

AcoustIQ: The Intelligence Behind Beltone Illuminate

How real-time sound sensing and feature engagement help users hear their best automatically

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Beltone Illuminate™ offers AcoustIQ™, a system that accurately classifies the listening environment and engages the features in the hearing aid to provide the best hearing experience for the user.

ABSTRACT

Every listening environment is different. In a single day, a user can have conversations in a wide range of settings: quiet rooms, bustling cafés, busy streets, workplaces, and social gatherings. To provide meaningful hearing support, hearing aids must do more than amplify sound; they must continuously understand the user's listening environment and respond appropriately as conditions change. AcoustIQ is the new intelligent sound sensing and feature engagement system. It represents an enhanced steering model and feature engagement logic, with updated activation thresholds engineered especially for the most difficult listening situations. Working automatically in real time, it harnesses the power of the Environmental Classifier to analyze the listening environment and determine what the user is hearing, but it doesn't stop there. It is a fine-tuned system designed to optimize how the technologies within the hearing aid respond to that environment, to provide the most appropriate listening experience in any setting. The goal of AcoustIQ is to sense the sound and get it right – not only in classification accuracy, but in how the technology works for the user. As the fundamental activation system supporting the new True Directionality feature introduced in Beltone Illuminate, users can feel confident they will automatically receive the support they need in any environment – from the peaceful one-to-one conversation over a morning coffee, to the most lively, noisy discussion at an evening dinner. Wherever the day takes them, Beltone Illuminate users will enjoy a natural sound experience that automatically adjusts to what they need to hear well wherever they go.

The Beltone Organic Hearing™ philosophy has guided the development of our hearing aids for many years. At the foundation of this philosophy is the accurate characterization and classification of listening environments, so that all features work as they were designed and thereby provide users with the natural sound quality and help for hearing in noise that is possible with the best hearing aid technology available. With the advent of highly sophisticated new features such as DNN-enabled denoising noise reduction, the requirement for the most accurate classification and engagement of automatic features has become even more elevated than ever before. Powerful noise-reducing features that harness the power of AI in a hearing aid must activate – and deactivate – precisely when they should. Further, users should feel confident knowing that their choice in hearing aids has been tested for accuracy not only in how well they can classify the environment, but in how the technologies of the hearing aid work as a result of that classification.

For that reason, the new AcoustIQ system in Beltone Illuminate connects our industry-leading environmental classification accuracy with tested, appropriate feature steering. Building on the foundation of the Environmental Classifier that has been shown to provide extremely accurate classification of the sound environment in Beltone hearing

aids for years,¹ AcoustIQ takes the decision-making and feature activation resulting from that classification to a new level.

AcoustIQ was developed for Beltone Illuminate as the engine that steers features designed to automatically help users hear better in environments that are the most challenging. Despite numerous advancements in directionality and noise reduction over the past decade, users still report that hearing a desired speaker in the noisiest situations remains frustrating, tiresome or sometimes even impossible. Ironically, difficulties in these same situations are often the primary reason why people decide to try hearing aids in the first place! Getting the hearing aid technology right in these intensely difficult listening environments is of paramount importance to users. Whether it's holding a conversation across the table at a crowded restaurant with other conversations taking place around them, communicating with a store clerk at a busy grocery store checkout stand, or chatting with an acquaintance at a social gathering, these are the moments when hearing aid technology must perform to its absolute best potential. When a hearing aid user is in these loud, multi-talker situations, they typically need 3 things from their hearing aids in order to be successful:

1. DNN-based denoising noise reduction, to lift the speech out of the surrounding noise and simultaneously attenuate that noise, and
2. Narrow 4-microphone beamforming directionality, to ensure that the speech they want to hear is the speech that is the most audible, and
3. Automatic, accurate activation of these powerful DNN-based denoising noise reduction and narrow 4-microphone beamforming directionality features.

The fine-tuned feature activation of AcoustIQ enables the unique hearing-in-noise technology of Beltone Illuminate 17 level hearing aids: the new True Directionality. True Directionality provides an AI-powered automatic listening experience built around three technologies working as one. With the updated steering provided by AcoustIQ, True Directionality automatically activates DNN-based denoising noise reduction at the same time as narrow 4-microphone beamforming directionality in precisely the listening situations where the greatest speech audibility benefit is required for successful hearing outcomes. This means that a hearing aid user will experience relief from the surrounding noise, while being able to focus on just the speech they choose by looking in the direction in which they want to hear a speaker best. As people have an innate tendency to look at a speaker that is of interest during a conversation, Beltone Illuminate supports this natural behavior to make hearing more effortless and a desired speaker more audible, even in the most difficult listening situations.

While AcoustIQ was fine-tuned to support the automatic switching behavior of the True Directionality feature in the Beltone Illuminate 17, its role in enhanced feature activation is implemented across the Beltone Illuminate hearing aid family. In addition to True Directionality, it ensures that other advanced technologies such as CrossLink Directionality 4, CrossLink Directionality 3, Synchronized Speech Spotter Pro and Sound Cleaner engage when they are needed – and only when they are needed. In other Beltone hearing aids, the foundational version of AcoustIQ works to accurately characterize listening environments and steer features as well, but without the additional enhancements available for the Beltone Illuminate family.

AcoustIQ: Taking Environmental Classification and Traditional Feature Steering the Important Step Forward to Intelligent Action

The effectiveness of any hearing aid depends on its ability to respond appropriately to the sounds around the user. Even the most advanced hearing technologies can only deliver benefit when they activate at the right time and in the right situations. This requires two things:

1. Accurate understanding of the listening environment,
2. Accurate activation of the technologies designed to help a user hear better in that environment.

AcoustIQ is the intelligence that connects these two steps into one cohesive system. It continuously classifies the listening environment and automatically engages the appropriate features and processing strategies, helping users receive the right support for each listening situation.

At the core of AcoustIQ is the Beltone Environmental Classifier, which divides listening situations into seven primary categories according to the input level and the signal-to-noise ratio. However, these seven categories are conceptual only; in actuality, the Environmental Classifier classifies the environment on a continuum, as illustrated in Figure 1 by the light and dark gray shaded areas surrounding the primary categories. With this design, it is possible for the Environmental Classifier to accurately describe listening situations that have input levels and SNRs that are bordering two or more categories. Once the listening environment is properly classified by the Environmental Classifier, the AcoustIQ system activates and deactivates features accordingly.

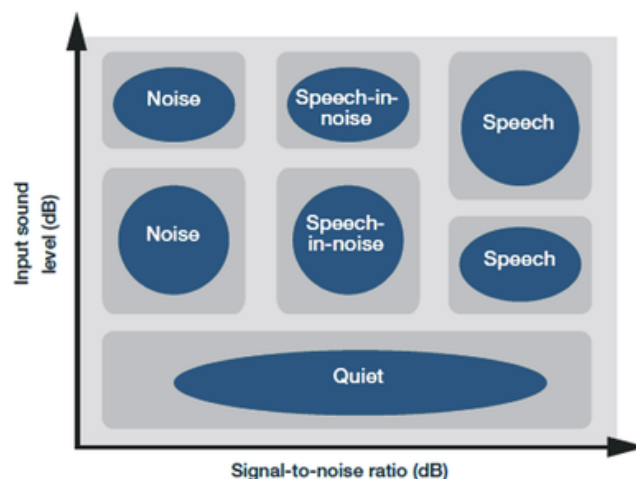


Figure 1. Primary categories of the Beltone Environmental Classifier.

The most premiere feature that is driven by AcoustIQ is True Directionality, an all-in-one directionality option offering three automatically switching modes designed to support the listening needs of users in real-world situations. Based on years of research, the modes of True Directionality are steered by the acoustics of the environment and the typical listening needs of the user in that environment. Switching transitions between modes are designed to occur gradually, to preserve sound quality and to avoid abrupt or jarring sound perceptions. In addition, True Directionality is designed to respect the higher-level processing in the user's brain and is integrated into the Organic Hearing philosophy. Table 1 shows the rationale, technical details and environments in which each mode of True Directionality is activated. Note that in addition to input from the Environmental Classifier, the location of speech in the environment also determines the mode of True Directionality.

Beltone True Directionality Mode	RATIONALE	MICROPHONE SETTING AND NOISE REDUCTION PAIRING	ENVIRONMENTS
Spatial Cue Preservation	Emphasizes natural sound quality and spatial perception	Bilateral omnidirectional with binaural compression and pinna restoration cues Beltone Sound Cleaner	• Quiet • Soft Speech • Loud Speech
Better Ear/Binaural Listening Mode	Uses the brain's binaural processing ability to shift focus to a speaker while maintaining auditory awareness of the surroundings	Asymmetric multiband directionality with directional on one side and omnidirectional on the other side Beltone Sound Cleaner	• Speech in Moderate Noise – when there is no speech in front • Speech in Loud Noise – when there is no speech in front • Moderate Noise • Loud Noise
Speech Intelligibility	Provides the best SNR in noisy situations where there is speech in front of the user	Bilateral multiband 4-microphone beamforming directionality Beltone True Noise Reduction (Illuminate tech level 17) Beltone Sound Cleaner (all other price points)	• Speech in Moderate Noise – when there is speech in front • Speech in Loud Noise – when there is speech in front

Table 1. Beltone True Directionality modes, and when they are activated by AcoustIQ.

The settings of True Directionality were curated to support users in all different environments. Spatial Cue Preservation mode is activated when a user is in Quiet, Soft Speech and Loud Speech environments. Examples of these environments with minimal noise include quiet offices, walking outside, having a conversation with a friend in a quiet area, or watching television at home. In environments classified as Moderate Noise, Loud Noise, Speech in Moderate Noise when speech is not in front, and Speech in Loud Noise when speech is not in front, the Better Ear/Binaural Listening mode is elicited. This mode capitalizes on the principles of how the brain uses the “better ear” to focus on an intended speaker or sound in the environment. Asymmetric directionality provides relief from noise from the directional response on one side while keeping the user aware of their surroundings via the omnidirectional response from the other side. Common listening environments where this mode would be elicited would be sitting at a counter having lunch with a friend, moving through a department store, or in a small group setting. Finally, Speech Intelligibility mode is elicited when speech is in front of the user in a noisy environment. This is a situation where hearing speech in front can be of utmost importance, so the strongest, narrowest-beam directionality setting is provided. Airport ticket counters, supermarket checkout aisles, and conversations across the table at loud restaurants are settings where this mode is most advantageous.

The combination of directionality with noise reduction in True Directionality has a significant effect on user benefits and sound quality. Beltone Sound Cleaner, which uses spectral subtraction to reduce all types of noise including speech babble or “cafeteria noise,” is paired with True Directionality in most environments. In contrast, Beltone True Noise Reduction uses strong DNN-based denoising

noise reduction that is specifically designed to isolate speech and remove noise in speech-in-noise environments. For this reason, True Noise Reduction is activated only in those difficult listening situations. This judicious application of Sound Cleaner and True Noise Reduction ensures that users receive the optimal amount of relief from noise in any environment they encounter. Pairing the strong noise reduction of True Noise Reduction in tech level 17 Beltone Illuminate hearing aids with bilateral 4-microphone beamforming directionality in noisy listening situations with a speaker in front – similar to a restaurant or party scene – further ensures that noise is diminished while the speaker in the look direction is amplified. This can be highly beneficial to users when there is competing speech to the side but they desire to hear the person speaking directly in front of them.

Aside from True Directionality, AcoustIQ also determines how Synchronized Speech Spotter Pro is activated and applied. Synchronized Speech Spotter Pro uses the input from AcoustIQ to determine the level of noise and speech in the environment, as well as where the speech is located, and elicits either a bilateral directional or a bilateral omnidirectional setting. This directional option does not include asymmetric directionality or 4-microphone beamforming directionality. Based on where the speech is originating in front of the user, the Smart Beam option will automatically narrow or widen the 2-microphone directional beam. Synchronized Speech Spotter Pro, as well as its non-synchronized version available at lower tech levels, does not provide as narrow a directional beamwidth as the 4-microphone directionality provided by the Speech Intelligibility mode of True Directionality. For the best audibility of speech in front with loud noise surrounding the user, True Directionality is recommended.

AcoustIQ also plays a pivotal role in determining the output of the Smart Gain, a specialized feature that helps users achieve the most customized fitting. Smart Gain applies gain offsets according to the listening environment. Smart Gain Pro provides gain offsets as well as Sound Cleaner settings per the listening environment. Since different levels of gain and noise reduction may be advantageous in different settings, this allows the hearing care professional to fine tune the fitting without having to change the overall gains or overall noise reduction settings. It is an automatic gain and/or noise reduction feature that activates only in certain listening environments, reducing the need for global fine tuning of the fitting or user-initiated manual adjustments.

For example, imagine a user who indicates that they are doing well with their hearing aids overall, but are bothered by the noise level in loud environments. Their hearing care professional could then ask specific questions about how loud the noise is, and whether these environments also include speech, to better pinpoint where the user is having difficulties. If the user’s response indicates they need more relief from noise in loud environments without speech, the hearing care professional could then adjust the Loud Noise slider to elicit a stronger noise reduction setting only in that listening environment (Figure 2). The beauty of this solution is that the gains and noise reduction settings remain unchanged for all other listening environments.

Since the user was doing well in other environments, making a change only to a specific environment allows for extremely fine-tuned adjustments.

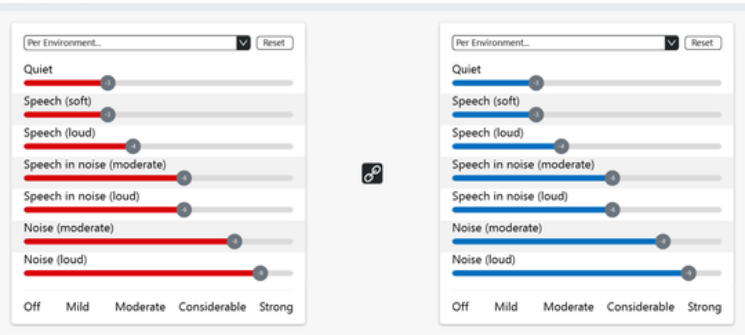


Figure 2. Smart Gain Pro sliders for Sound Cleaner per environment.

Accurate Decisions Drive Better Listening Outcomes

The listening benefits of hearing aids are driven by the gains and features applied for users as they encounter different listening situations. However, if those gains and features do not activate when they should, either because the hearing aid fails to classify the environment correctly or does not engage features appropriately, the user will have reduced benefits from hearing aids. To ensure users receive the benefits they expect and deserve, it is imperative to measure the accuracy of the classification and feature activation of the hearing aid.

To verify the accuracy of AcoustIQ, including the input from the Environmental Classifier as well as the resulting activation of features, two studies were conducted. The first study¹ quantified the accuracy of the Environmental Classifier in 3 different environments – quiet and speech only, speech in noise, and noise. Beltone hearing aids were revealed to be the most accurate in classification across all three environments, when compared to other hearing aids (Figure 3).

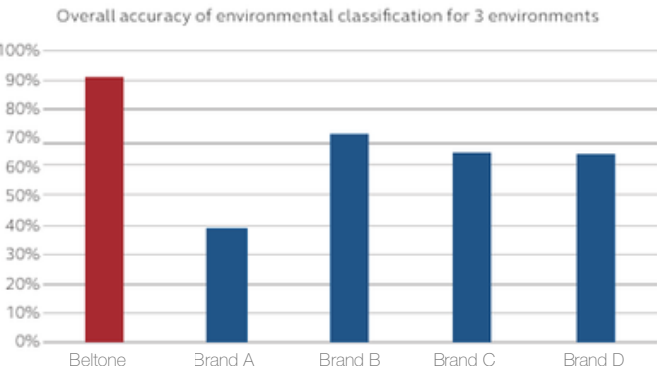


Figure 3. Accuracy across different sound scenarios for each hearing aid brand.

An additional study² explored the outcome of classification in hearing aids; specifically, whether features activate when they should, in speech in quiet, speech in noise, and noise environments. Features that affect gain outside of the basic amplification system in hearing aids, including directionality, noise reduction and automatic volume control features, were referred to as “gain agents” in the study.

Results indicated that Beltone hearing aids had the highest accuracy of feature engagement among other hearing aid brands (Figure 4).

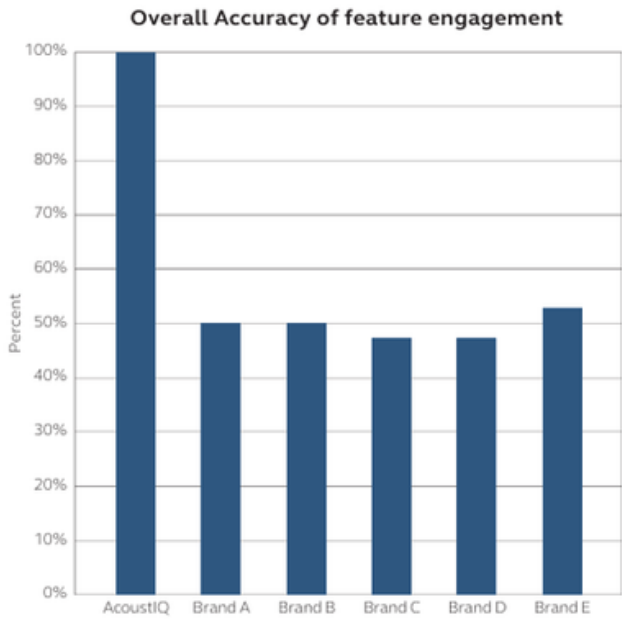


Figure 4. Overall accuracy of gain agent activation across hearing aid brands.

Conclusion

Today’s hearing aids have technology and features that can help users succeed more than ever before, especially in the most difficult, noisy listening situations. However, it stands to reason that these advancements can only benefit users when they are applied accurately according to the listening environment. When hearing aid technology activates as it should, users receive the benefits that they need to engage in the world around them. As such, ensuring the accuracy of hearing aid classification and feature activation is an important step in providing quality hearing care. With AcoustIQ, the solid foundation of accurate environmental classification enables the automated features of Beltone Illuminate hearing aids to optimally activate, promoting greater confidence and better hearing outcomes for the user in any listening environment they encounter.

References

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