

A10. If after run 3 you have a comfortable CR then doing a 4th would probably not be the best use of time if there is more to do. However, do a 4th run if the alternative is putting the kettle on! As your peer reviewer or mentor, I'd want to satisfy myself that you didn't get into the habit of routinely doing only 3 runs. Good clinical practice involves the judgement of where to most effectively devote test time – the delicate balance between technical precision and maximising clinical information.

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