

Field Study News

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Verifying the Lyric Audibility Advantage

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Introduction

Since 2008, Lyric has presented people with mild to moderate hearing loss a unique solution: extended wear technology with deep ear canal placement that provides acoustic benefits along with complete device imperceptibility.

Although the cosmetic and ease-of-use benefits of Lyric are clear, the acoustic advantages and resulting audibility improvement enabled by the deep ear canal placement of the instrument can be more difficult for clinicians to assess. Consequently, some clinicians have mistakenly attributed the "Lyric advantage" solely to cosmetic and ease-of-use factors—disregarding the ability of the device to address their primary fitting goal of improving audibility.

In this paper, we will discuss the important role that real ear measurements play in demonstrating and verifying the Lyric Audibility Advantage.

Lyric Overview

The Lyric hearing instrument is the world's first and only deep canal, extended wear device for patients with mild to moderate hearing loss. Since 2008, Lyric has provided users with multiple benefits based on its combined novel approach: deep ear canal placement and extended, 24 hour a day, 7 days a week usability. Deep ear canal placement provides key acoustic benefits along with complete device imperceptibility, while 24 hour a day, 7 days a week usability allows freedom from daily insertion and removal, battery changes, and cleaning.

The Benefits of Deep Canal Placement

As described in multiple research articles and papers following the advent of deep canal CIC devices (e.g., Chasin, 1994; Mueller and Ebinger, 1996), locating a device deep in the ear canal can provide a number of acoustic benefits, including:

- Increased gain and output
- Greater headroom
- Reduced occlusion effect
- Improved directionality
- Reduced wind noise

The unique design and placement location of Lyric (Figure 1) enable these deep canal benefits as the device is located 4 mm or more inside the ear canal, leaving the pinna and concha unobstructed, and the receiver is located approximately 4 mm from the tympanic membrane resulting in less residual volume (Arbogast and Whichard, 2009).

In addition, to facilitate consistent access to these acoustic benefits across patients, the sizing and device insertion system

used with Lyric is designed to enable appropriate placement of the device by the trained Lyric hearing healthcare professional.



Figure 1. Lyric hearing device by Phonak

The Importance of Audibility

In order for patients to fully realize the Lyric acoustic benefits outlined above, Lyric fitting software is designed to account for deep canal-specific factors and generate optimized output that is audible across a wide input and frequency range without discomfort.

While the actual gain/output levels required for various hearing losses in each patient's case may be up for debate, there is no doubt that audibility is the foundation for hearing aid benefit. To paraphrase David Pascoe (1980), while it is true that mere detection of sound does not guarantee its recognition, it is even more true that without detection, the probability of correct identification is greatly diminished.

To increase the likelihood that the initial programming of the Lyric device is appropriate for each patient (i.e., meets the goals of audibility, comfort and good sound quality), the fitting software pre-calculation is based on an industry standard fitting formula, NAL-NL2, while also capturing the unique acoustic attributes of the Lyric deep canal hearing device. Given the individual variability in ear canal acoustics and associated interaction with the placement of the hearing device, the clinician would be well served to verify that the initial settings have achieved the goal of providing audibility.

Audibility Verification Method Overview



Clinicians resort to multiple verification techniques to document the combined impact of acoustic factors and programming parameters on patient audibility. Among these is a subjective method of interaction with the patient, sometimes referred to as the **"How Does That Sound?"** approach. While this is an important aspect of audibility to assess during the verification process—that the patient is happy with the sound provided by the

device and is willing to use it as configured—there are a number of limitations to relying solely on this approach.

For instance, the signal levels/types used during this procedure can be highly variable (e.g., uncontrolled, inconsistent) and may not necessarily tell us the whole story regarding how the device will perform in the real-world across multiple input levels.

There is also some error introduced by the nature of this approach involving a behavioral response where there is undoubtedly a level of test-retest variability. This variability can make it difficult to systematically assess that a particular setting change is appropriate and will result in a beneficial audibility improvement.



The **"aided audiogram"** is another method sometimes used by clinicians to verify hearing instrument performance (Figure 2). This technique is helpful in assessing the softest sound a client

may hear for distinct frequency signals and in that respect can provide useful information regarding auditory performance with amplification. It can also prove helpful in problematic real-ear measurement (REM) cases where the introduction of a probe tube introduces feedback, or in rare cases where the hearing instrument closes-off the probe tube against the incompressible bony portion of the ear canal.

However, as outlined by multiple authors (e.g., Dillon, 2001; Scollie and Seewald, 2001) there are several limitations with the aided audiogram verification technique that impact the ability to thoroughly assess hearing instrument performance. For instance, this technique will only assess how the device will perform at one input level—the level at which threshold is obtained. It is clear that hearing devices with compression processing change their performance (gain) based on input level. As a result, the amount of benefit (functional gain) determined for soft input levels (aided vs. unaided) would not necessarily reflect the amount of benefit provided for louder input levels.

Also, the aided audiogram is only informing us about the performance of the device at the discrete frequencies used during the test—we would not know what was occurring for the numerous frequencies in regions between the audiometric frequencies (i.e., assess any unusual peaks/dips in the frequency response). Error is also introduced in the verification process by the nature of this approach involving a behavioral response and the associated test-retest variability. In fact, some researchers (e.g., Hawkins et al., 1987; Stuart, Durieux-Smith and Stenstrom, 1990) have found that threshold differences need to be at least 10-15 dB for one to conclude that the difference measured (e.g., the impact of a setting change) is a "true difference."

Aided thresholds for people with near-normal hearing at any frequency will also often be invalid due to masking by noise in the environment or internal hearing aid noise (Dillon, 2001). Finally, the aided audiogram does not allow us to assess the maximum output capabilities of the hearing instrument to determine whether this important performance aspect is appropriate across the entire frequency response being delivered by the device.

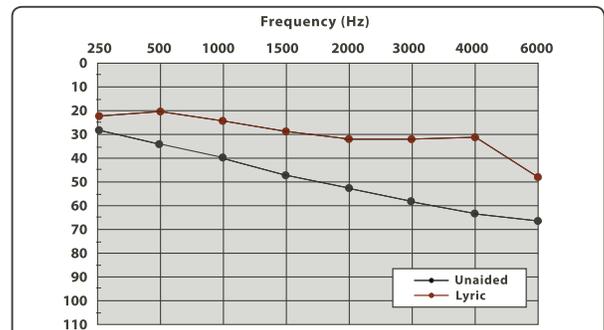


Figure 2. Mean unaided and aided soundfield thresholds (n=74) averaged across ears for Lyric (from Arbogast and Whichard, 2009)

The Real-Ear Measurement Standard



In the battery of approaches used to assess and verify the acoustic performance of hearing instruments, **real-ear measurement (REM)** represents the gold standard. This verification technique has been available for a number of

years and is widely seen within the audiology community to represent a best practice approach for verification of hearing instruments. Beyond ensuring that hearing instruments are functional, REM allows the provider to objectively assess whether or not audibility has been provided across a range of input levels, and use this information to guide any subsequent fine tuning adjustments. Furthermore, REM addresses many of the shortcomings of other verification techniques, as it is reliable, provides enhanced frequency resolution, assesses performance at multiple inputs, and is not impacted by masked aided thresholds.

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While REM does involve some additional upfront work in the fitting and verification process, it ultimately has the potential to save the clinician time by guiding their decision making. For instance, this approach allows one to objectively assess appropriate trade-offs between reducing levels of audibility and addressing a sound quality complaint (e.g., tinniness). REM can also be used to anticipate various problems on the part of the patient. For instance, lack of audibility in particular frequency regions across various inputs can be observed and addressed via programming adjustments by looking to the responses being measured.

Audibility, Real-Ear Measurements and Lyric

In the case of Lyric devices, REM can be used to objectively document the combined impact of the aforementioned acoustic components and provide evidence that the Lyric benefit extends beyond ease-of-use and cosmetic factors.

Figures 3 and 4 below and on the following page show a set of actual REMs conducted with two representative Lyric patients fitted at the Lyric Clinical Research Center.

The "SPLogram" format shown in these figures is intended to be a replacement for the aided audiogram approach and allows direct comparison of hearing aid output to the patient's threshold and uncomfortable loudness levels to assess the adequacy of the device performance. The graphs plot real-ear sound pressure level (SPL) by frequency so that all comparisons (i.e., between device output and the patient's dynamic range) can be viewed on the same scale. The patient's dB HL thresholds are converted to dB SPL values and plotted as red O's (right ear) or blue X's (left ear), while predicted (or measured) loudness discomfort levels (LDLs) are plotted as asterisks (*).

Hearing instrument measurement curves falling above the patient's threshold line (X's or O's) are deemed to be audible while those falling below the patient's LDL (*'s) are not uncomfortable.

Using this SPLogram format, the clinician can quickly assess whether the goal of audibility has been achieved (i.e., hearing aid output is above threshold and below LDLs). Further, if desired, the REM system may also be used to assess how closely the pre-calculation has matched a particular fitting formula target for various speech input levels (+'s).

While the value of using REM to guide adjustment of a device to precisely match a particular prescriptive target can be debated, there is no doubt that the dynamic range details (i.e., area between threshold and LDLs) provides a clear indication of whether an amplified signal will be audible without exceeding a level considered to be uncomfortable.

As an example, Figure 3 represents a REM obtained for the right ear of one patient at the quick fit setting for their hearing loss. As can be observed, audibility of the long term average speech spectrum (LTASS) for soft speech (green curve), average speech (pink curve) and loud speech (blue curve) has been provided from ~250 to 3000 Hz. As a reference, the graphs also display the corresponding NAL-NL2 targets (+'s) as generated by this real-ear measurement equipment for each input level. The results also suggest that the maximum output (MPO) of the device will not exceed the predicted LDLs (*'s) for the patient.

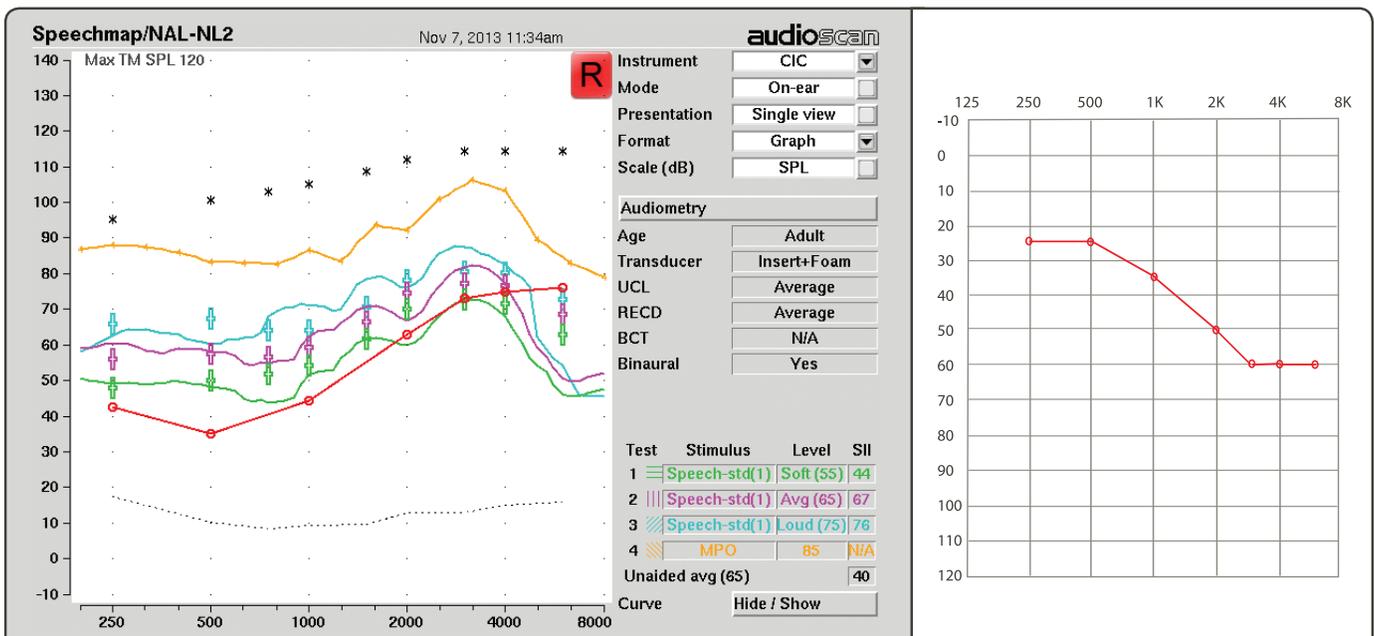


Figure 3. Real-ear measurements, plotted in dB sound pressure level (SPL) (ear canal level) as a function of frequency for the right ear of one patient fitted with Lyric at quick fit settings. The patient's dB HL audiogram is shown at right. Shown in the SPLogram are normal thresholds (lower dotted line) along with the patient's thresholds (O's) and predicted loudness discomfort levels (LDLs) (*). Also displayed are real-ear aided responses (REARs) for soft, average, and loud speech, the corresponding REAR targets (+) for these input levels and the real-ear saturation response (RESR) for an 85 dB SPL pure-tone input.

Additional fine tuning of the hearing instrument could be conducted at this point if desired to further impact audibility and/or more closely approximate the displayed fitting formula targets.

Figure 4 shows REMs obtained for the right and left ears of another Lyric patient following minimal fine tuning of the hearing instrument to approximate the generated fitting formula targets. As can be observed, the measurements document that audibility has been provided for the LTASS of soft (green curve), average (pink curve) and loud speech (blue curve) for both ears from ~ 250 to 4000 Hz.

Furthermore, we can observe a close match to the corresponding NAL-NL2 targets (+'s) as generated by this real-ear measurement system for each input level. Finally, the results suggest that the maximum output of the Lyric device will not exceed the predicted LDLs (**s) for the patient bilaterally. To be certain, REM results may not always provide such an "ideal" audibility response for each patient being fitted with Lyric. However, REM provides the fitter with the opportunity to make an informed decision regarding the appropriateness of a particular fitting or hearing device for a particular patient and guide decision making regarding the need for, and the audibility impact of, any programming changes.

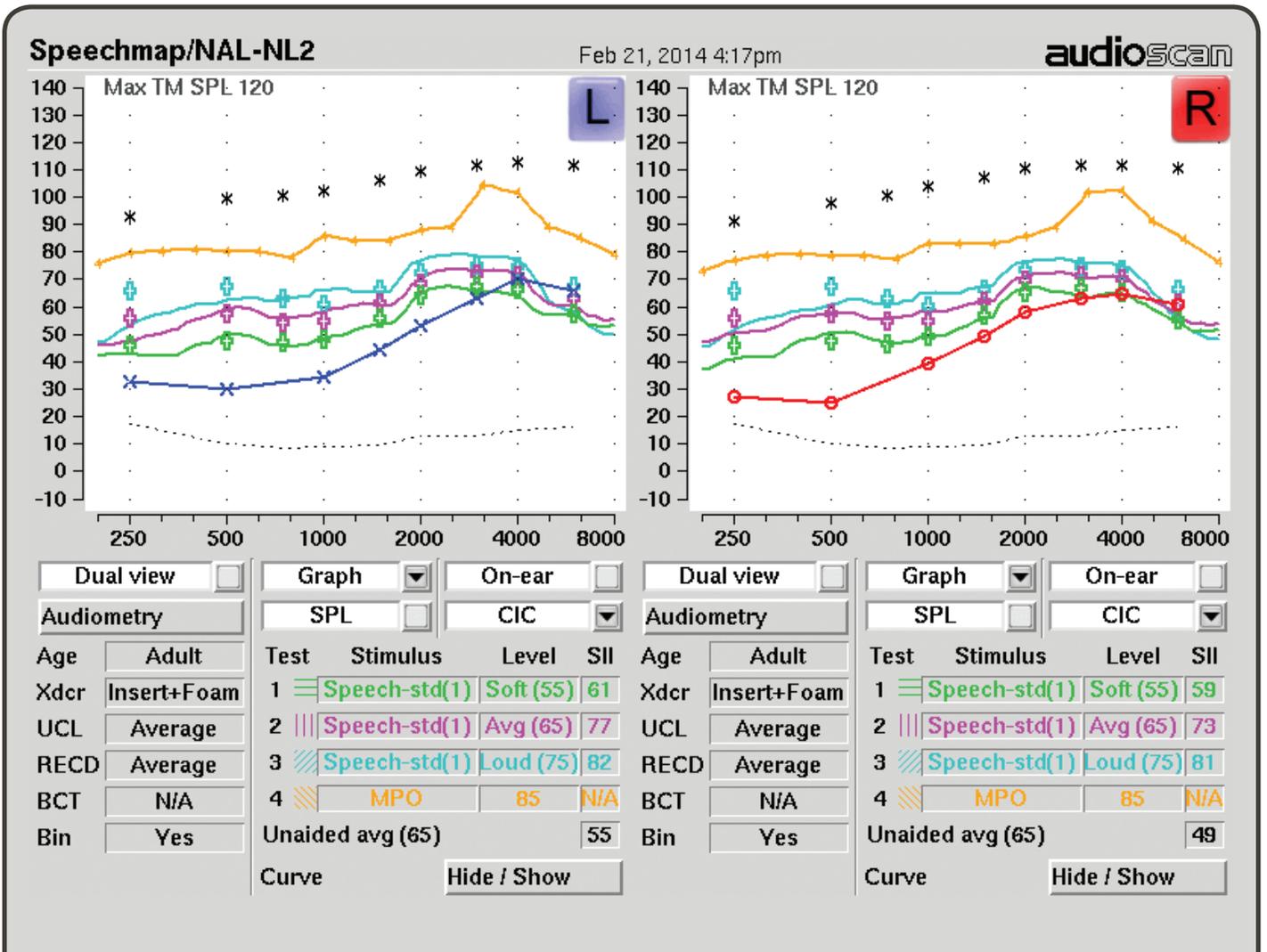


Figure 4. Real-ear measurements, plotted in dB sound pressure level (SPL) (ear canal level) as a function of frequency for the left and right ear of one patient fitted with Lyric following fine tuning to the generated fitting formula targets. Shown in each SPLogram are normal thresholds (lower dotted line) along with the subject's thresholds (X's and O's) and predicted loudness discomfort levels (LDLs) (*). Also displayed are real-ear aided responses (REARs) for soft, average, and loud speech, the corresponding REAR targets (+) for these input levels and the real-ear saturation response (RESR) for an 85 dB SPL pure-tone input.

How to Conduct REM with Lyric

While there are no doubt some unique challenges when conducting REM with Lyric given its deep canal placement, it is entirely possible to use this verification approach with these devices as shown in Figures 3 and 4 above.

The process of conducting REM with Lyric involves the same principles followed when using this verification technique with any type of hearing instrument. That is, the concepts of ensuring appropriate probe tube calibration, otoscopic examination, loudspeaker placement and probe tube placement still apply as described in Pumford and Sinclair (2001).

Differences essentially involve: a) the need to ensure placement of the probe tube a little deeper in the ear canal (i.e., closer to the eardrum) to ensure the end of the tube is beyond the end of the Lyric instrument; and b) methods to minimize the presence of feedback caused by slit leak venting introduced by the probe tube (e.g., via lubricant on seals, probe tube).

It should be noted that there may be patients for whom REM cannot be reasonably completed given the presence of feedback at user settings. In these cases, the fitter can revert to other verification approaches.

Conclusion

Lyric hearing instruments provide a number of unique benefits for those with mild to moderate hearing loss, not the least of which are those resulting from the acoustic advantages of deep ear canal placement. To document these advantages and ensure that they result in appropriate audibility for patients, various verification approaches can be used, each with its own benefits and limitations.

REM represents a valuable component in this process that can be used to ensure hearing instruments are performing appropriately based on the auditory needs of our patients. While conducting

REM with Lyric may pose a number of unique challenges, recent clinical experience confirms that this verification procedure can be accurately and efficiently conducted with patients. Furthermore, via this technique, it can be objectively shown that the "Lyric advantage" is not only the result of cosmetic and ease-of-use factors but also due to the ability to provide an audibility benefit.

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