Sonic Spotlight

Speech Priority Noise Reduction: The Process Revealed

Hearing in background noise has long been identified as one of the biggest problems facing hearing instrument users.[1,2] Whereas noise reduction algorithms developed for hearing instruments have been shown to improve sound comfort, they also can degrade speech recognition if applied too aggressively.[3] It is important that hearing instruments strike the right balance between providing exceptional listening comfort in noise while maintaining speech intelligibility.

Speech Priority Noise Reduction – A Modulation-Based Algorithm

Modulation-based noise reduction algorithms, like Speech Priority Noise Reduction (SPNR) from Sonic, aim to improve listening comfort in noise.[4] This is done by a two-part process—an elegant sequence of events that works to first identify, then reduce the gain of bothersome background noise. Speech intelligibility remains intact, thanks to the speed of Sonic's digital signal processing, Speech Variable Processing (SVP). But exactly how does SPNR work once a signal in noise is detected?

Detect the modulation rate

SPNR's first requirement is to detect the modulation rate, or individual 'fingerprint' of the incoming signal. As shown in Figure 1, signals with a low modulation rate are classified as undesirable (e.g. steady-state background noise, fan); signals with a high modulation rate are classified as desirable (e.g. speech, music). Modulation rates for speech, music or noise can be detected at any intensity level, whether low, medium or high input levels of loudness. Once the characteristics of speech and/or noise are determined by detecting the signal's distinctive rate, then the second part of the process begins.

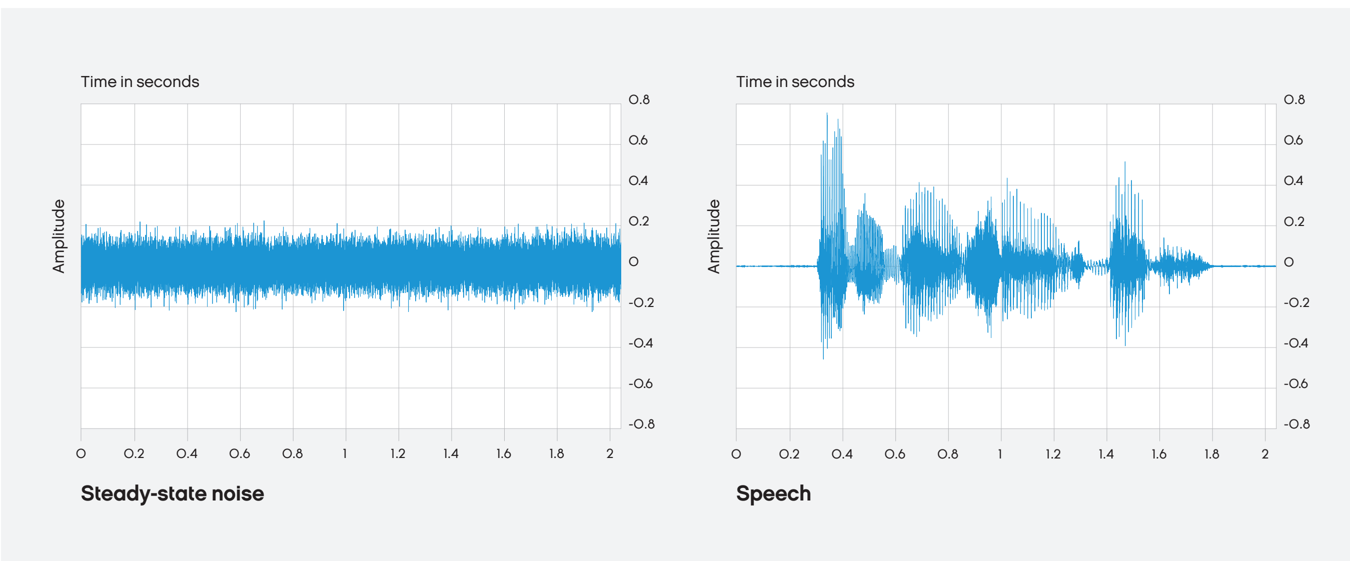

Figure 1:
Illustration of low versus high rates of modulation for two different acoustic signals: steady-state noise (left) and speech (right).

Determine the modulation depth

After the modulation rate is detected, the noise reduction algorithm is responsible for determining the signal's modulation depth. This process estimates the signal-to-noise ratio (SNR) of the incoming signal. SPNR continuously monitors the peaks and troughs of the signal to determine their specific modulation depth. If a large peak-to-trough value is estimated, the SNR is determined to be high; if a small peak-to-trough value is estimated, the SNR is determined to be low. The algorithm's main goal is to reliably estimate the SNR in order to provide an accurate snapshot of modulated signals (e.g. speech) versus steady-state noise (e.g. background noise). SPNR's fast time constants provide the best way to reliably estimate the SNR, compared to slow time constants, as seen in Figure 2.

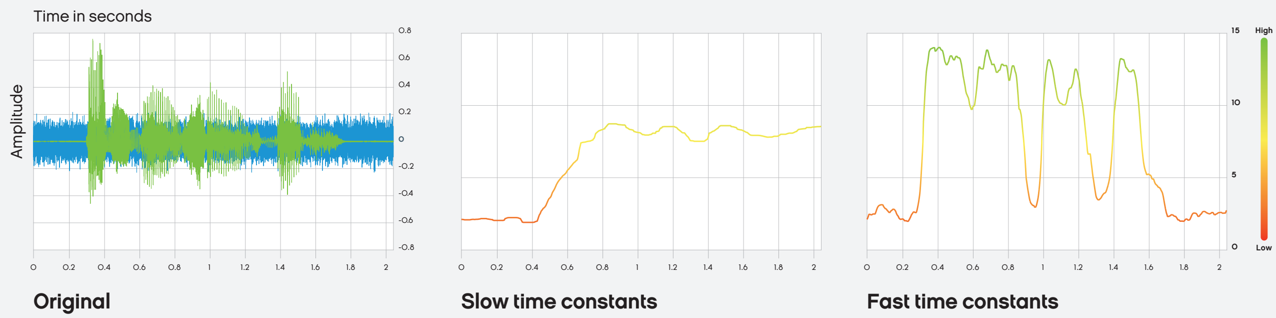

Figure 2:
Original speech-in-noise waveform of the word 'Everyday' in 65 dB SPL broadband noise (left), and the corresponding SNR estimates for two hearing systems with slow vs. fast noise reduction systems. Slow systems (center) lead to inaccurate SNR estimation by inaccurately measuring the signal's modulation depth. Faster time constants (right) lead to the reliable and accurate estimation of the SNR in noisy conditions, by tracking the appropriate modulation depth (peaks, troughs) of the original signal.

The Relationship with Speech Variable Processing (SVP)

Once the SNR is estimated, the system decides how to (1) maximize comfort and (2) preserve speech information. Fast acting, symmetric attack and release times help to achieve both objectives.

Comfort is swiftly maximized by SPNR's adaptive settings, which applies only the necessary amount of attenuation needed for the situation. For example, if a lot of noise is present and the SNR is poor, then the maximum amount of noise reduction will be applied; if the SNR becomes favorable, then the minimum amount of reduction is applied.

Whether the SNR is good or poor, SPNR's fast attack times allow noise reduction to engage instantly. Likewise, SPNR's fast release times allow SVP to independently apply the correct amount of gain to the incoming speech signal without delay, so speech sounds are preserved. In this way, SPNR attenuates more noise when speech-in-noise is present. Due to the efficient speed and temporal precision of both SPNR and SVP, comfort and accuracy result: SPNR attenuates noise even between the smallest pauses within speech, while SVP preserves speech, down to the phonemic level.

SPNR Tested: How SPNR Compares With a Competitive Device

Hearing instruments with modulation-based noise reduction algorithms that use slower time constants may do a fine job of amplifying speech sounds in quiet. However, they often miss the mark when it comes to providing listening comfort in noise, as summarized in the following study.[5] How does Sonic's SPNR rate in comparison?

To find out if SPNR's fast time constants support preferred listening conditions in background noise, an independent study was conducted to evaluate the noise reduction settings found in Sonic hearing instruments compared to a different, commercially available hearing instrument that employs noise reduction with slower time constants.

SPNR's baseline state (off) was also compared, as a control. All three devices were matched on measures of speech intelligibility in quiet and noise, in order to focus solely on the variable of time constants.

In the study, 20 hearing-impaired subjects were asked to complete a blinded paired comparison task. Through insert earphones coupled to a 'Virtual' research hearing aid, they listened and compared four different listening situations (Table 1) digitally recorded under three different noise reduction configurations (Table 2), and provided their ratings on three preference attributes (Table 3) by making their choices on a touchscreen monitor.

Table 1:

Listenting Situations
Speech in Traffic Noise
Traffic Noise
Speech in Quiet
Quiet (Birds)

Table 2:

NR Label	NR Setting
NR A	SPNR High
NR B	SPNR Off (control)
NR C	Competitor NR High
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Table 3:

Preference Attributes
Sound Quality: *"Which HI sounds better?"*
Listening Effort: *"For which HI is listening less tiring/stressful?"*
General Preference: *"Which HI do you generally prefer?*
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Sonic
Everyday Sounds Better

The data was statistically managed in two ways: (1) all Attribute ratings were pooled together and graphed according to the four Listening Situations; and (2) all Listening Situation ratings were pooled together and graphed according to the three Attributes. In this way, various meaningful conclusions could be parsed out from the large volume of paired comparison ratings obtained for the three NR settings, labeled NR A, B and C.

As shown in Figure 3a, the results for the tested Listening Situations in noise are striking: NR A (SPNR High) was chosen significantly more times over NR B and NR C for the two noise categories, Speech in Traffic Noise, and Traffic Noise. That is, SPNR outperformed the Competitor NR and the Control NR by a significant degree in noisy conditions, as seen in the first two bar graphs. In the two quiet conditions, Speech in Quiet, and Birds, SPNR showed no disadvantage to having the maximum noise reduction setting activated when noise is not present, compared to the Competitor or Control NR, as seen in the last two bar graphs.

Figure 3b shows the results for the tested Attributes. NR A is rated significantly better than NR B and better than NR C for Sound Quality; NR A also shows a much greater advantage for Listening Effort and Preference over NR B and NR C. Again, SPNR outperformed the other two devices in terms of the attributes tested.

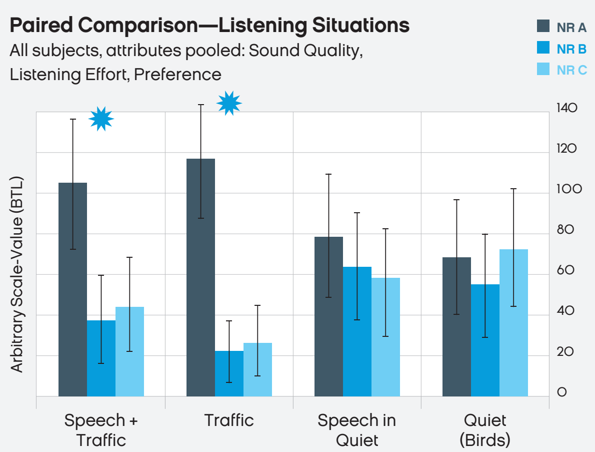


Figure 3a:
Paired comparison results for the four listening situations, pooled over the three attributes Sound Quality, Listening Effort, and Preference. The error-bars represent the 95% confidence interval. (✷) Indicates a significant difference.

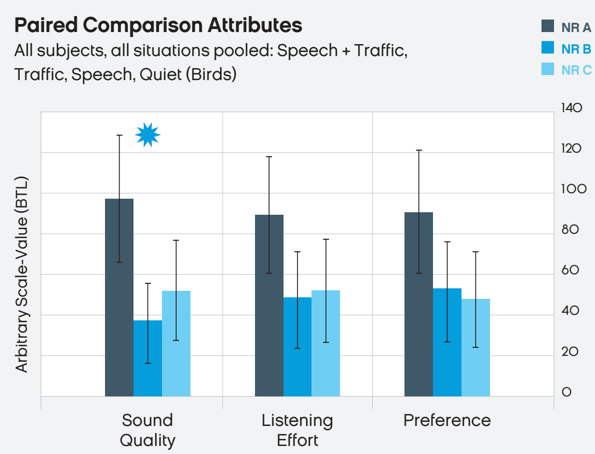
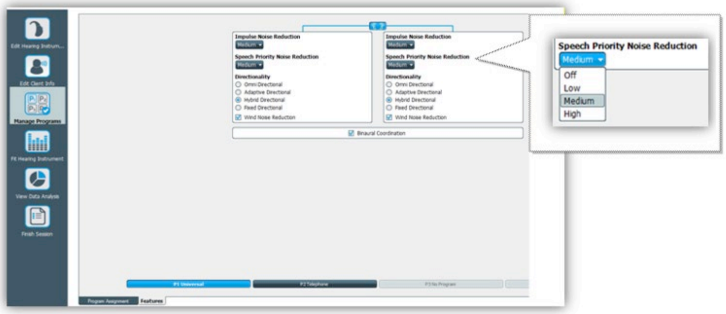


Figure 3b:
Paired comparison results for the three attributes, pooled over the four listening situations. The error-bars represent the 95% confidence interval. (✷) Indicates a significant difference.

Overall, SPNR was found to be the better hearing instrument compared to the Competitor and Control NR for the listening situations in noise and attributes tested. The single variable that contributes to these convincing results is the speed of the respective noise reduction strategies implemented in the hearing instruments, with the fast time constants surpassing the slow time constants for subjective preferences in noise.

Easy Adjustments with EXPRESS*fit*

In keeping with the Sonic commitment to Simplicity, the EXPRESS*fit* fitting software makes the selection of desired noise reduction strength simple and straightforward. Easy to locate, SPNR is set in the Features tab in the Manage Programs screen. The fitting system will automatically suggest the best level of noise reduction based on the selected environmental program (e.g. Universal, Telephone, Classroom). However, you may select a different level based on your patients needs, and apply it either monaurally or binaurally.



Guidelines for Use

SPNR levels are designed to be intuitive for the busy hearing healthcare professional. Simplified labeling takes away much of the guesswork for knowing how much noise reduction to apply for individual patient needs. The following guidelines further categorize the levels according to patient-specific listening requirements and scenarios.

SPNR Level:	Best Setting for:
Off	Patients not bothered by background noise; listening to music in quiet surroundings.
Low	Patients who want to retain auditory awareness of environmental noises
Medium	Patients who are distracted by background noise. This is the default setting for the Universal listening environment.
High	Patients who are strongly disturbed by loud, medium or soft noise. Those listening in environments with fast and often changing background noise levels.

Attenuation Ranges

Remember that SPNR is an adaptive noise reduction system. Depending on the SNR, it will adaptively attenuate background noise within a certain range, **only as much as needed,** to restore listening comfort in noisy conditions. Listed below are the designated ranges of attenuation for each selectable level in EXPRESS*fit*.

SPNR Level	Minimum NR in dB	Maximum NR in dB
Off	0 dB	0 dB
Low	3 dB	4.5 dB
Medium	4.5 dB	7.5 dB
High	6 dB	15 dB

Speech Priority Noise Reduction: The Take Home Message

Speech Priority Noise Reduction from Sonic is the next generation noise reduction strategy designed to help patients hear more comfortably and clearly in background noise. It can be found within all family levels of Sonic Bliss, Charm, and Flip hearing instruments. Delivering on a wide range of technological benefit, SPNR is designed to:

- *Detect the modulation rate and depth of signals with accuracy*
- *Respond to noise changes instantly when they happen*
- *Identify and attenuate noise at varying input levels*
- *Attenuate more noise in speech-in-noise situations*
- *Avoid attenuation of speech in noisy conditions*
- *Enjoy a greater advantage when compared to a competitor device*
- *Provide listening comfort in noise and preserve underlying speech signals to keep speech natural and clear*

For a demonstration or to learn more,
please contact your local Sonic provider.

References

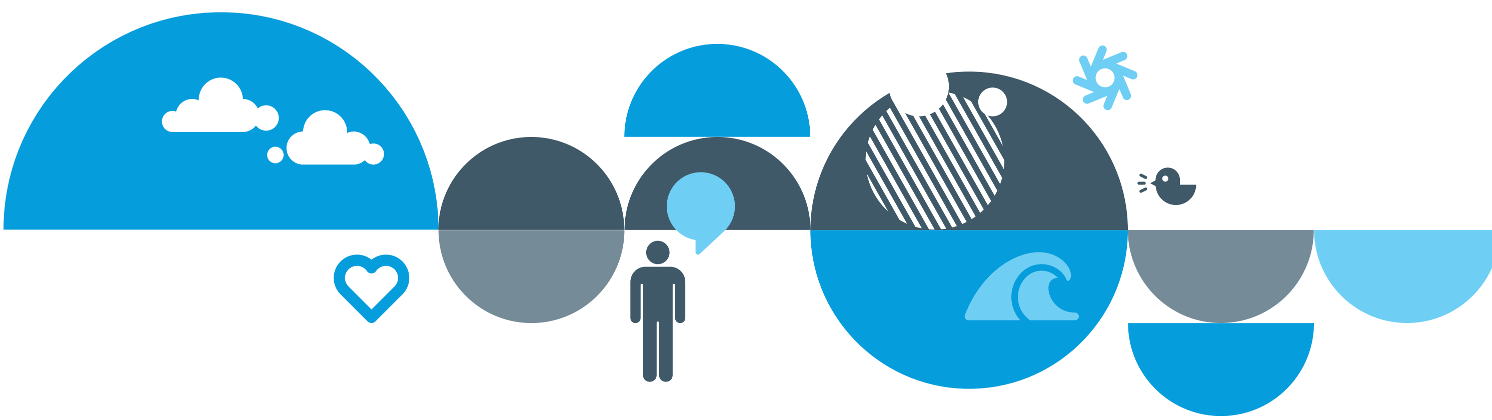
[1] Kochkin S. MarkeTrak V: Why my hearing aids are in the drawer: The consumer's perspective. Hear Jour. 2000;53(2):34-42.

[2] Kochkin S. MarkeTrak VIII: Customer satisfaction with hearing aids is slowly increasing. Hear Jour. 2010;63(1), 11–19.

[3] Ricketts T, Hornsby, B. Sound Quality Measures for Speech in Noise through a Commercial Hearing Aid Implementing "Digital Noise Reduction." J Am Acad Audiol. 2005;16:270–277.

[4] Chung, K. Reducing Noise Interference: Strategies to Enhance Hearing Aid Performance. The ASHA Leader. 2010, April 06.

[5] Helbling T, Vormann M, Wagener K. Speech Priority Noise Reduction: A digital noise reduction preference study. Hearing Review. 2013;10(11):34-43.



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