Sonic Spotlight

SmartCompress

Advancing compression technology into the future

Speech Variable Processing (SVP) is the unique digital signal processing strategy that gives Sonic hearing aids their signature natural sound. With flexible engineering, SVP takes full advantage of emerging technologies as they develop. Now, the addition of **SmartCompress** on the SoundDNA platform delivers a new dimension to signal processing. Read on to learn about SmartCompress, a significant step forward in advancing compression technology into the future.

See pages 8-9 for clinical and field tests results.

SmartCompress

Hearing loss, hearing aids and compression

Hearing care professionals know that patients with a sensorineural hearing loss have a reduced ability to understand speech. We try to compensate for the loss of auditory resolution by prescribing amplification via hearing aids. Linear amplification applies equal gain to all sounds regardless of input level. This preserves temporal and spectral contrasts in the original signal, but may under-amplify soft sounds and over-amplify loud sounds. Comparatively, non-linear amplification uses compression to apply more gain to soft sounds and less gain to loud sounds to attempt to restore normal loudness levels. Unfortunately—and perhaps surprisingly—compression introduces temporal and spectral distortion which may affect the speech envelope of the signal and may cause further problems, particularly in noise (Moore, 2008). Although both amplification strategies have advantages and disadvantages, compression is used most often in hearing aid fittings. Let's take a deeper look.

Problem: Compression in noise

Hearing aids typically apply compression in a manner that optimizes speech in quiet listening conditions (Figure 1). In fact, the most commonly used fitting rationales prescribe amplification targets specifically for this type of listening environment—speech in the absence of background noise. However, in listening environments that contain noise, there are parts of the signal that potentially have different gain requirements compared to a speech signal in quiet (Figure 2).

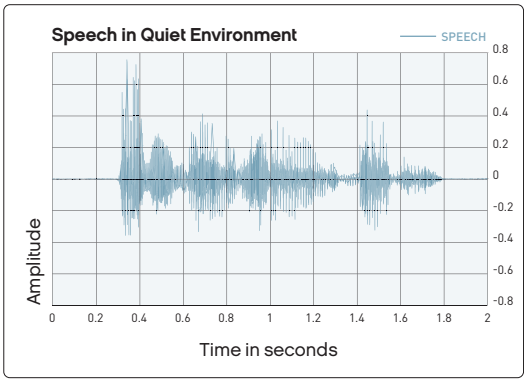

Figure 1: Speech signal in quiet environment.

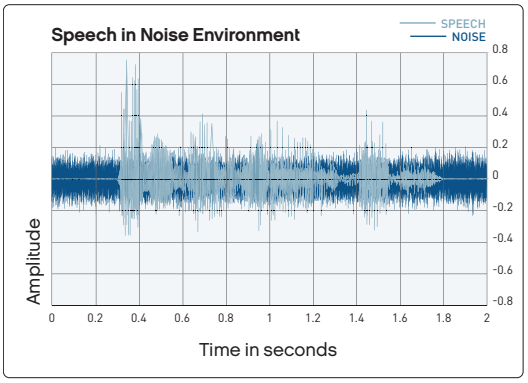

Figure 2: Speech signal in noise environment.

For signals that contain speech and noise, compression may negatively affect the signal-to-noise ratio (SNR) coming out of the hearing aid – the output SNR – simply because parts of the noise are amplified when they should ideally be reduced (Naylor and Johannesson, 2009). Knowing this, we must realize that compression is prescribed for speech-in-quiet conditions and may degrade the output SNR in speech-in-noise conditions. In addition, it may disproportionately amplify signals in quiet and noise-only environments where speech is not present. The reason is that compression technology by itself does not consider the signal type (speech vs. noise), nor the SNR of the input signal going into the hearing aid. In other words, compression is applied without regards to the presence or absence of noise in the environment.

The good news is that technology such as directional microphones and noise reduction algorithms can help to improve the SNR of the input to provide a cleaner signal to amplify (Valente et al., 1995; Stelmachowicz et al., 2010). However, if the compression system cannot distinguish the signal from the noise, it will continue to unnecessarily amplify noise signals, undermining the positive effects of directionality and noise reduction. Therefore, to achieve optimal amplification in noise, the compression system must be able to distinguish the signal from the noise by knowing the real-time SNR as it occurs. Based on this knowledge, it can then apply gain and compression in an appropriate manner for a given signal.

Solution: SmartCompress

SmartCompress from Sonic offers an effective solution to the problem of applying compression in noise. SmartCompress is an adaptive compression system that works together with SVP, directionality and noise reduction. It aims to accomplish two basic—but important—tasks:

Control how compression is applied in speech-in-noise listening environments

Control how gain is applied in quiet and noise-only listening environments when speech is not present

By doing so, SmartCompress adapts the amplification of sound based on the input level **and** the environment. It is automatically activated in situations where speech is mixed with noise to optimize challenging listening conditions. It is also automatically activated in quiet and noise-only situations to limit the amount of amplification applied to sounds originating in listening environments without speech. SmartCompress has no effect in speech-in-quiet listening environments. It complements any selected directionality pattern and noise reduction setting. Additionally, it works together with any generic or Sonic proprietary fitting rationale of choice.

Enhancing compression with SmartCompress

The main goal of SmartCompress is to provide an accurate assessment of the sound in the environment. How does it do this? It rapidly detects not only the short-term SNR of the signal at phonemic speed, but also the ongoing long-term SNR of the overall environment (Figure 3). This allows the system to apply amplification based on robust SNR information from both short- and long-term signal analyses. In other words, SmartCompress detects the SNR in real time to discriminate speech vs. noise – and applies gain and compression based on an accurate SNR detection.

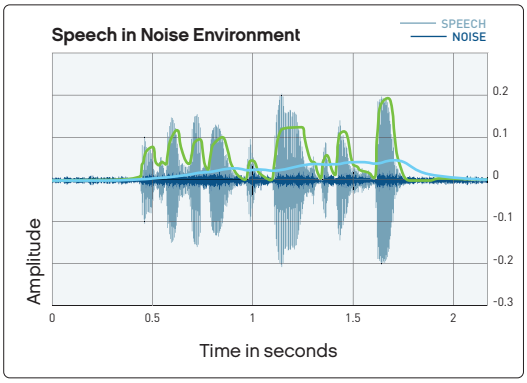

Figure 3: SmartCompress detects the short-term (green) and long-term (light blue) SNR of a speech in noise environment.

SmartCompress then controls how the system reacts in two ways:

Compression Control – adaptively varies the compression in speech-in-noise environments. It determines how much the compression has to be decreased, or made more linear in speech-in-noise listening environments.

Gain Control – adaptively limits gain when speech is not present. It determines the occurrence of quiet and noise-only situations and applies less gain to signals detected in the absence of speech.

The benefits of SmartCompress

SmartCompress benefits the hearing aid wearer by optimizing amplification in a variety of challenging and/or rapidly changing listening environments. Depending on the SNR, SmartCompress reacts in the following ways:

Very low SNR:

In quiet and noise-only environments without speech, SmartCompress via the Gain Control applies less gain to the incoming signal (Figure 4a). This action aims to offer greater listening comfort in non-speech listening environments.

Low SNR:

For signals that contain speech and noise, SmartCompress via the Compression Control reduces compression which minimizes the amplification of noise following short pauses in speech or even between phonemes to improve the output SNR (Figures 4b and 4c). This action aims to support speech and listening comfort in complex environments.

Very high SNR:

For speech signals detected in quiet, SmartCompress will not be activated. It applies no correction or control. Rather, SVP applies the prescribed gain and compression as designated by the selected fitting rationale along with any fine tuning actions made by the hearing care professional.

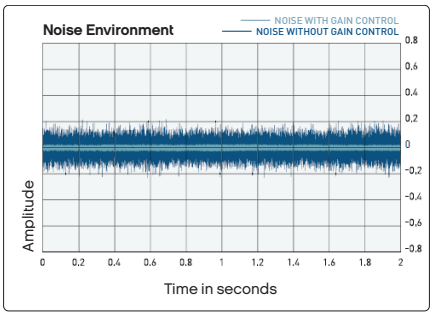

Figure 4a: Amplitude of noise signal without Gain Control (dark blue), comparison with Gain Control activated (light blue).

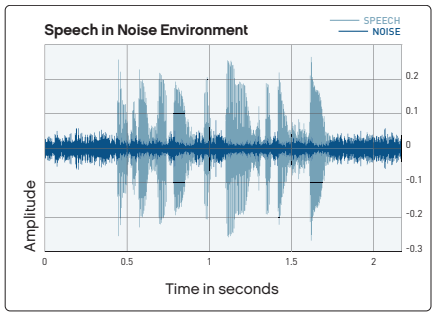

Figure 4b: Speech in noise output signal without SmartCompress.

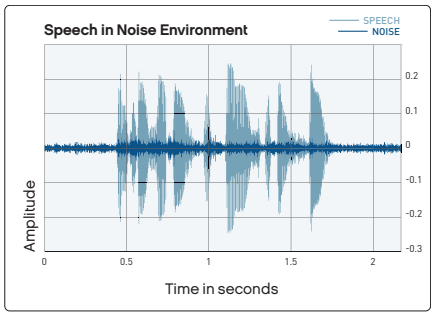

Figure 4c: Speech in noise output signal with SmartCompress.

SmartCompress vs. Environment Classification

The adaptive nature of SmartCompress differs from the similar concept—but static design—of our previous Environment Classification compression system. As a fixed decision-making algorithm, Environment Classification could optimize gain and compression for one specific environment beyond speech in quiet, for example, speech in noise, noise, or quiet. SmartCompress, on the other hand, instantly adapts gain and compression to optimize all environments beyond speech in quiet listening conditions, based on robust SNR analyses of the environment in real time.

SmartCompress in EXPRESS*fit*® Pro

SmartCompress is flexible and can be personalized according to individual needs in the EXPRESS*fit* Pro fitting software. SmartCompress includes up to two control options plus a variety of performance settings that optimize audibility and comfort, depending on an individual's listening preferences. In addition, it can be configured independently per selected listening program, where available. Locate SmartCompress within the General Settings tab of EXPRESS*fit* Pro, and apply settings as described below.

Gain Control:

The Gain Control regulates the amount of prescribed amplification in listening environments without speech. This feature applies less gain during quiet and noise-only conditions. Various Gain Control performance levels are available to meet patient needs.

Select the Gain Control level that corresponds to the individual's listening preferences in quiet or noisy environments. Performance levels may include Maximum, Medium, Minimum, or Off, depending on the technology level of the product. As shown in the table below, Maximum will limit the gain of non-speech signals to the greatest degree, supporting patients who are most bothered by environmental sounds. This means the non-speech signal will be amplified 6 dB less than a speech signal. Conversely, Medium and Minimum will limit the gain of non-speech signals to progressively lesser degrees, useful for patients who prefer to retain more auditory awareness of the environment.

Performance levels	Gain Control in dB
Maximum	6 dB
Medium	4 dB
Minimum	2 dB
Off	0 dB

Compression Control:

The Compression Control automatically reduces the compression applied in speech-in-noise environments, creating a more linear response in the instrument. This action limits the amplification of noise following short pauses in speech or even between phonemes, optimizing the SNR of the output.

To apply, select Audibility when speech intelligibility for soft phonemes is most critical for auditory needs. When patients prefer greater listening comfort in difficult listening situations, select Comfort. This option helps listeners particularly bothered by noise. When both audibility and comfort are mutually beneficial to daily listening needs, select Balanced. This option offers a practical approach to amplification in changing listening environments. Compression Control performance levels may vary per product technology level.

SmartCompress clinical and field tests

SmartCompress supports ease of listening in speech-in-noise situations:

Twenty-three male and seven female experienced hearing aid users with a moderate to severe hearing loss were tested to evaluate hearing aids with and without SmartCompress. Binaural amplification was fit to target according to NAL-NL2 fitting rationale and verified with real ear measurements. An adapted version of the WAKO word recognition rhyme test (v. Wallenberg & Kollmeier, 1989) which concurrently measures the listener's answer and response time was used as the test material. Speech and noise were presented from one single loudspeaker in the front at a fixed SNR of +5 dB SNR and speech level at 65 dB SPL. The test presentation was automated so that for each word the response and the response time were recorded. The test results for word recognition and response times are shown in Figure 5.

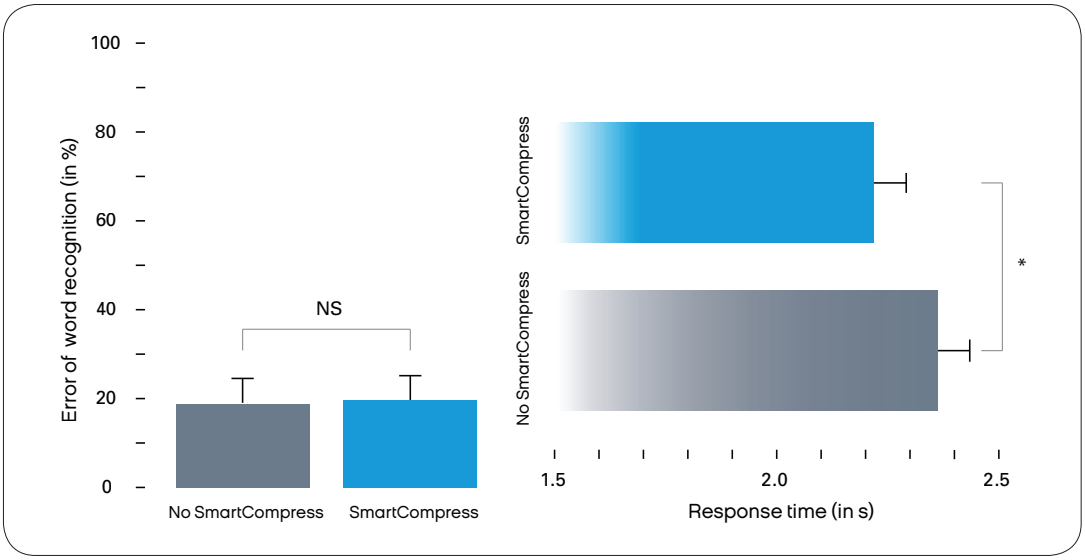

Figure 5: Results from word recognition tests without SmartCompress in grey and with SmartCompress in blue. Performance is measured with error of word recognition percentage on the left side and with response time in seconds on the right side. Average performance and one standard error are shown on the graphs.

The first graph shows word recognition performance with and without SmartCompress. This result suggests that when SmartCompress is activated, it leaves the speech signal unchanged as it applies less gain to the noise signal. The second graph shows response times measured with and without SmartCompress for all the tested words. The average response time is significantly faster with SmartCompress activated, indicating that listeners responded 145 ms faster ($p = 0.03$) to give their answer at the same intelligibility level when SmartCompress is activated.

SmartCompress reduces the level of noise for a speech-in-noise signal which improves the output SNR. Interpreting these results, this reduction is accurate enough so that speech intelligibility is not affected by this processing, and it makes the response time faster during the test. Gustafson et al. (2014) reported that reduced response times reflect a benefit in terms of ease of listening. Similarly, these results show that SmartCompress reduces the response times while it preserves word recognition, suggesting that SmartCompress also has a positive impact for ease of listening.

SmartCompress supports listening comfort in noise and overall improved sound quality:
In a second experiment, the same thirty subjects participated in a blinded take-home field test wearing hearing aids with and without SmartCompress. Using a randomized and counterbalanced test order, subjects wore one set of aids one week, the next set the following week, and reported their listening experiences in journals. The open-ended responses were analyzed via a qualitative research method that identifies the frequency of recurring key words for each test condition (Knudsen et al., 2012). When the analysis was complete, it revealed improved sound quality with the amplification from all tested hearing aids that belong to the SoundDNA platform. The participants reported the overall sound quality as natural and detailed, whether or not SmartCompress was activated. Moreover, in the condition with SmartCompress activated, listeners reported more comfort in noisy environments.

With advantages like these – improved ease of listening, listening comfort in noise and natural sound quality – SmartCompress aims to increase hearing aid acceptance for hearing aid users in quiet or in noise, compared to our previous technology.

Summary

Compression in hearing aids helps to restore speech audibility while maintaining comfort for individuals with a sensorineural hearing loss. However, when compression applies amplification to noisy signals, it may negatively affect the output SNR. SmartCompress aims to provide a better solution by applying compression in a more intelligent way, based on the signal's input relative to real-time environmental cues. With accurate short- and long-term SNR detection, SmartCompress decreases compression in speech-in-noise environments, and controls gain in quiet and noise-only environments. The result is optimized amplification in multiple listening environments. Easily personalized for patient preferences and needs, the SmartCompress adaptive compression system is available in EXPRESS*fit*® Pro.

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

References

Gustafson, S., McCreery, R., Hoover, B., Kopun, J. G., & Stelmachowicz, P. (2014). Listening Effort and Perceived Clarity for Normal-Hearing Children With the Use of Digital Noise Reduction. Ear and Hearing, 35(2): 183–194.

Knudsen, L. V., Laplante-Lévesque, A., Jones, L., Preminger, J. E., Nielsen, C., Lunner, T., & Kramer, S. E. (2012). Conducting qualitative research in audiology: A tutorial. International Journal of Audiology, 51(2): 83–92.

Moore, B.C.J. (2008). The Choice of Compression Speed in Hearing Aids: Theoretical and Practical Considerations and the Role of Individual Differences. Trends in Amplification; 12(2): 103-112.

Naylor G., Johannesson R.B. (2009). Long-term signal-to-noise ratio at the input and output of amplitude-compression systems. Journal of the American Academy of Audiology, 20(3): 161–171.

Stelmachowicz P., Lewis D., Hoover B., Nishi K., McCreery R., Woods W. (2010). Effects of Digital Noise Reduction on Speech Perception for Children with Hearing Loss. Ear & Hearing, 31(3): 345-355.

Valente M., Fabry D.A., Potts L.G. (1995). Recognition of speech in noise with hearing aids using dual microphones. Journal of the American Academy of Audiology, 6: 440–449.

v. Wallenberg E.L., & Kollmeier B. (1989). Sprachverständlichkeitsmessungen für die Audiologie mit einem Reimtest in deutscher Sprache: Erstellung und Evaluation von Testlisten. Audiologische Akustik 28(2): 50-65.

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