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beat

Bernafon ENT Audiology Trends

How does a hearing aid reacts to live music?

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Live Music Plus: For the Pure Enjoyment of Live Music

Throughout time, playing and listening to music have been universal human behaviors with no known geographical or cultural boundaries. When people gather together, music is most often present, such as at a wedding or a party to name but two (Levitin, 2006). As hearing care professionals our primary goal is to improve the communication abilities of our clients and enhance the quality of their lives. While concentrating our clinical efforts on the perception of speech in many different environments, we sometimes forget about other signals such as music, which may be very meaningful to the client. Music may be a hobby or a profession or perhaps just a pleasant way to spend some time. Unfortunately, music lovers and musicians are often disappointed by the sound of music through their hearing instruments, due to the fact that they are designed to focus on speech. Settings and electroacoustic characteristics of hearing instruments may be ideal for speech signals but not for music (Chasin & Russo, 2004). There are many acoustic differences between speech and music, so naturally the hearing instrument may react inappropriately when music is present.

Bernafon recognizes that music is very important for many clients and so has developed a dedicated listening program for live music called: **Live Music Plus.** This program combines the power of ChannelFree™ processing with a wideband frequency response along with Live Music Dynamics to enhance the listening experience for both musicians and music lovers.

In this paper we will first review some of the differences between music and speech signals, then we will explore the three elements that make up **Live Music Plus.**

The differences between Music and Speech

Chasin (2006) and Chasin & Russo (2004) have pointed out that there are a number of differences between music and speech. Here are just three of them:

1. Speech vs. Music Spectra

Speech has a relatively uniform spectrum (the range of frequencies produced) due to the fact that the human vocal tract is the source. While there are individual differences between males, females and children, the sound source is similar. There is also a long term average speech spectrum referred to in a variety of acoustical standards (e.g. Byrne et al, 1994 and ANSI S3.5-1997) which demonstrates how the sounds of speech are acoustically represented. The speech spectrum is used as a foundation by fitting rationales in order to restore the audibility of speech via amplification. Music, on the other hand, has many sources which are highly variable and the resulting spectrum can resemble noise in some cases and speech in others (Chasin & Russo, 2004). A truly representative long term music spectrum therefore does not really exist.

2. Different intensities

As hearing care professionals we typically consider soft speech as being 50 dB SPL, conversational speech as 65 dB SPL and loud speech as 80 dB SPL. Shouted speech is around 83 dB SPL (Chasin, 2006). Music on the other hand is quite different and can easily reach 105 dB(A)1 and can have peaks of 120 dB(A). Killion (2009) measured peaks of a symphony orchestra in a concert hall at 114-116 dB (C). It must be noted however that these high intensity peaks are very short and so should not be considered to be damaging to our hearing (Killion, 2009).

Speech has a well defined relationship between loudness (the psychological impression of the intensity of a sound) and intensity (the physical quantity relating to the magnitude or amount of sound). For music this relationship is variable and greatly depends upon the musical instrument being played (Chasin, 2006).

3. Crest Factor

The crest factor can be described as the difference between the peak level and the average (RMS) level, in other words the instantaneous difference between the peak of a signal and the overall level. Speech has a fairly consistent crest factor of 12 dB while music has a crest factor of up to 18-20 dB for many instruments (Chasin, 2006). This acoustic characteristic is very important for the dynamic impact of music.

From this discussion of the differences between speech and music, it is quite easy to see why these signals must be processed differently within the hearing instrument. Now we will explore the three systems in Live Music Plus that Bernafon has implemented to improve musical sound quality.

Live Music Plus

The three systems that make up **Live Music Plus** are

1. Live Music Dynamics
2. ChannelFree™ processing
3. Wideband frequency response

We will now look at each of these systems individually and how they work together.

1. Live Music Dynamics

As we have discussed earlier, music has different intensities and crest factors than speech. These dynamic characteristics create a challenge to digital hearing instruments. Typically a digital hearing instrument compresses the peaks of the signal once they reach 95 dB before the conversion from the analog domain to the digital domain. This is more than adequate for even loud speech, however, for the peaks of live music this is too low and the music will sound compressed, unnatural, and even slightly distorted. This is especially a drawback for musicians who may be trying to hear their fellow musicians in order to play correctly. Live Music Dynamics increases the level to 110 dB in order to preserve the peaks in music before they reach ChannelFree ™ processing.

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1. The dB A scale is used to approximate what we hear as opposed to the physical sound pressure level (SPL). The dB C scale is used to measure the peaks of a signal. Both dB A and dB C filters are found on most sound level meters.

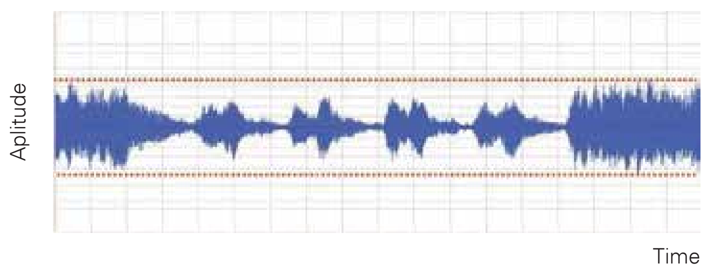

Figure 1: Amplified music without Live Music Dynamics

In Figures 1 and 2 we see amplified music displayed as waveforms with amplitude on the y axis and time on the x axis. In Figure 1 we can see a live music signal without Live Music Dynamics. The peaks of the waveform are cut off, indicated by the red dotted line. This line signifies the maximum level that the hearing instrument will permit to be converted to the digital domain. The same signal can be seen in Figure 2 with Live Music Dynamics, the peaks of the musical signal are preserved and the dynamic range is higher, demonstrating that the natural dynamic characteristics will be converted into the digital domain.

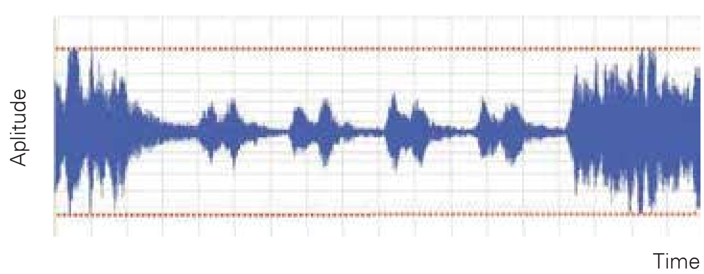

Figure 2: Amplified music with Live Music Dynamics

2. Channelfree™ processing
ChannelFree™ processing is a great step forward in the processing of musical signals. It has a fast processing time and treats signals as a whole to maintain the balance between low and high frequency harmonic energy[2]. The high frequency harmonics, for example, are especially important for the judgment of the timbre (the difference between musical instruments playing the same note at the same intensity) e.g. a trumpet and a violin playing the same musical note. This balance is crucial for musical sound quality. With ChannelFree™ processing the level differences between the sounds of music are maintained resulting in a natural perception of the musical signal. The peaks of musical signals may be sharper than speech as described earlier in our discussion of the crest factor and may send a standard hearing instrument into compression early. ChannelFree ™ processing however can quickly follow the level of the signal in order to preserve the relationships between different levels of the musical signal. The result is that the signal is amplified to a comfortable level for the client as defined by the Oasis fitting software and any fine tuning actions made by the hearing care professional.

Bernafon's ChannelFree™ processing has been judged to have high sound quality. In a study by Dillon et al in 2003 with hearing impaired listeners, it was found that Symbio, a first generation Channel Free™ processing hearing instrument, received the highest ratings for the sound quality of piano music compared with other digital hearing instruments.

3. Wideband frequency response
It is well known that a wide frequency response contributes to the perceived naturalness of music (e.g. Moore & Tan, 2003; Killion, 2009). Hearing instruments with Live Music Plus have a frequency response up to 10,000 Hz. This frequency response is more than enough to convey most musical sounds accurately. For example, the highest C note on a piano is 4186 Hz, while the highest C note on a violin is 2093 Hz (Levitin, 2006).
Putting it all together
Music differs quite dramatically from speech and is a potential challenge for hearing instruments. With **Live Music Plus** Bernafon has created a music program dedicated to presenting musical signals accurately to the client with three important elements. The first is Live Music Dynamics which ensures that the dynamic characteristics of music are preserved. The second is ChannelFree™ processing which ensures that the music is accurately amplified within the dynamic range of the client. The third is a wideband frequency response which contributes to the perceived naturalness of the music. The combination of these three elements is beneficial for both musicians and music lovers. **Live Music Plus** allows the client to enjoy the rich world of music as a listener and even as a performer.

References

ANSI S3.5 (1997). American National Standard Methods for the Calculation of the Speech Intelligibility Index. New York: **American National Standards Institute.**

Bernafon A.G. (2009). Channel Free™, proprietary Bernafon technology. **Topics in Amplification,** July 2009, www.bernafon.com.

Byrne, D., Dillon, H., Tran, K., Arlinger, S., Wilbraham, K., Cox, R., Hagerman, 8., Heto, R., Kei, J., Lui, C., Kiessling, J., Kotby, M.N., Nasser, N.H.A., El Kholy, W.A.H., Nakanishi, Y., Oyer, H., Powell, R., Stephens, D., Meredith, R., Sirimanna, T., Tavartkiladze, G., Frolenkov, G.I., Westermann, S., & Ludvigsen, C. (1994). An international comparison of long-term average speech spectra. **The Journal of the Acoustical Society of America,** 96(4), 2108 -2120.

Chasin, M. (2006). Hearing aids for Musicians. **Hearing Review,** 13(3), 11 -16.

Chasin, M. and Russo, F. A. (2004). Hearing aids and music. **Trends in Amplification,** 8(2). 35 -47.

Dillon, H., Keidser, G., O'Brien, A .. and Silberstein, H. (2003). Sound quality comparisons of advanced hearing aids. The **Hearing Journal,** 56 (4), 30 -40. Killion, M.C. (2009). What special hearing aid properties do performing musicians require? **The Hearing Review,** 16(2). 20 -31.

Levitin, D. J. (2006). This Is Your Brain on Music: The Science of a Human Obsession. New York: Dutton/Penguin.

Moore, 8. C. J. and Tan, C-T (2003). Perceived naturalness of spectrally distorted speech and music. **The Journal of the Acoustical Society of America,** 114(1), 408-418.

Schaub, A. (2008). Digital Hearing Aids. New York: Thieme.

Schaub, A. (2009). Enhancing Temporal Resolution and Sound Quality: A Novel Approach to Compression. **Hearing Review,** 16(8). 28 -33.

BernaFit NL: A Proprietary Fitting Rationale Compares Favorably with NAL-NL1

Fitting rationales such as NAL-NL1 and DSL i/o are well known rationales based on solid theoretical grounds. They have primarily been designed to improve speech intelligibility. They do this well.

However, in practice, hearing-impaired clients, especially clients who have not worn hearing systems before, can find the initial settings too loud. As a result, clients may need more fine-tuning sessions. In some cases, clients may even reject their devices.

Bernafon's proprietary rationale was designed to address these problems. BernaFit NL offers less amplification so that initial settings are not too loud, without sacrificing speech intelligibility. BernaFit NL helps to make the instrument more comfortable, and the first fit more acceptable for the client. This has been verified by independent testing.

In the following pages, you will learn about the methodology used for testing, the main differ-ences between BernaFit NL and NAL-NL1, the speech intelligibility scores and finally, the subjective preferences expressed by the participants.

Test Setup

To independently evaluate the performance of Bernafon's proprietary fitting rationale, Bernafon contacted Professor Patrick Plyler at the Univer-sity of Tennessee. Professor Plyler's team conducted a single blinded study to compare BernaFit NL with NAL-NL1. Their main goals were to find out if Bernafon achieved its objectives of reducing amplification to increase comfort while maintaining speech intelligibility, and whether end-users could differentiate between these two fitting rationales.
To do so, the research team recruited 17 partici-pants with mild sloping to moderate bilateral sensorineural hearing loss as shown in Figure 1.

Professor Plyler's team fitted all 17 participants binaurally with Bernafon Vérité receiver-in-the-ear instruments and divided them into two groups – Group A and Group B. For Group A, the researchers programmed the instruments with NAL-NL1 in Program 1 and BernaFit NL in Pro-gram 2. The opposite fitting configuration was programmed for Group B. This minimized any bias to a specific rationale assigned to Program 1.

To focus solely on amplification and the fitting rationales, the researchers disabled various adaptive features such as adaptive directional microphones and Adaptive Noise Reduction.

A client experience level of "Experienced Non-Linear" was selected. With the instruments prepared as outlined, the research team performed a series of objective and subjective evaluations.

Differences between BernaFit NL
and NAL-NL1

BernaFit NL is a non-linear rationale based on the principles of NAL-NL1 and incorporates recent independent research findings. These include modifications for gender and for children.

Compared to males, females generally prefer less gain due to their smaller ear canal volume1.
We all know that open fittings are designed to reduce the effects of occlusion through the loss of amplified, low-frequency sound, and that clients will notice an improvement in the sound of their own voice. However, another effect of an open fitting is that unamplified, low-frequency sound can also enter the ear canal through an open dome at the same time as the amplified sound from the hearing instrument. The interac-tion between these two signals, at the ear drum, can affect sound quality2.

To minimize the interaction between amplified and unamplified, low-frequency sounds, BernaFit NL incorporates a Bernafon proprietary algorithm. The minimization of these interactions improves the sound quality for open fittings3.

In addition, the BernaFit NL rationale incorporates modifications for Bernafon's ChannelFree™ signal processing. Amplification is optimized for this unique digital signal processing. One of the main objectives during the develop-ment of BernaFit NL, was to maintain speech intelligibility at a lower level of amplification. This reduced level of amplification is well reflected in the assessments conducted within this study.

Differences in Real Ear Measurements

To evaluate the amplification levels of the two rationales, Patrick Plyler and his team conducted real ear measurements. Three different input levels were used: soft, medium, and loud.

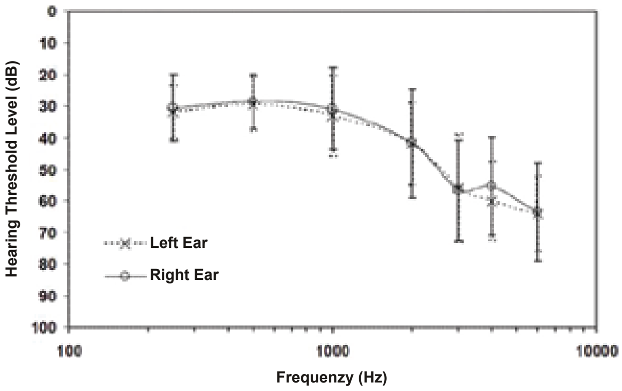

Figure 1: Average hearing thresholds with standard deviations

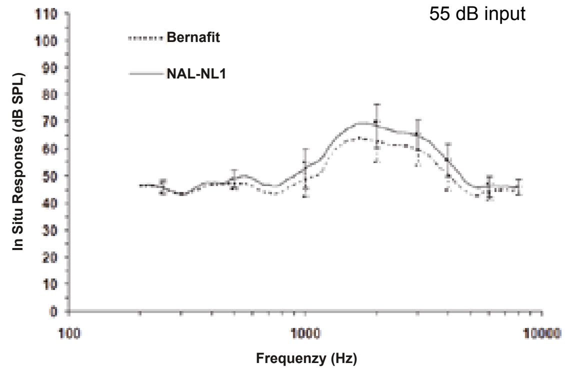

Figure 2: Average real ear measurements for soft input signal (55 dB)

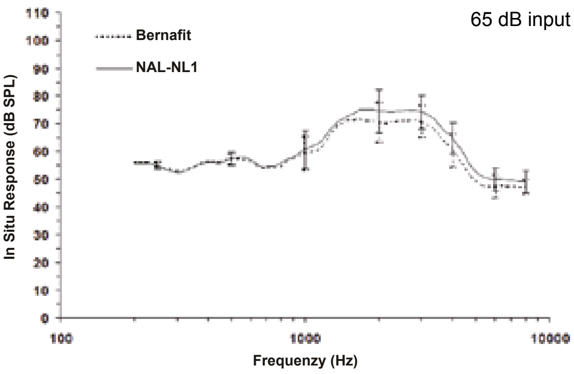

Figure 3: Average real ear measurements for medium input signal (65 dB)

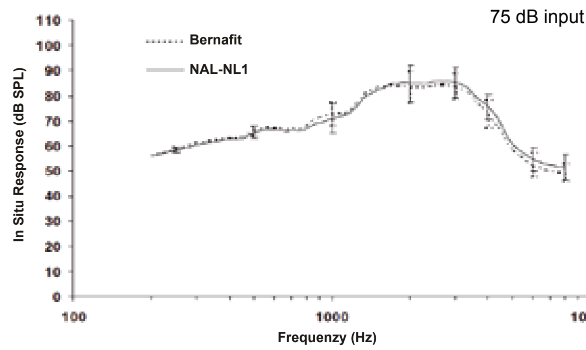

Figure 4: Average real ear measurements for loud input signal (75 dB)

In the results shown here, you can see that for the 55dB and the 65dB inputs (Figures 2 and 3), BernaFit NL prescribes less gain in the mid and high frequencies compared to NAL-NL1.

Naturally, the impact of less amplification on speech intelligibility was questioned. To investi-gate this further, all participants completed speech testing in quiet and in noise with BernaFit NL and NAL-NL1.

Equal Intelligibility Scores for BernaFit NL and NAL-NL1

The University of Tennessee evaluated speech discrimination for the unaided, NAL-NL1 and BernaFit NL conditions in quiet and in noise. The Pascoe high-frequency speech test was administered.

This speech test consists of 4 lists containing 50 monosyllabic words. The participant must repeat every word correctly. The order of speech intelligibility testing in quiet and in noise was randomized. In the quiet condition, speech was presented at 65 dB SPL and the noise level was lower than 30 dB SPL.

To evaluate its performance in more challenging situations, the speech-in-noise test was conducted. Speech was once again presented at 65 dB SPL and noise was simulated by 12-talker babble presented at 60 dB SPL.

Figure 5 shows the results for the unaided, NAL-NL1 and BernaFit NL conditions in quiet and in noise. You can see that BernaFit NL and NAL- NL1 scores are better than the unaided condition. This improvement in scores was found to be statistically significant. Both in quiet and in noise, there is no significant difference between BernaFit NL and NAL-NL1.

We can conclude that even with less gain than NAL-NL1, BernaFit NL achieves the same level of speech discrimination performance.

Higher Satisfaction Rating for BernaFit NL

In addition to objective evaluations, all partici-pants had to complete several subjective assessments: the APHAB (Abbreviated Profile of Hearing Aid Benefit), satisfaction ratings and a measure of overall preference. In all of these assessments, BernaFit NL scored higher than NAL-NL1.

APHAB Results

Professor Robyn Cox, at the School of Communi-cation Sciences and Disorders in Memphis, USA, developed the APHAB questionnaire to quantify hearing aid benefit4. The APHAB is a 24-item self-assessment inventory in which clients report the amount of trouble they are having with communication or noises in various everyday situations.

The APHAB is divided into five main subtests – Global, Ease of Communication, Background Noise, Reverberation and Aversiveness. All participants completed an APHAB question-naire for each testing condition: unaided, NAL-NL1 and BernaFit NL. The results, in Figure 6, represent the percentage of problems for each of the five subtests. It is important to recognize that a lower score is better. Results indicate that scores for both the BernaFit NL and NAL-NL1 settings are significantly better than unaided
scores on each APHAB subtest except Aversive-ness. Furthermore, BernaFit NL achieved better scores than NAL-NL1 in all subtests. The improve-ment in scores for Bernafit NL was statistically significant with the exception of one subtest, Ease of Communication. These statistically significant differences are represented by the red stars in Figure 6.

Satisfaction Ratings

In addition to the APHAB, the research team collated satisfaction ratings from all participants. Each had to rate their satisfaction with sound quality, speech clarity in quiet, speech clarity in noise, localization and overall satisfaction. The 17 participants completed this evaluation twice a week for each program during the five-week trial period.

Satisfaction was scored on a 5-point scale where 5 is extremely satisfied and a score of 1 is extremely unsatisfied. You can see in Figure 7 that BernaFit NL scored statistically better than NAL-NL1 for sound quality and overall satis-faction.

Overall Preference

At the conclusion of the study, each participant indicated which hearing instrument setting they preferred when listening in quiet, in noise, and overall.
Preference results were summed across partici-pants and are displayed in Figure 8. As one can clearly see, BernaFit NL was the preferred choice in quiet, in noise and overall.

Conclusions

BernaFit NL is Bernafon's proprietary fitting rationale developed specifically for all ChannelFree™ instruments. How does it compare to other well-known and well-accepted fitting rationales? The results of this study show that even with less gain, BernaFit NL performed equally to NAL-NL1 in speech discrimination tests. Independent tests also showed that end users could tell the difference, and that they preferred Bernafon's BernaFit NL fitting rationale for sound quality and overall performance. Bernafon achieved its objectives of reducing amplification to increase comfort while main-taining speech intelligibility. This can give you added confidence in recommending Bernafon's ChannelFree™ technology to your clients. Bernafon instruments deliver clear and natural sound, without compromising speech – a true benefit for the client.

References

1. Keidser G. and Dillon H. (2007). What's new in prescriptive fittings Down Under ? In Seewald R. (Ed.), Hearing Care for Adults 2006. (pp. 133 – 142).
2. Michael A. Stone, Brian C. J. Moore, Katrin Meisen-bacher, and Ralph P. Derleth, Tolerable Hearing Aid Delays. V. Estimation of Limits for Open Canal Fittings. Ear & Hearing 2008; Vol. 29, No. 4,601– 617
3. Scheller T. (2004). More than you ever wanted to know about vents and digital hearing aids. Audiology Insight; (1): 9 – 14. Bernafon AG, Bern
4. Cox R. M., Alexander G. C.: The abbreviated profile of hearing aid benefit. Ear & Hearing 1995; Apr; 16(2): 176 – 186

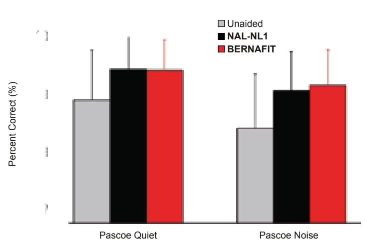

Figure 5: Speech discrimination results in quiet and in noise

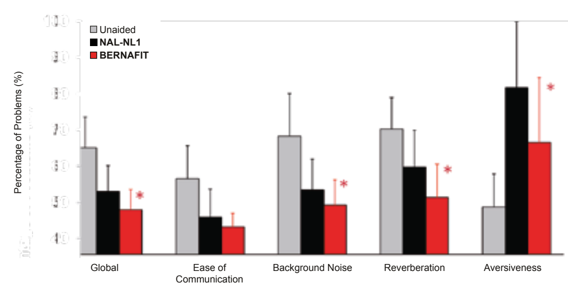

Figure 6: APHAB results (note that a lower score indicates a better result)

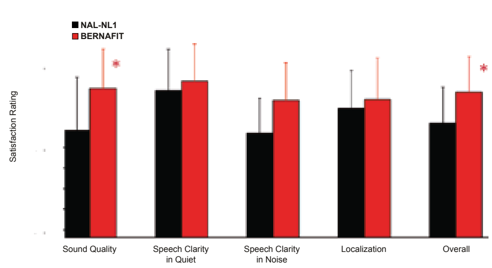

Figure 7: Satisfaction ratings (note that a higher score indicates a better result)

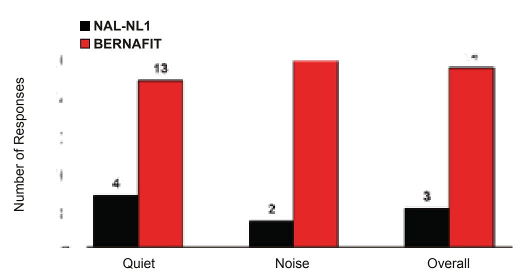

Figure 8: Preference results