July 2017

Topics in Amplification

DYNAMIC NOISE MANAGEMENT™ – A WINNING TEAM

Speech in noise continues to be the most difficult situation reported by hearing aid users. The good news is that the development of technology has given users an improved listening experience and feeling of benefit. According to a MarkeTrak survey (Abrams, et al., 2015), in recent years, hearing aid users report more consistent satisfaction with their hearing aids in multiple environments. However, environments in which users are trying to understand speech in the presence of noise continue to be the most problematic. These listening situations are difficult for normal hearing individuals; therefore, they pose even greater problems for hearing instrument users. To combat this problem, hearing aid development continually investigates new methods and has advanced in the effort to make speech in noise more intelligible. Specifically, directional microphone processing strategies have contributed a significant improvement to speech intelligibility in noise. Directional microphones are designed to create a better signal-to-noise ratio (SNR) for the user. Studies have shown that hearing-impaired listeners experience increased speech recognition difficulty with less advantageous SNRs (Ricketts, 2001). Directional microphones offer the best method of improving the SNR. Another significant technological improvement are noise reduction algorithms. Noise reduction algorithms were added to hearing aids to provide more comfort to the user in noise. They have been improved over the years to target more specifically noise and reduce their impact on speech.

With this goal in mind, Bernafon introduces Dynamic Noise Management™: a new solution that combines Dynamic Directionality and Dynamic Noise Reduction into one integrated processing strategy to maximize the speech intelligibility and comfort for the hearing aid user.

Progress through development

Directional microphones were introduced to the market as early as 1971 (Ricketts, 2001). They have evolved from only offering a fixed directional setting that was manually activated to offering various processing strategies of adaptive directionality. Adaptive systems typically switch automatically between different polar plots of directionality. Some adaptive systems additionally offered the capability of transitioning from omnidirectional to adaptive polar plots of directionality. This improvement increased the usability for the end user by eliminating the need for them to decide when it was necessary to switch manually from omnidirectional to a fixed directional setting.

With further development, noise reduction systems were added to provide comfort for the user. Traditionally these are a separate processing system. With the two systems working independently, and with the noise reduction always on, there is the potential to apply too much noise reduction. Too much noise reduction can reduce speech as well as noise. Directional microphones also have their disadvantages. Even though directional microphones have a potential to improve the SNR by 4–5 dB, they also reduce the hearing aid output in the low frequencies (Thompson, 2000). Both fixed directional and adaptive directional systems can potentially apply too much directionality leaving the end user feeling closed off from their surroundings. Omnidirectional settings provide the most gain and allow the user to be fully aware of their environment, but are not ideal for speech when noise is present. An adaptive strategy that remains in an omnidirectional setting until speech is detected is the ideal strategy to give the user a natural hearing experience. Adding noise reduction only when the directionality cannot sufficiently improve the SNR provides the user with necessary comfort without interfering with speech.

For this reason, Bernafon introduces a system in which the directionality and the noise reduction work in conjunction to provide the optimal SNR. We will further describe the new Dynamic Directionality and Dynamic Noise Reduction systems in better detail, discuss the testing of those systems in the clinic, as well as give an introduction to their place in the new Oasis^nxt software.

The best of both worlds

Team: Together everyone achieves more. This is the concept behind DNM™. Instead of having two strong systems within a hearing aid that may contradict each other, they have now joined together to form a strong team to achieve a better functioning system overall. DNM™ in the new Bernafon Zerena hearing aids combines two new systems, Dynamic Directionality and Dynamic Noise Reduction into one improved efficient feature.

With the new system, DNM™ is inclined to allow the hearing aids to remain in an omnidirectional state until noise is detected. Once noise is detected there are multiple polar plots applied over 16 bands to attenuate the noise from various angles without reducing speech. Leaving the hearing aids in omnidirectional as much as possible allows the end user to hear sounds from all around them and makes them more aware of their environment. It only applies directionality and/or noise reduction when necessary to help the end user understand speech by improving the SNR. In Figure 1, the image on the top is a picture of a situation in which no directionality or noise reduction is applied. In this case there is no noise, and the user requires no improvement to understand. In the picture on the bottom, noise has entered the environment. This could include some additional speakers talking in the background or random household noises as those represented in the picture.

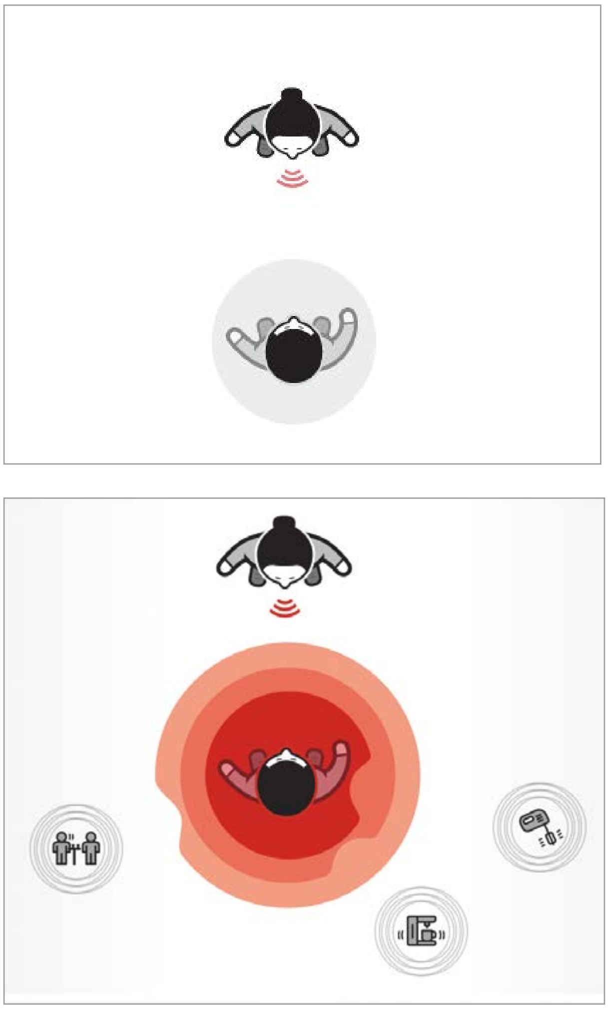

Figure 1. Top: Environment in which no directionality or noise reduction is needed. Bottom: Directional polar plots seen in red and noise reduction presented as rings around noise sources.

The system recognizes the change in the environment and applies the correct amount of directionality in order to improve the SNR. The directionality is applied over 16 bands, but does not mean that it's applied to all 16 bands. The system will always determine at which frequencies it's needed and how much is needed by analyzing the input signal. This means that various degrees of directionality with null points at different angles, can be applied over different frequencies. When mixed together, noise can be targeted from different levels and different angles allowing the end user to concentrate on the speech that they want to hear.

The directionality does not apply null points to angles in front of the listener. Therefore, if the environment gets even noisier, the system can apply noise reduction for extra help to improve the SNR. Like the directionality, the noise reduction is applied over 16 frequency bands so that each frequency only receives the needed amount of attenuation, and in some cases none at all. Engaging the minimum amount of noise reduction necessary preserves all speech cues by avoiding too aggressive an attenuation on the incoming signal. Because the system is dynamic it will constantly change the directionality and noise reduction settings as the environment changes. The primary goal is maintaining an SNR that allows the end user to communicate satisfactorily.

Proof through testing

Improving the SNR is decidedly the optimal method of improving speech intelligibility for hearing-impaired listeners as well as normal hearing people. Moore wrote that typically normal hearing people require an SNR of +6 in order to experience "satisfactory communication" (1989). Hearing-impaired listeners require an even better SNR in order to understand. As a reference by which to gauge common noise levels, speech-in-noise situations have an average SNR of +5 dB (Smeds, et al., 2015). Researchers typically measure SNR improvement with hearing aids in a clinical setting. This often involves a set-up of a speaker array with the hearing aid user seated in the center. Figure 2 shows a schematic of the test set-up.

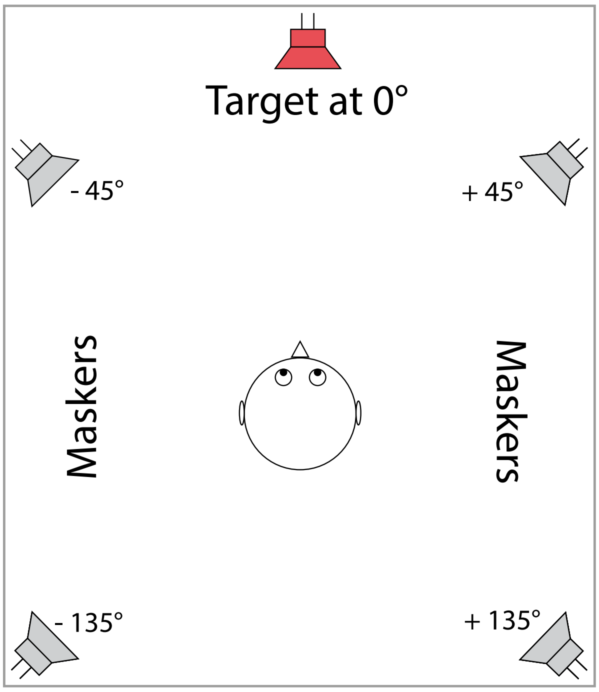

Figure 2. Speaker array for OLSA speech test.

Speech is presented directly in front of the listener at 0° azimuth and 4 noise sources are presented from various points around them ranging from 45° to 135° azimuth. Using this set up, the difference between the unaided and the aided SNR can be measured as well as the difference between distinctive directional strategies.

Using this test method, a clinical trial using volunteer hearing-impaired persons was conducted at Bernafon headquarters in Bern, Switzerland. The goal of the trial was to compare the performance of the new Zerena hearing aids with the performance of the previous family of Juna hearing aids. Thirty experienced hearing aid users were included. They had an average age of 67.4 years and an average weighted pure tone average (PTA) of 45.6 dB. The volunteers were fit with a pair of Juna devices and Zerena devices with the same acoustical options, prescribed individually for each client. The gain was prescribed using NAL-NL2 targets which was verified with REM (Verifit Audioscan) equipment.

Speech testing was completed in the lab in a simulated environment using the Oldenburg Satztest (OLSA) (Wagener, et al., 1999). The OLSA is an adaptive speech in noise test. For this specific test, the 50% speech intelligibility level was used. This means that the speech will grow louder or softer depending on the responses of the volunteer in order to maintain an understanding of approximately 50% of the speech material. Speech Reception Threshold (SRT) is measured by the level of SNR achieved with 50% intelligibility. A low SNR score means a greater benefit. Three test conditions were used: unaided, aided with Juna devices, and aided with Zerena devices.

The results were analyzed by comparing the difference between the improvements from unaided to both aided conditions and then between both aided conditions with Juna and Zerena instruments. There was an overall improvement of SRTs with amplification (mean difference 3.3 dB and $p < 0.001$). The results also showed a significant difference between the Zerena and Juna hearing aids (mean difference 1.4 dB and $p < 0.001$). The graph in Figure 3 shows the individual SRTs (in dB SNR) for all tested conditions. The graph demonstrates that the scores were better for the Zerena aided condition meaning that there was a greater benefit between unaided and aided with Zerena devices than with the Juna devices.

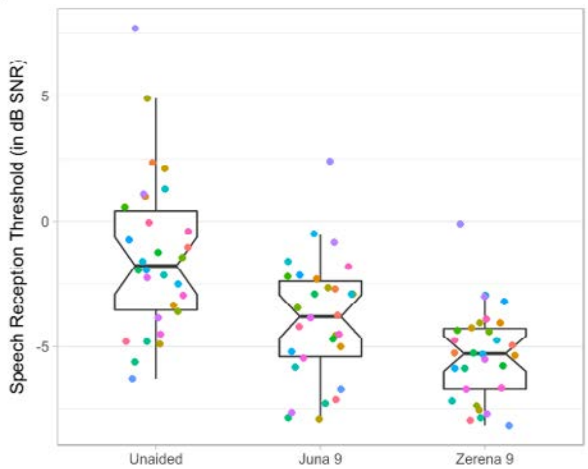

Figure 3. Individual speech-in-noise performances from the OLSA test expressed in dB SNR for the unaided and aided, with Juna and Zerena, test conditions.

Personalized settings

The new Zerena hearing aids will adapt the directionality and noise reduction features to acquire the best possible SNR for every environment. The lab test was completed using the default settings for the hearing aids. However, does every person require the same SNR at the same time? The answer is no. It is well understood that hearing aid users are unique and have different listening needs. For this reason, in the new Oasis software, Oasis^{nxt}, it is possible to fine tune DNM™ to match your individual clients. In Zerena 9, Dynamic Directionality offers two settings from which to choose, High and Medium Focus. The default setting is High Focus because it allows the directionality to adjust from full omnidirectional to the narrowest directional pattern available. Medium Focus will limit the width of the directional pattern that the microphones can achieve. The Medium Focus fine tuning possibility is ideal for those clients that don't like too much directionality or prefer to maintain the ability to hear more of their surroundings even if it means that slightly more noise will persist. The fine-tuning tool for Dynamic Noise Reduction has a default setting of medium, but it can be changed to minimum, maximum, or even off depending on your client's needs. This setting will limit the maximum amount of noise in dB that can be reduced.

A new innovative tool allows you to specifically refine DNM™ to meet your clients' noise preferences. This tool is the Transition Level, and has three settings: low, medium, and high. The different settings alter the SNR at which the directionality and/or noise reduction will be applied to the signal. The default setting is medium; however, if you have a client who is sensitive to noise and would prefer to have noise reduced as soon as possible, you have the flexibility to change their setting to high. This will tell the system to activate the DNM™ features before the SNR becomes too difficult for these clients. And on the opposite end of the spectrum, some clients prefer to hear everything in their environment and don't want help from the directionality or noise reduction until the SNR becomes negative or when the noise is actually louder than the speech. The picture in Figure 4 shows the controls in the software.

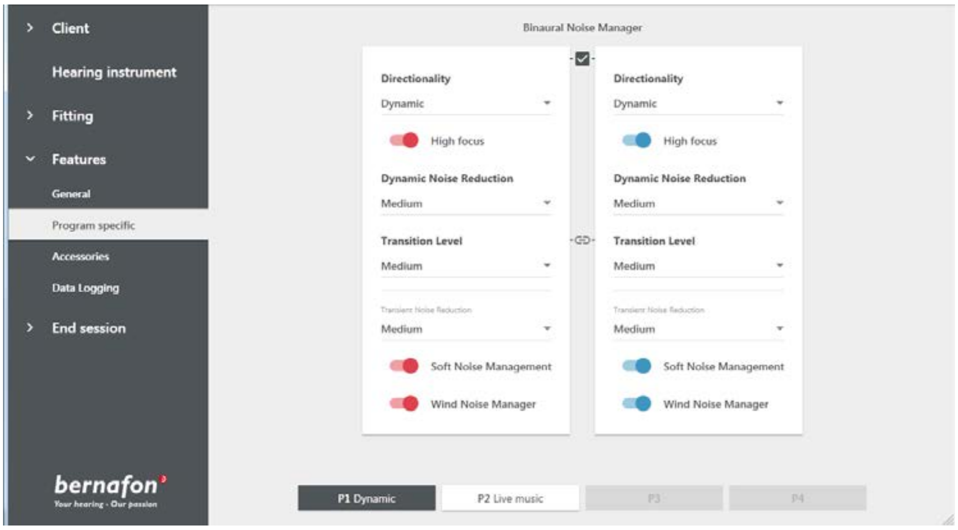

Figure 4. DNM™ controls in the Oasis^{nxt} software.

To find the screen, go to Features in the navigation bar, and then click on Program specific. There you can manage the Dynamic Directionality, Dynamic Noise Reduction, and Transition Level settings for each program independently.

Seamless experience

Directionality and noise reduction systems have improved over the years, and Bernafon's newest implementation offers a most innovative solution for the two features. Combining the directionality and the noise reduction allows the two systems to communicate and apply only the necessary amount of each feature, providing the best of both worlds for your clients: speech understanding and comfort. Listening environments change quickly. The new Bernafon Zerena hearing aids can stay in step with the environment to optimize the SNR at all times and provide a seamless listening experience for the end user. Offer your clients the opportunity to experience the new dynamics of hearing with Bernafon Zerena hearing aids.

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Headquarter
Switzerland
Bernafon AG
Morgenstrasse 131
3018 Bern
Phone +41 31 998 15 15
Fax +41 31 998 15 90

Local Manufacturer
& Distributor:
Bernafon Canada
500 Trillium Drive, Unit 15
Kitchener, ON, N2R 1A7
www.bernafon.ca

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2017-11-22/CA-US/subject to change

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