ADVANCED BIONICS
POWERFUL CONNECTIONS

CLINICAL RESEARCH

AutoSense OS™ 3.0 Operating System

Allowing Marvel CI users to seamlessly connect with the moments they love

INTRODUCTION

As cochlear implant (CI) recipients move through their day, they encounter a variety of acoustic environments, each of which places unique listening demands upon them. AutoSense OS 3.0, first introduced in Phonak hearing aids, is an operating system designed to automatically steer sound processing, optimizing hearing performance and recipient comfort while minimizing the need for manual changes.[1, 2] In the Advanced Bionics Naída™ CI M Sound processor and Sky CI™ M sound processor, AutoSense OS 3.0 and AutoSense Sky OS 3.0 have been adapted and optimized for CI users.

HOW DOES AUTOSENSE OS 3.0 WORK?

AutoSense OS 3.0 leverages artificial intelligence that was trained using modern machine learning methods. Training this system for classification of listening environments involved analysis of thousands of sound scenes that reflect the broad range of acoustic experiences that are encountered during daily life. The result is a system that monitors acoustic parameters, including level differences, estimated signal-to-noise ratios, synchrony of temporal onsets across frequency bands, amplitude, and spectral information. Every 0.4 seconds, the algorithm calculates the statistical probability that the listening environment matches one of seven pre-defined sound classes. Based on these probabilities, AutoSense OS 3.0 determines a combination or blend of sound classes that best matches the listener's environment. The appropriate blend of sound classes, features, and settings for that environment is then automatically activated. This optimizes sound quality and speech intelligibility by applying sound processing intelligently based on real-time analysis of the listening environment.

Acoustic environments are classified into seven different sound classes: Calm situation, Speech in noise, Speech in loud noise, Speech in car, Comfort in noise, Comfort in echo, and Music (see Figure 1). Of these, Speech in loud noise, Music, and Speech in car are exclusive classes, meaning that these classes cannot be blended with other sound classes. The other four sound classes can be activated either exclusively or as a blend, with the possibility for up to three sound classes to be blended at once. For example, Comfort in echo, Comfort in noise, and Speech in noise may be blended when the listener is having a conversation in a moderately noisy environment with high ceilings. This advanced technology allows AutoSense OS 3.0 to create over 200 possible settings that are designed to optimize listening based on the CI user's dynamic sound environment and the settings programmed by the professional. In addition to classifying acoustic environments, AutoSense OS 3.0 is the first in the industry to classify streamed audio signals. Streamed input is classified as Media speech or Media music, and the appropriate parameters are adjusted to optimize the listener's audio streaming experience, whether they are watching TV, listening to music, or streaming podcasts.

Figure 1: Acoustic and streaming classification in AutoSense OS 3.0.

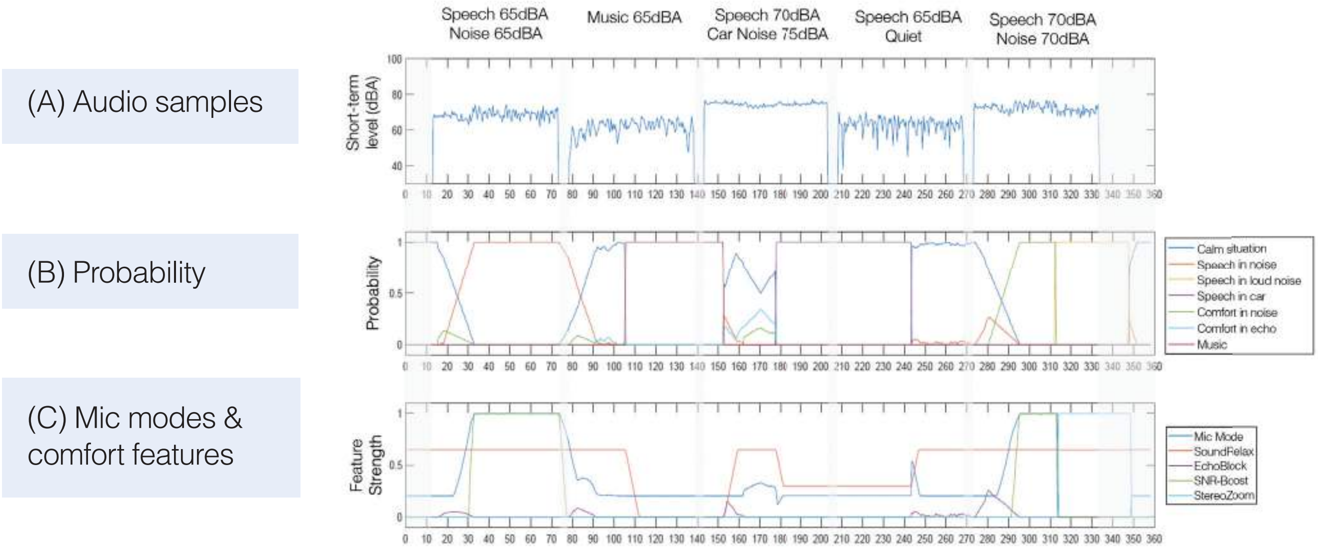

Figure 2: The classification of acoustic input by AutoSense OS 3.0. Panel A depicts audio samples from five sound environments — speech and noise at 65 dBA (Speech in noise), music at 65 dBA (Music), speech at 70 dBA in 75 dBA car noise (Speech in car), speech in quiet at 65 dBA, and speech and noise at 70 dBA each. Each audio sample is 60 seconds in duration. Panel B shows the corresponding statistical probabilities calculated by AutoSense OS 3.0 for the acoustic input matching the seven sound classes either exclusively (i.e., 100%) or in a blended manner. Panel C depicts how the strengths and the blend of the microphone modes as well as front-end processing features automatically change accordingly over time. Microphone (mic) mode varies from omnidirectional (T-Mic/RES) to more directional (UltraZoom) to maximum directionality (StereoZoom). The strength of SNR-Boost is varied depending on the presence of noise. Depending on the probability match with Comfort in echo, EchoBlock strength is varied. The microphone modes and comfort features named here and in Figure 3 are defined in Table 1.

Clinicians can review the proportion of time each sound class (acoustic and streaming) is active via the datalog section of the Target CI programming software. Figure 3 shows sample data from a Marvel CI processor fit on the left ear of a recipient.

MARVEL CI MICROPHONE MODES AND FRONT-END SOUND CLEANING FEATURES

Once finished with classifying the recipient's listening environment, AutoSense OS 3.0 activates the microphone mode and front-end processing feature(s) that are appropriate for that environment (Table 1). These features are complemented by AB sound processing technologies and proven noise reduction features like ClearVoice™ sound processing,[3-7] SoftVoice,[8,9] industry-leading wide Input Dynamic Range (IDR),[10,11] dual-loop Automatic Gain Control (AGC),[12,13] and Span.[14]

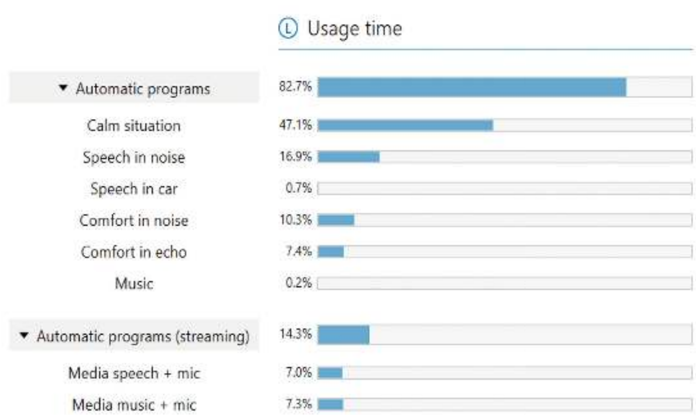

Figure 3: Example of information regarding AutoSense OS 3.0 activity from a unilateral CI recipient's datalog, as displayed in Target CI fitting software.

	FEATURE	PURPOSE
Microphone Modes	**Real Ear Sound (RES)**	Mimic response and benefit of the T-Mic[15-18] by mildly attenuating sounds from behind the listener[19]
	UltraZoom	Adaptively attenuate noise sources located on the sides and back to improve face-to-face speech understanding in noise[20-25]
	UltraZoom & SNR-Boost	UltraZoom plus application of additional noise cancellation based on location of noise[26]
	StereoZoom	Create narrow focus for front-facing communication in extreme noise for bilateral or bimodal recipients[21, 24]
Front-end Processing Features (FEPs)	**NoiseBlock**	Reduce bothersome background noise (for M Acoustic Earhook users)
	WindBlock	Reduce bothersome impact of wind noise
	SoundRelax	Reduce bothersome impact of sudden impulse sounds
	EchoBlock	Reduce bothersome impact of reverberation

Table 1: Automatic microphone modes and front-end processing features available in the Marvel CI sound processor system.

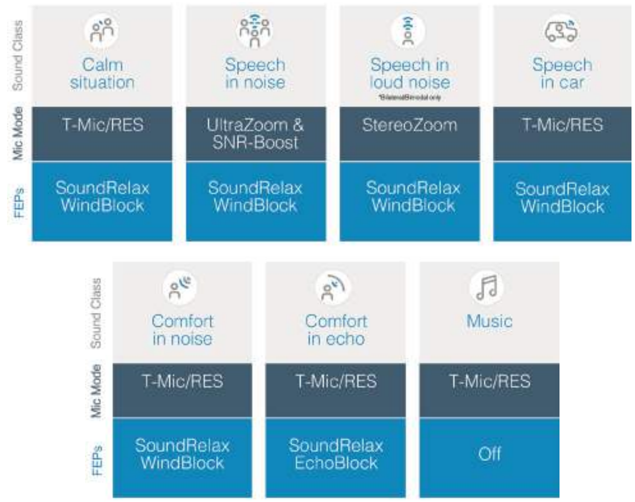

Figure 4: AutoSense OS 3.0 sound classes and associated microphone modes and front-end processing features (FEPs). Note that default strength settings for FEPs may vary by sound class.

Figure 4 displays a simplified overview of the microphone modes and front-end processing features that are activated within each acoustic sound class of AutoSense OS 3.0. The strength and the blend of the microphone modes and front-end processing features will change depending on the environment, which allows for optimized listening all day, every day. The seamless and automatic activation of these features is designed to allow CI users to move from one listening environment to the next without the need to manually adjust their sound processor settings as they go. Recipients do not need to manage various programs for different listening environments.

CLINICAL RESULTS WITH AUTOSENSE OS 3.0

Studies with Phonak Marvel hearing aid users have demonstrated better speech perception in real-world listening conditions when using a program with AutoSense OS 3.0 technology.[1, 2] Participants in these studies preferred the AutoSense OS 3.0 program to their manually selected program in all listening conditions. As a part of the Marvel CI development, multiple clinical studies provided evidence for an improved listening experience with AutoSense OS 3.0 in Advanced Bionics CI recipients.[27-29]

In one study completed at the labs of Advanced Bionics, LLC,[30] ten adult CI recipients underwent speech recognition tests in quiet and in noise. Target stimuli (AzBio sentences at 65 dBA) were presented from a loudspeaker at 0 degrees azimuth. Noise (multi-talker babble at +5 dB SNR) was presented from a loudspeaker positioned at 180 degrees.

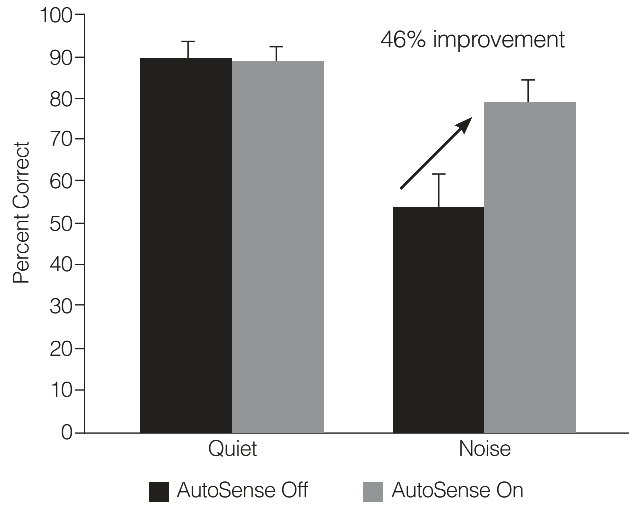

Figure 5: Speech recognition scores with the Marvel CI sound processor as a function of listening environment and AutoSense OS activity.

Figure 5 shows speech recognition scores in quiet and in noise with AutoSense OS 3.0 set to OFF and ON. As hypothesized, performance was equivalent in quiet, and an improvement (46%) was observed in noise with AutoSense OS 3.0 set to ON, demonstrating the benefit provided when AutoSense OS 3.0 adapts to the user's listening environment.

AUTOSENSE SKY OS 3.0

AutoSense Sky OS 3.0 is the world's first operating system for a CI sound processor designed for children, Sky CI M.[31, 32] AutoSense Sky OS 3.0 was developed specifically for the listening environments children experience to ensure that kids and teens have the optimal listening experience in their unique listening situations, including classrooms, libraries, the playground, and when listening to music. AutoSense Sky OS 3.0 applies customized settings without the need for manual adjustments, so kids and their parents can focus on more of life's great adventures and let the sound processor do the work.

SUMMARY

AutoSense OS 3.0 and AutoSense Sky OS 3.0 combine innovations from AB and Phonak that are designed to provide adult and pediatric recipients with a powerful hearing experience and the ultimate ease of use throughout the day, reducing the need to manually switch programs. AutoSense OS 3.0 provides improved speech recognition in noisy listening environments by seamlessly activating the microphone modes and processing features that are appropriate for the environment in real time. The automatic adaptation to the listening environment enabled by AutoSense OS 3.0 allows Marvel CI users to stay fully connected to the world, rather than focusing on how their CI sound processor is functioning.

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