Author's response to reviews

Title: Tone burst-evoked otoacoustic emissions in neonates: normative data

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Author's response to reviews: see over
A list of changes and/or rebuttal against each point

Reviewer's report
Title: Tone burst-evoked otoacoustic emissions in neonates: normative data
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Reviewer: Michael Epstein

-Major Compulsory Revisions

1. The issue of the specific bandwidth of the stimulus still has not been addressed. I would strongly recommend simply recording the signal (or generating the signal in Matlab) and doing a spectral analysis to determine the bandwidth of the signal. Without this information, the degree to which this measure is frequency specific is wholly unknown. Additionally, there are arguments in the paper based on claims of spectral splatter, but no quantification.

Thank you for your valuable comments. Using the ILO OAE recording system’s ASCII files, we have drawn the waveforms and spectrums for both 1 kHz TB and click stimuli (new Figure 6; page 14). The figure shows that the 1 kHz tone burst stimulus has a narrow bandwidth, compared with the conventional click sound. The Fourier analysis of the TBOAEs indicated that the emission spectra are similar to those of the tone burst stimulus, but the maximum evoked energy of a 1 kHz TBOAE response may have a spectral spread which is not confined to the 1 kHz frequency range. Figure 6 helps to make this point clear. However, the claim of major spectral splatter on page 16, first paragraph has been deleted.

-Minor Essential Revisions

1. Page 5 "Part I": please specify the specific purpose for determining the "appropriate stimuli level." What is being optimized? Pass rate for normal-hearing infants?

As there is no standard protocol for TBOAE measurements presented in the previous literature (as summarized in manuscript—Table 1), the specific purpose of Part I was to determine the tone burst stimulus level that provided high prevalence of detectable emissions, based on consideration of prevalence findings and other factors. This has now been noted on page 5: “Part I: To determine the appropriate stimulus level for 1 kHz TBOAE response measurement, based on TBOAE prevalence rate and other considerations.” This intent has also been mentioned in the analysis section of the manuscript on page 7-8 as well as in the discussion (page 14, second paragraph).
2. Page 6 - last sentence - if the stimulus rate was 50 Hz (repeated every 20 ms),
using a 20.48 ms analysis window is not possible unless the window is somehow
padded. Can you explain this? Also, does the window include the stimulus? How is
the stimulus cancelled?

The stimulus and recording parameters have been confirmed with the Otodynamics
(London) ILO company. The default setting of tone-burst OAE (TBOAE) in the ILO
clinical V6 software is 20.48 ms response window with a stimulus delivered at the beginning
of each measurement. To avoid overlapping, the stimulus should be repeated after at least a
20.48ms interval. According to the reply from the ILO company, the stimulus repetition rate
is approximately 50 Hz (not exactly equal to 50 Hz), which implies the stimulus repetition
rate may be closer to 49 Hz. To avoid confusion, the statement has been changed to “The
analysis window and stimulus repetition rate for 1 kHz TBOAE measurements were
20.48ms and approximately 50 Hz, respectively.” (See page 7, second paragraph).

In the ILO default setting, TBOAE recordings are digitized at a rate of 25000 samples per
second, resulting in 512 sampled points within a 20.48 ms analysis window. Around the first
2.5 ms of the analysis window of 20.48 ms have been eliminated to reduce the contribution
of possible stimulus artifact to the average 1 kHz TBOAE response waveform. Therefore,
the following part of window, which is the part used in the analysis, does not include the
stimulus.

3. Page 7 - I do not think that a reference is sufficient for defining stability and
reproducability. It needs to be clarified directly in the paper. To me, high
reproducability means that if you do the test and then repeat the test at another time,
you get the same result. I am not clear what you mean here, particularly because you
give %s and standard deviations for reproducibility.

Stimulus stability reflects changes of the stimulus intensity occurring during the test. In the
ILO system it is normally calculated every 3 s and should be greater than 75% of the initial
stimulus amplitude. The ILO system distributes and stores the averaged OAE recordings
into two memory buffers, A and B. The reproducibility is calculated by the cross-correlation
between A and B waveforms which represents their similarity during data collection and
then is used clinically as a quality index of the recorded OAE (Robinette & Glattke, 2002).
Both of these two parameters (stability and reproducibility) have been very commonly used
in clinical settings and readers who have worked in the neonatal OAE field should be familiar with these two terms. However, to avoid confusion, the following statement has been added on page 8, first two lines: “This initial study used five stimuli levels (60, 65, 70, 75, 80 dB peSPL), and investigated the relationship between individual stimulus level and TBOAE parameters, including stimulus stability (which reflects changes in stimulus intensity occurring during the test and which should be greater than 75% of the initial stimulus amplitude [16]), whole reproducibility (which is calculated by the cross-correlation between A and B waveforms and which is used clinically as a quality index of the recorded OAE [16]).”

4. Page 11 - You state that the mean test duration is 57.2 seconds per ear. You stated earlier that your presentation rate was 50 Hz. This means that the average number of presentations was 2860. However, on page 7, you state that 260 is the maximum number of responses obtained. Please explain this discrepancy.

The “test time” (or test duration) records the total duration of the test, which includes time spent collecting both accepted and rejected responses. In nonlinear mode of operation in ILO system, the OAE responses are gathered from a stimulus sequence with sets of four stimuli (Hall, 2000). Three are presented in one phase with the same amplitude and the fourth is presented in opposite phase at a level that is three times greater than each of the three previous stimuli. Since the default ILO system stores the average response for one group of tone-burst transient stimuli in A buffer and the response for the other group of stimuli is stored in buffer B, if the default sampling process continues until responses are obtained from 260 sets of stimuli, the A and B waveforms each represent the mean of responses to 260*4=1040 transients or 1040 stimuli. Hence, a total number of stimuli is 2080 for recordings from the two buffers. Therefore, the stimulus duration should be around 42.6s (2080*20.48ms). However, the “Nlo” value (i.e., 260 valid, low noise responses) in V6 software represent the number of data samples accepted and processed when the noise level is below the set noise reject level (in this study, it was set as 8 mPa). When the noise level is above the set noise reject level the response is rejected during the sampling procedure and is saved as an “Nhi” (high noise, rejected responses) value. So some time is usually spent in collecting data that is rejected in the final analysis. Also, when the test is paused during recordings, which may happen with a restless baby, the test time continues to accrue. So, it is entirely possible that the final test duration/test time may be much longer than 42.6s.
5. Page 12 - Typo - The word "bust" instead of "burst"

Thank you. This error has been corrected in the revised manuscript.

6. Page 14 - The clarity of the writing needs some revision in this section.

The large second paragraph on page 14 has been revised throughout to make the meaning clearer. The page now reads, with changes highlighted: “From the Part I study, recommendations regarding the setting of appropriate TBOAE stimulus levels for newborns were made, based on TBOAE performance—which included overall mean response, whole reproducibility, stimulus stability, as well as the prevalence rate and SNR in different frequency ranges. With decreased stimulus level, all of these parameters had a trend towards reduced values. Figure 2 showed that TBOAEs evoked by lower stimulus levels (60 and 65 dB peSPL) resulted in lower whole reproducibility (< 60%), lower stimulus stability (< 90%), and unacceptable lower overall mean response (SNR < 0 dB). Stimuli levels of 70, 75 and 80 dB peSPL did not show significant differences among each other on the above three parameters. However, setting stimulus levels at 70 dB peSPL or below made for a large variation in some TBOAE parameters, such as reproducibility and stimulus stability. Also, it was demonstrated that when the stimulus level was 75 dB peSPL or above the prevalence rate for detectable 1 kHz TBOAEs was higher than 90% in the 1 and 1.5 kHz frequency bands. Therefore, based on all the above results, in the Part II study the target tone burst stimulus level was set at 75 dB peSPL using the ILO system software. The real stimulus level recorded in situ—which was measured using the ILO system—ranged from 75 to 80 dB peSPL and this was viewed as an acceptable stimulus range.”

7. Page 15 - you state that 7.23% failed at both 1 kHz and 1.5 kHz. However, on page 12, you state that the prevalence rate at 1.5 kHz is 97.4% Please explain this discrepancy. Does prevalence rate mean any positive SNR?

We are discussing different results on pages 12 and 15. In page 12, the prevalence rate of 97.4% (687/705) at 1.5 kHz was calculated from the 1 kHz TBOAE measurement. While in page 15, the 51 ears (51/705=7.23%) referred to those passed ears which still had a SNR lower than 3 dB at both 1 and 1.5 kHz by using conventional CEOAE measurement. Prevalence rate is now clearly defined on page 8 of the revised manuscript: “Prevalence rate
was defined using a criterion of \( \text{SNR} \geq 3 \text{ dB} \) [1]”. However, to avoid confusion, the statement on page 15 has now been deleted.

8. Page 15 - Even with spectral splatter, you would expect that the maximum energy should be at the frequency present in the stimulus. Again, a plot of the stimulus content would be very useful here.

Agreed, and a plot is now included. Please note new figure 6 (page 14).

9. Page 16 - You are suggesting that using TBOAEs in conjunction with CEOAEs will increase pass rate. Perhaps I am confused, but are you suggesting that if a test fails using a click, but passes using a 1 kHz tone-burst, that should be considered a pass? What about hearing losses at high frequencies? If instead you mean that tone burst should be used as an additional criterion, then more babies would inherently fail. Please clarify the basic way in which these two tests would be combined to increase the pass rate without increasing the miss rate.

The results in current study showed that 1 kHz TBOAEs were more robust than CEOAEs in terms of emission response level and SNR at comparable frequency components for both 1 and 1.5 kHz. Thus, ears which failed CEOAE testing (defined as \(< 3\) frequency bands with \(\text{SNR} \geq 3 \text{ dB}\)) screening outcome may be still considered as pass if a combined 1 kHz TBOAE/CEOAE protocol fulfills the criteria noted on pages 6 (CEOAEs) and 16 (TBOAEs) of the manuscript. We state on page 16: “By using these criteria as a reference, supplementary information in the lower frequency region may be provided by 1 kHz TBOAE measurement.” Hence the TBOAE information would only change fail status if it was used as an additional contribution to decisions regarding low frequency pass/fail. We have recently published a description of the potential application of such a combined TBOAE and CEOAE technique in neonatal hearing screening in another journal paper (Zhang, McPherson, Shi, Tang, & Wong, 2008).

10. Figure 1 - What level was the stimulus for this figure? Is this just from the results of Part II?

Thank you for this comment. To clarify this aspect of the study, a sentence has been added in page 9 second paragraph: “A 1 kHz tone burst stimulus with a target level of 75 dB peSPL usually could evoke a TBOAE response in the 1 to 2 kHz frequency range, using a half-
octave analysis (figure 1)”. Also, the figure 1 caption has been modified in the revised manuscript to reflect this point.

References