PHILIPS

HearLink

White Paper

A hearing aid to create connections

February 2020

Introduction

Humans have a fundamental need to be socially connected - hearing loss can compromise one's ability to connect.

Creating connections? It may seem obvious, but humans have a fundamental need to be socially connected.[1] Interactions between individuals and within social groups have benefits at any age. For instance, as children, social connections are important for several aspects of development,[2] and as adults, they strongly contribute to an improved quality of life.[3]

The issue is that the ability to create and maintain relationships can be compromised if communication becomes difficult due to hearing loss.[4] Philips HearLink is designed to help users connect to people and realize the positive benefits of being connected.

Relationships and connections between people are typically developed through conversations that take place in shared acoustical environments; however, the increase in globalization has influenced people's lifestyles and the methods in which they communicate allow for greater mobility throughout the course of life.[5] For retiring adults, this could mean an increase in relocation after retirement.[6] These users also need a hearing aid that supports their communication needs. Philips HearLink offers the ability to create connections in new environments and to maintain connections remotely, helping the user stay connected to those near and far.

1 R. Baumeister and M. Leary, *'The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation'*, Psychological bulletin, vol. 117, 1995, p. 497-529.

2 R. Coplan et. al., *'Alone is a crowd: Social motivations, social withdrawal, and socioemotional functioning in later childhood'*, Developmental Psychology, vol. 49, no. 5, 2013, p. 861-875, https://doi.org/10.1037/a0028861.

3 G. Martin, N. Carlson, and W. Buskist, *Psychology*, 4th edn, Boston, Allyn & Bacon, 2009.

4 P. Mick, I. Kawachi, and F. Lin, *'The association between hearing loss and social isolation in older adults'*, Otolaryngol Head Neck Surg, Vol. 150, no. 3, 2014, p. 378-384, doi: 10.1177/0194599813518021.

5 J. Urry, *Sociology beyond societies*, London, Routledge, 2000.

6 F. Longino, J. Carles, and M. Warnes, *'Migration and Older People'*, in V. Bengtson, P. Coleman, and T. Kirkwood (Authors) & M. Johnson (Ed.), The Cambridge Handbook of Age and Ageing, Cambridge, Cambridge University Press, 2005, p. 538-545.

Direct connections: SoundMap sound processing

To help the user connect to people close by in the listening environment, Philips HearLink offers SoundMap sound processing, which is designed with a focus on providing clearer speech. SoundMap provides innovative solutions in the three pillars of sound processing customarily found in hearing aids (see Fig. 1).

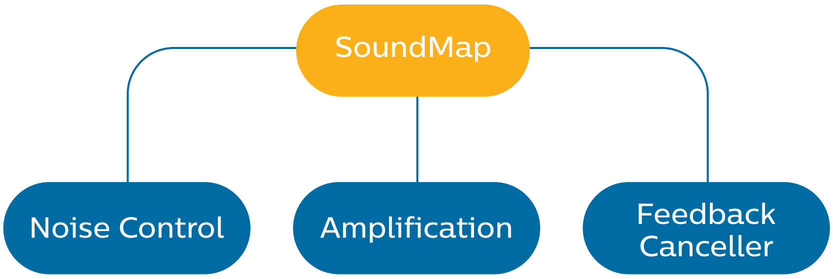

Figure 1: SoundMap covers the three pillars of sound processing in Philips HearLink: Noise Control, Amplification and Feedback Cancellation

SoundMap Amplification

Amplification is arguably the most important function of hearing aids. Its goal is to make inaudible sounds below the user's hearing threshold level audible. This is commonly achieved by a compression function, which amplifies soft sounds more than loud sounds. The actual implementation of such a compression function differs between hearing aids.

Compression works by applying a certain amount of gain to the incoming sound depending on its level and the user's hearing loss. Because the intensity of natural sound varies rapidly (nearly instantaneously in fact), in theory, the gain could also be adjusted more or less instantaneously. However, applying such a fast-varying gain would be similar to listening to music and adjusting the volume up and down rapidly – which would not only sound unpleasant, but would also distort the information carried by the sound. To prevent this effect in hearing aid amplification, the gain applied during compression is calculated based on a time-average estimate of the sound level. The duration of the time-averaging can vary typically between 10 and 1500 ms,[7] which allows the gain to be applied in a smooth manner.

There is no absolute consensus on how fast or slow compression should react.[8] Fast compression systems are inherently better at following level changes than slow systems and are thereby better at making soft sounds audible and loud sounds comfortable. Fast multi-channel compression systems tend, however, to even out rapid changes in the speech level created by the successions of syllables and speech pauses. This means that important speech cues, such as the temporal modulation of the speech envelope, will exhibit less contrast between its peaks and valleys – omitting valuable sound details for some listeners – compared to a

[7] J. Kates, *'Understanding compression: Modeling the effects of dynamic-range compression in hearing aids'*, International Journal of Audiology, vol. 49, 2010, doi: 10.3109/14992020903426256.

[8] B. Moore, *'The Choice of Compression Speed in Hearing Aids: Theoretical and Practical Considerations and the Role of Individual Differences'*, Trends in Amplification, vol. 12, no. 2, 2008, p. 103-112.

The compression system in Philips HearLink can operate at different speeds, which can be adjusted by hearing care professionals.

slower compression system.

The compression system in Philips HearLink can operate at different speeds, which can be adjusted by hearing care professionals in the fitting software, Philips HearSuite. The two speeds Envelope Focus and Phoneme Focus are selectable in the general settings of the Feature Selection screen. Envelope Focus is a slow acting compression system, which better preserves rapid changes in speech, protecting the peaks and valleys of its envelope. Phoneme Focus is a fast-acting compression system, which is fast enough to follow rapid level changes related to phonemes of speech and will provide better audibility compared to the Envelope Focus setting. While selectable by hearing care professionals, Philips HearSuite sets the default strategy based on the client's age and level of hearing loss entered in the software.

Amplifying soft sounds more than loud sounds may also have an impact on accessing some speech cues. Let us consider a simple acoustic scenario where the voice of a dominant talker is acoustically competing with some background noise, as shown in Figure 2. The figure shows the overall variation of the sounds over time, i.e. the envelopes of signals here in two acoustical conditions. On the left side, the noise level is clearly weaker than the speech, illustrated by the separation between the envelope of the primary speech (blue line) and the envelope of the noise (yellow line). On the right side, the noise level is closer to that of the speech, such that the envelope of the noise overlaps with that of the speech at times.

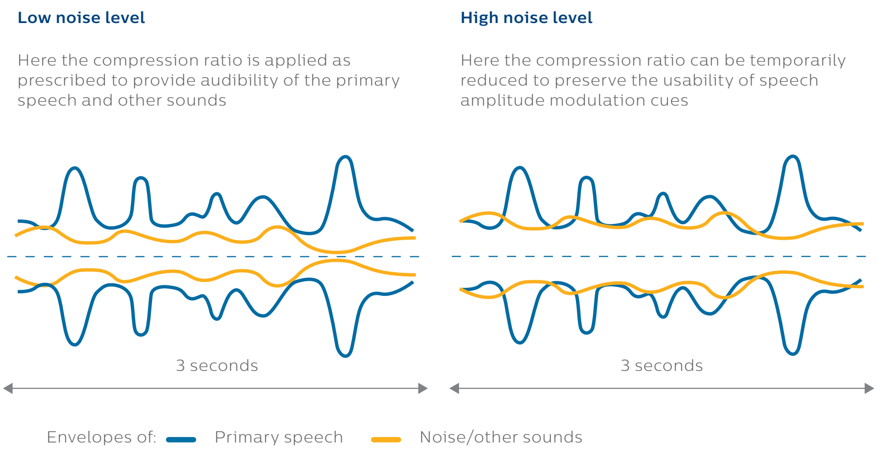

Figure 2: Envelopes of speech and noise at two different noise levels; low (left) and high (right)

Compression systems will always apply more gain to weaker sounds. Consequently, the envelope of the noise will become closer to that of the speech. This may have no impact on the accessibility of the speech envelope in the low-noise environment (left), because the envelopes of speech and noise are acoustically well separated. However, compression could further reduce the accessibility to the speech envelope cues in the high-noise environment (right), because the envelopes will further overlap as the system applies more gain to the weaker noise signal.

To improve on the availability of sounds in noisy places, Philips HearLink embeds a special technology that automatically controls the compression ratio as a function of the noise level. Effectively, SoundMap Amplification embeds a noise measure in order to control the compression ratio (see Fig. 3). When the noise level is low (see left panel of Fig. 2), the system will behave according to the fitting rationale. When the noise level increases (see right panel of Fig. 2), the system lowers the compression ratio to make the amplification behave more linearly.

Philips HearLink automatically controls the compression ratio as a function of the noise level.

This better preserves the amplitude modulation of speech, as well as the difference between speech and noise, facilitating the access to speech cues in noisy environments. Where available, the default setting for this feature in Philips HearSuite is Adaptive Compress. The feature can be turned off, or, when turned on, its sensitivity can be adjusted independently for environments consisting of a mix of speech and noise (compression control), and environments more dominated by noise (gain control).

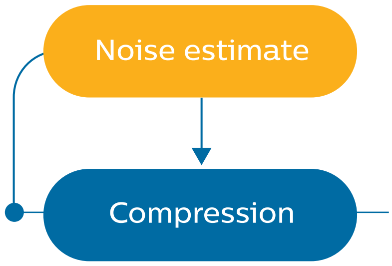

Figure 3: SoundMap Compression with its noise estimate

Compression systems have existed for decades in hearing aids and their design has primarily been focused towards making sounds audible. Philips HearLink makes use of two premium features that aim at improving the availability of speech sounds, and thereby making speech clearer and helping the user to connect to others.

SoundMap Noise Control

While the noise measure in SoundMap Amplification improves traditional compression by better preserving speech information in noisy places, users will also benefit from active noise reduction when the environment grows louder with noise.

The noise processing in Philips HearLink takes place in SoundMap Noise Control, a feature designed to support the user in creating connections with others in social environments which are especially noisy. It consists of a directionality and a noise reduction module (see Fig. 4). The modules operate in 16 frequency bands and have a fast reaction time of 8 and 2 ms, respectively. The directionality and the noise reduction systems have a complementary effect whereby the directionality attenuates noise primarily behind the user, while the noise reduction further reduces noise, regardless of the incoming direction. With this design, voices of talkers in the front, but not necessarily directly ahead, remain accessible to the user and this helps the user to connect to others in group discussions, typically at social gatherings.

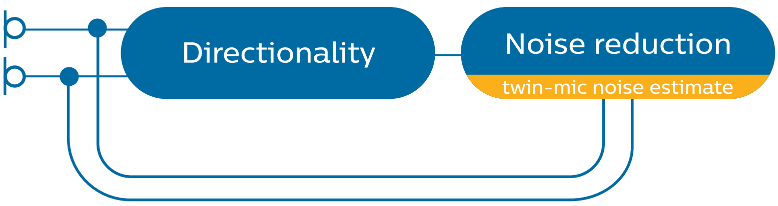

Figure 4: SoundMap Noise Control with its twin-microphone noise estimate

In addition, the noise reduction system is equipped with a twin-microphone noise estimate (see Fig. 4). Noise reduction can measure noise using the input of a single microphone. In SoundMap, the input of the two microphones is combined in order to obtain a more accurate

SoundMap Noise Control is equipped with a twin-microphone noise estimate, which makes the noise reduction more precise.

estimate of the noise level, which makes the noise reduction of SoundMap Noise Control more precise.

SoundMap Feedback Canceller

The natural expectation for many users and hearing care professionals is that feedback in hearing aids is a non-issue. On the surface this may seem to be the case, but in reality, all hearing aids have a high risk of feedback. An effective anti-feedback system is key to providing audiological benefits.

The physical proximity between the loudspeaker and the microphones increases the risk of feedback in hearing aids. Feedback, audible or not, happens because the sound from the loudspeaker is picked up by the microphones, which is then amplified and played back by the loudspeaker, amplified again, and so on – this is the feedback loop. Anti-feedback systems are designed to break the feedback loop and stabilize the hearing aids. They have two actions: (1) detect a feedback loop, and (2) apply a form of processing to either break the feedback loop, or at least keep the audible whistling low. SoundMap Feedback Canceller brings significant innovation in both areas.

Traditionally, anti-feedback systems operate in parallel to the amplification and the noise reduction. This architecture tends to limit their reactivity. In SoundMap, feedback sensors are placed directly in the amplification block (see Fig. 5). This architecture allows SoundMap Feedback Canceller to detect the feedback loop more quickly, typically before the whistling becomes audible.

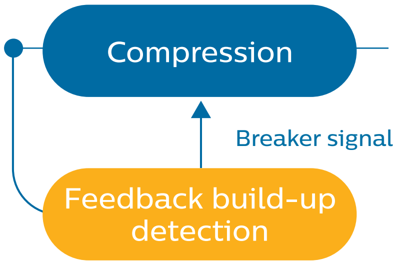

Figure 5: SoundMap Feedback Canceller directly placed in the amplification block

Figure 6 illustrates the growth and management of feedback in hearing aids with a traditional anti-feedback (blue line) and in Philips HearLink (black line). In traditional systems it can take up to 1 second to detect and manage feedback. Techniques such as phase inversion, frequency shifting and gain reductions are applied for stabilizing the hearing aid. In contrast, SoundMap Feedback Canceller can detect the feedback as the feedback loop is still building up and the whistling is potentially not audible yet. Furthermore, its primary technique to handle feedback is by applying a breaker signal.

SoundMap Feedback Canceller applies a breaker signal that is added to the amplified sound and is designed to break the feedback loop.

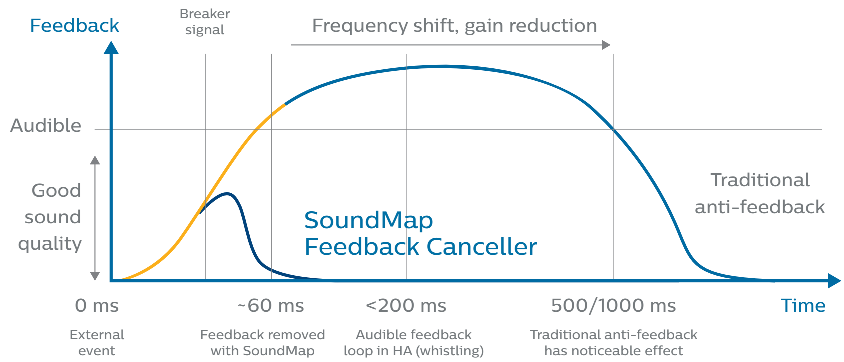

Figure 6: Growth and management of feedback in hearing aids. After an abrupt initial acoustical change around the hearing aid (e.g. phone to the ear), a feedback loop can be triggered, and feedback whistling may become audible. The figure shows the difference in reaction time between a traditional anti-feedback strategy, which often reacts after feedback has become audible and SoundMap Feedback Canceller, which can prevent feedback while it is still building up and not yet audible.

The breaker signal is a weak sound that is added to the amplified sound and is designed to break the feedback loop while being nearly inaudible. The signal is illustrated in Figure 7 as a function of time (x-axis) and frequency (y-axis).[9] The breaker signal has two states: 'on' shown in gray, where the gain in the amplification is maintained; and 'off' shown in white, where the gain is essentially zero, for a very brief moment. At a given frequency, the breaker signal sequentially turns the amplification gain on and off, as shown by the horizontal succession of gray and white colors; the off state is designed to be as short as possible to maintain as much sound information as possible, and long enough to break the feedback loop. The rapid succession of on and off states and their short duration make the breaker signal as transparent as possible. In addition, as illustrated by the tilted zebra pattern, the on and off times of the breaker signal are not applied simultaneously in all frequency channels, but rather in a delayed manner across frequency channels to optimize its transparency.

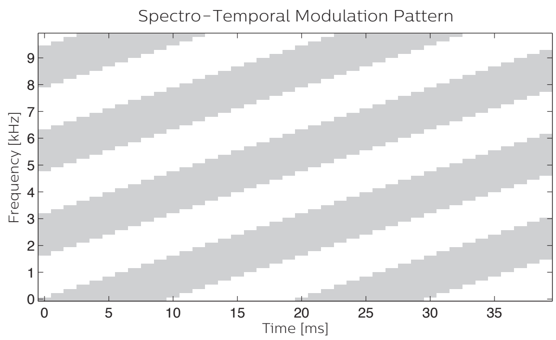

Figure 7: Illustration of the breaker signal used in SoundMap Feedback Cancellation

SoundMap Feedback Canceller is a multi-patented technology. Not only does it raise the internal stable gain limit by 6 dB, but it also gives Philips HearLink a solid foundation for its sound processing, ensuring that the amplification and the noise processing are working in optimal conditions.

[9] M. Guo, and B. Kuenzle, *'On the Use of Spectro-Temporal Modulation in Assisting Adaptive Feedback Cancellation for Hearing Aid Applications'*, 51st Asilomar Conference on Signals, Systems, and Computers, Institute of Electrical and Electronics Engineers (IEEE), 2017, p. 797-801, doi: 10.1109/ACSSC.2017.8335456.

SoundTie helps users connect with people who are geographically distant.

Remote connections: SoundTie wireless technology

While SoundMap helps users of Philips HearLink connect with people who are in their same acoustical environment by making speech clearer, Philips HearLink also features SoundTie, a wireless connectivity solution powered by 2.4 GHz Bluetooth® Low Energy (BLE) that helps users connect with people who are geographically distant.

SoundTie connects Philips HearLink to a range of BLE accessories (TV adapter, remote control), and most importantly, to smartphones and smart devices (e.g., iPhone® and Android™). It not only enables interactions with smart devices, but also makes remote communication with people easier, for example, by playing sound notifications directly into the hearing aid for an incoming call alert, and streaming phone conversations into both hearing aids (direct streaming with iPhone, or via AudioClip sound accessory with Android).

Outlook

SoundMap and SoundTie feature many innovations and – together with convenient rechargeability and a discreet design – make Philips HearLink a premium hearing aid that helps users connect to others, directly or remotely. Because social connections are such a fundamental need for humans, the future development of Philips HearLink will continue to focus on innovations that make Philips HearLink fit seamlessly into the lives of people with hearing loss, helping them to create and maintain connections with the many people in their lives.

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