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Technology in 10: Directional Microphones

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Directional Microphones

Presented by:
Jennifer Gehlen, AuD

Hearing
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Directional microphone technology
Background

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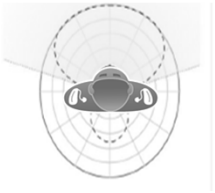

- Available in hearing aids in the U.S. since the 1970s
- Improves signal-to-noise ratio by reducing sound outside of the angle of focus
- Utilizing hearing aid processing alone, directional microphone technology is the only proven way to increase signal-to-noise ratio
- Directional microphones have been shown to reduce listening effort in background noise in older adults with sensorineural hearing loss[1]

[1] The Effects of Hearing Aid Directional Microphone and Noise Reduction Processing on Listening Effort in Older Adults with Hearing Loss, Desjardins, J Am Acad Audiol. 2016 Jan;27(1):29-41

Advanced directionality

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Bilateral beamforming

e2e wireless 3.0
Binaural audio processing

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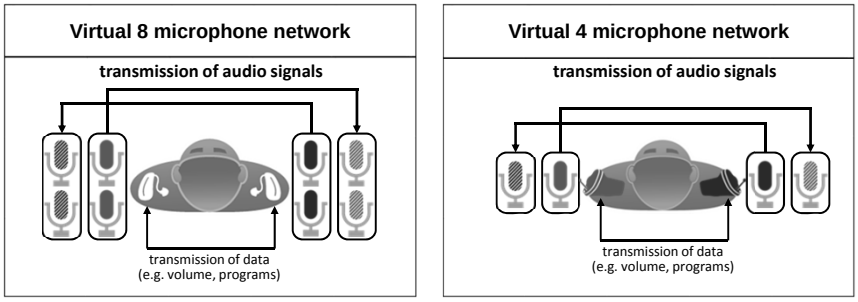

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Whitepaper

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Lotter, T., Schätzle, U., Fischer, T. (2014). e2e 3.0 – energy efficient inter-aural audio transmission. Siemens Technology Backgrounder

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Directionality algorithms
Automatic in Universal program

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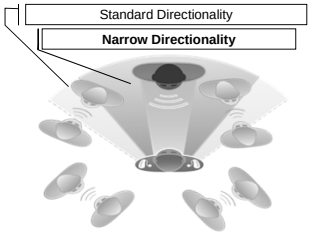
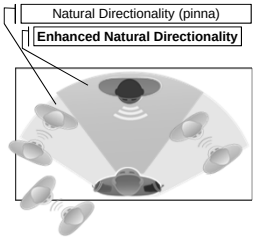
Narrow directionality



e2e wireless 3.0

Binaural OneMic directionality



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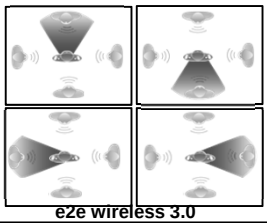
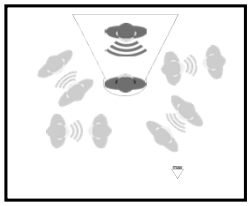
Spatial SpeechFocus



e2e wireless 3.0

Directional speech enhancement



Narrow Directionality
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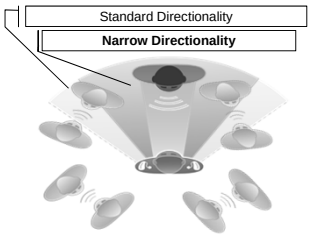
Narrow directionality



e2e wireless 3.0

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Narrow Directionality
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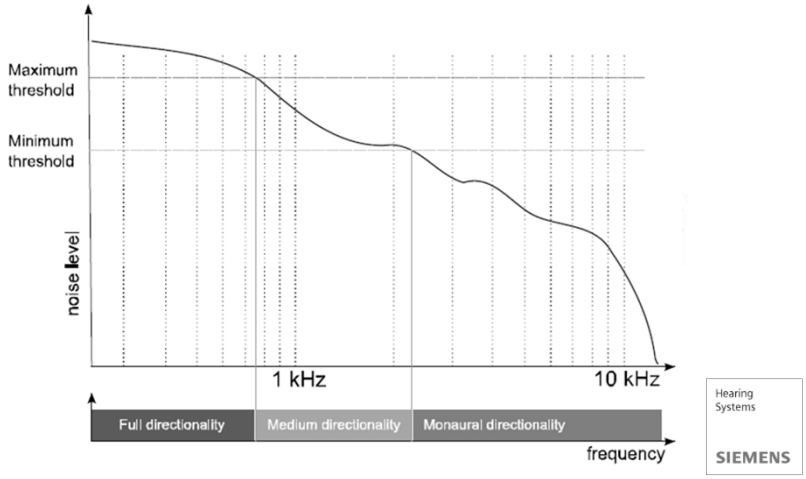
NOTE: Our automatic ND algorithm is only engaged in extremely noisy environments and only in the channels where the SNR is negative



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Narrow Directionality
Wearer Benefits

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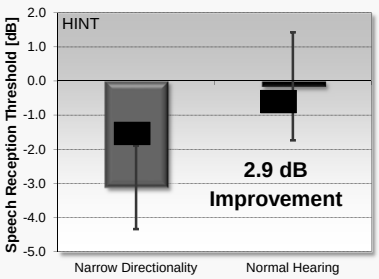
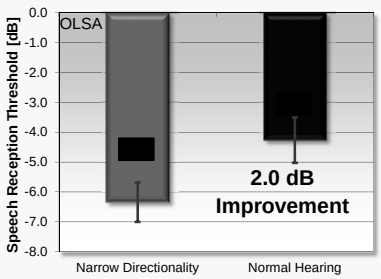
1 dB SRT corresponds to 11% improvement in speech understanding for the HINT and 17% improvement for the OLSA

Univ. Northern Colorado



Hörzentrum Oldenburg



better

*Two clinical studies have shown that binax provides better than normal hearing in certain demanding environments (University of Northern Colorado, 2014; Oldenburg Horzentrum, 2013). Speech Reception Thresholds (SRT) in cocktail-party situations improved up to 2.9 dB for wearers with mild to moderate hearing loss using Carat binax or Pure binax hearing aids with narrow directionality, compared to people with normal hearing.

***Studies conducted at University of Northern Colorado (2014) and Oldenburg Horzentrum (2013) showed that Speech Reception Thresholds (SRT) in cocktail-party situations improved up to 2.9 dB for wearers with mild to moderate hearing loss using binax with Narrow Directionality, compared to people with normal hearing. This corresponds to over 25% improvement in speech understanding.**

Published Research Article

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May 2015 *Hearing Review*
by Rebecca Herbig, AuD
and Matthias Froehlich, PhD

Binaural Beamforming: The Natural Evolution

http://www.hearingreview.com/2015/04/binaural-beamforming-natural-evolution/

TECH TOPIC // BEAMFORMING

Binaural Beamforming: The Natural Evolution

BY REBECCA HERBIG, AuD, AND MATTHIAS FROEHLICH, PhD

This paper reports on a new measurement protocol based on the Hagerman-Olsffson Method that yields a sequential directivity index (sDI), and demonstrates that the Siemens binaural beamformer Narrow Directionality in a new 2-microphone device is as effective as in the RIC form factor—the latter of which has been shown in clinical studies to result in better SRT-in-noise for patients in certain noisy environments than those with normal hearing. Additionally, a new binaural beamformer designed for single-microphone devices, like CICs, is shown to have significantly higher sAI-DI values than relying on omnidirectional processing and the natural pinna effect alone.

With the introduction of bidirectional ear-to-ear wireless audio data transmission, each hearing device in a bilateral pair can now operate with input not only from microphones on its own housing, but it also receives acoustic signals detected and processed by the other hearing device. This has opened up new possibilities for advancements in many aspects of hearing instrument processing—most remarkably binaural beamforming technology.

Ear-to-ear wireless audio transmission allows for an algorithm that can provide a spatial focus on speech signals originating from the side or the back, in addition to the more common frontal patterns. As illustrated in Figure 1, we have been able to create a binaural beamforming algorithm, which can narrow the directional focus of the beam even further so that essentially everything outside of what is immediately in front of the wearer is attenuated (for a review, see Kamkar-Parsi, Hocher, and Aubreville[1]). This technology, commercially marketed as Siemens Narrow Directionality, has been shown in two clinical studies to allow hearing-impaired wearers to have a better speech reception threshold (SRT) in noise than those with normal hearing in certain noisy listening situations (see Figure 2 from Froehlich and Powers[2]).

The benefit we have observed in clinical studies, however, is not reflected in conventional lab measurements used to quantify directionality, such as the directivity index (DI). This is because standard measurement techniques do not reflect the real-world benefit of modern dynamic beamforming technology.

The primary goal of conventional measurements has been to capture directivity in a controlled and reproducible way, accepting deviations from real-world application where necessary. Following this rationale, directionality has often been measured in anechoic chambers, without playing any frontal target signal, or using pure-tone signals as the interferer[3]—all of which do not represent real-world applications.

The Hagerman-Olsffson Method Using Speech Signals

While clinical study results are highly informative, it is not efficient or feasible to use this efficacy measure to assess the effectiveness of every new directional microphone technology for every hearing aid model. Therefore, a lab measurement utilizing measurement conditions close to real-world environments is necessary. This is the only means by which we can quickly assess and quantify directional performance for new beamforming techniques as they are applied in various hearing aid form factors.

This was the motivation behind the development of a new protocol for assessment of directionality in modern hearing aids, which has the benefit of simulating both a target source and an interfering source at the same time using speech signals.[4] This protocol uses the established Hagerman-Olsffson Method, but approximates real-world situations, such as noisy restaurants or cocktail parties where the wearer wants to listen to a specific speech source, but the unwanted interfering noise is other people talking in the background. This new measurement method results in a sequential directivity index or sDI. (Audiers' Note: We use the term "sequential" to reflect the Hagerman-Olsffson approach, where signals with phase-inverted components are measured sequentially in order to obtain the final result.)

Rebecca Herbig, AuD, is Manager & Editor of Scientific Marketing, and Matthias Froehlich, PhD, is head of Product Management Audiology for Siemens GmbH, Erlangen, Germany.

24 HEARINGREVIEW.COM | MAY 2015

Published Research Article

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May 2016 *Hearing Review*
by Thomas A. Powers, PhD
and Veronika Littmann, PhD

Benefits of Binaural Beamforming for Individuals with Severe Hearing Loss

http://www.hearingreview.com/2016/04/benefits-binaural-beamforming-individuals-severe-hearing-loss/

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Benefits of Binaural Beamforming for Individuals with Severe Hearing Loss

By Thomas A. Powers, PhD, and Veronika Littmann, PhD

Tech Topic | May 2016 *Hearing Review*

New research shows it is reasonable to expect the same speech recognition benefit for individuals with severe hearing impairment when using binax beamforming technology as previously reported for those with mild-to-moderate losses.

Historically, one of the most effective methods to improve speech understanding in background noise has been the use of directional technology. In recent years, through the use of wireless full-audio transmission between a bilateral pair of hearing aids, binaural beamforming technology has taken the benefit of directional technology to a new level.[1,2] Clinical trials with these new products have shown a substantial benefit over omnidirectional, and in fact two independent studies have shown that hearing-impaired individuals fitted with these instruments experience significantly better speech recognition in background noise than their normal-hearing counterparts.[3,4]

In general, the research with these beamforming instruments has focused on hearing-impaired individuals with mild-to-moderate hearing losses, as this is the audiometric profile of the most common hearing aid user. However, a significant minority of people who use hearing aids have a severe impairment. Can we expect the same speech recognition benefit for these hearing aid users?

When fitting hearing aids to individuals with mild-to-moderate hearing impairment, the primary goal is to restore the lost audibility due to their outer hair cell damage. However, when a severe hearing loss is present, we expect that there will also be inner hair cell damage. This is associated with broadened auditory filters causing loss of frequency selectivity, reducing the ability to separate two signals in the frequency domain. Broad filters allow more noise to pass, which then makes it even more difficult to detect the desired target speech in a competing background noise environment. Moreover, when signals are made audible, there may be a greater susceptibility to distortions.[5]

A related issue when fitting individuals with severe hearing losses is the consideration of "effective audibility." As reviewed by Ching et al,[6] when hearing loss becomes more severe, the ability of the ear to extract useful information from the signal is reduced, and there comes a point where more audibility will not provide more benefit, and in fact may even be detrimental, particularly if cochlear dead regions are present. Therefore, the amplified signal must be audible, but effective, which can be a small residual dynamic range window for many patients with severe hearing loss.

Simply said, there are many more factors present that can negatively impact the benefit obtained from hearing aids for the severe hearing loss patient than for those with mild-to-moderate losses. Limited research in this area suggests that people with severe losses will obtain at least some additional benefit when fitted with directional technology,[7] although this has not been studied with modern beamforming processing. Therefore, the current study was designed to determine if the large benefit obtained in previous research for individuals with mild-to-moderate losses using binaural beamforming technology would also be present when the participants had severe hearing impairments.

Signia research results
Narrow Directionality—Severe Hearing Loss

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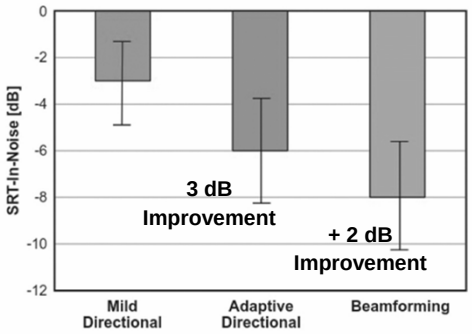
Results

- Adaptive directional ~ 3dB better than mild directional
- Binaural beamforming ~ additional 2 dB adaptive directional benefit
- Same benefit as reported for those with mild-to-moderate hearing loss as reported in the separate clinical study (Herbig & Froehlich, et al 2015)



Displayed are the mean SRT-In-Noise findings and error bars (English OLSA) for three different microphone conditions: Mild Directional (omnidirectional with pinna compensation), Adaptive Directional, and Beamforming

Narrow Directionality
Wearer control via TouchControl App

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If the wearer wants the greatest impact of bilateral beamforming in very demanding environments they can select the narrowest beam via the TouchControl App (Narrow Directionality is now fully engaged in all channels)

Available on the App Store

ANDROID APP ON Google play

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Spatial SpeechFocus Automatic in the car

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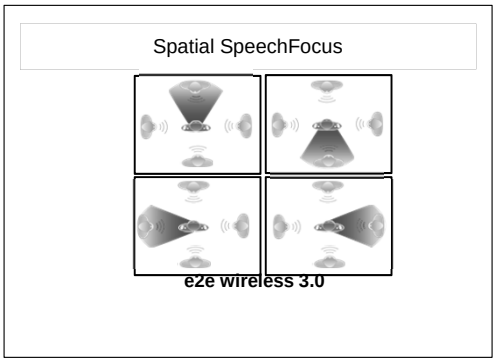

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Published Research Article

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September 2014
Directional Steering for Special Listening Situations: Benefit Supported by Research Evidence

The Siemens SpeechFocus algorithm has been available since 2010, and research with this product is starting to emerge in referred publications. In this paper, we review three of these articles.

Eric Branda, AuD, Joel Beilin, MScEE, Thomas A. Powers, PhD

http://www.audiologyonline.com/articles/directional-steering-for-special-listening-12974/

Directional Steering for Special Listening Situations: Benefit Supported by Research Evidence

Eric Branda, AuD, Joel Beilin, MScEE, Thomas A. Powers, PhD

September 22, 2014

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Since the introduction of the directional hearing aid over 40 years ago, this technology has proven to be one of the most successful solutions for improving speech understanding in background noise. Well-performing bilaterally-fitted directional instruments can improve the signal-to-noise ratio (SNR) by 6 dB or more (Powers and Beilin, 2013). This degree of improvement is substantial, and often determines whether a patient can follow a conversation. Moreover, the benefit is present for individuals with a wide range of hearing loss, different audiometric configurations and listening needs.

Historically, directional amplification has been designed so that maximum amplification is applied to signals from the front of the user, with maximum attenuation applied to signals originating from the back. This of course makes sense, as in most listening situations the wearer faces the speaker of interest. Even when a conversation originates from a location other than the front, most listeners will turn their head to face the talker. In this position, the fundamental design of directional technology is working at or near its maximum efficiency.

So while we would expect an SNR improvement using traditional directional microphone technology for most listening situations, there are some cases when the wearer is unable to face the speaker. One such commonplace situation is when the hearing aid user is driving a car and a passenger in the back seat is speaking. Here, the noise comes from the sides and front while, speech comes from the back—yet the hearing aid user cannot turn to face the speaker. In fact, in this situation we would predict that traditional directional technology would actually be worse than omnidirectional. Other similar communication situations might occur in group events, large gatherings, when the wearer is in a wheelchair, or when having a conversation while walking.

Spatial SpeechFocus
Manual control via TouchControl App

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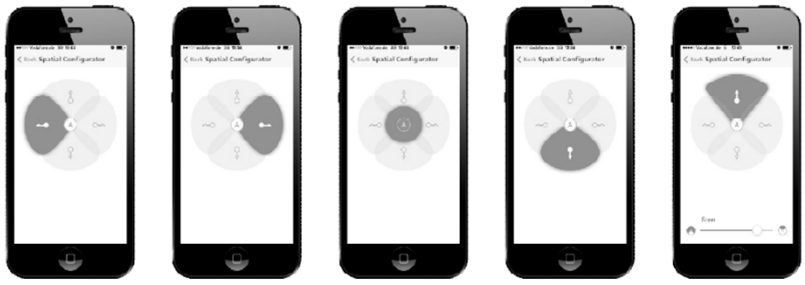

Left Right Automatic Rear Front

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ANDROID APP ON Google play

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Summary

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Benefits of directionality and binaural beamforming technology:

- Automatic SNR benefit in difficult environments with Narrow Directionality, including listeners with severe hearing loss
- Automatic SNR benefit for CICs using directionality with binaural beamforming technology
- Automatic directional benefit toward targeted speech source in the car
- Manual access to directional preference via the discrete app available for Apple® and Android® phones

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CEUs Available

June 27, 2016 at 12 PM ET

Driving a Hearing Aid on Highway 80

Presented by Yu-Hsiang Wu, MD. Ph.D.

It is important to know whether new interventions, such as hearing aid technologies or fitting strategies, deliver greater benefit to listeners with hearing impairment than older interventions. Measuring the intervention benefits – or the outcomes – is not as straightforward because many factors, such as the acoustic characteristics of listening environments, can affect the outcomes. In this talk, a series of studies will be presented to illustrate the effect of hearing aid directional microphone technology on speech understanding and listening effort in a laboratory setting and in an automobile. The use of dual-task paradigms to measure listening effort will also be discussed.

July 8, 2016 at 12 PM ET

Speech-in-noise testing for selection and fitting of hearing aids: Worth the effort?

Presented by H. Gustav Mueller, Ph.D.

Hearing aid fitting protocols must be efficient, and some have questioned if there is value in including speech-in-noise testing. In this course, we'll review evidence showing that indeed, the findings from this testing can be used for the selection and adjustment of special features, selection of accessories, and most importantly, patient counseling. We'll also discuss what specific speech tests easily can be implemented into a busy schedule.

July 26, 2016 at 12 PM ET

Impact of auditory access on speech and language development

Presented by Merry Spratford, Au.D.

Recent results from the Outcomes of Children with Hearing Loss (OCHL) study indicate that auditory access – aided audibility levels (i.e., speech intelligibility index) and amount and duration of hearing aid use – contributes to speech and language development for children who are hard of hearing. Longitudinal trends in audibility and hearing aid use show some children to be at consistent risk for decreased auditory access, thus also at risk for speech and language delays. Auditory access profiles for individual children will be discussed relative to speech and language outcomes and recommendations for audiological/amplification management.

June 27, 2016 at 12 PM ET

Driving a Hearing Aid on Highway 80

Presented by Yu-Hsiang Wu, MD. Ph.D.

It is important to know whether new interventions, such as hearing aid technologies or fitting strategies, deliver greater benefit to listeners with hearing impairment than older interventions. Measuring the intervention benefits – or the outcomes – is not as straightforward because many factors, such as the acoustic characteristics of listening environments, can

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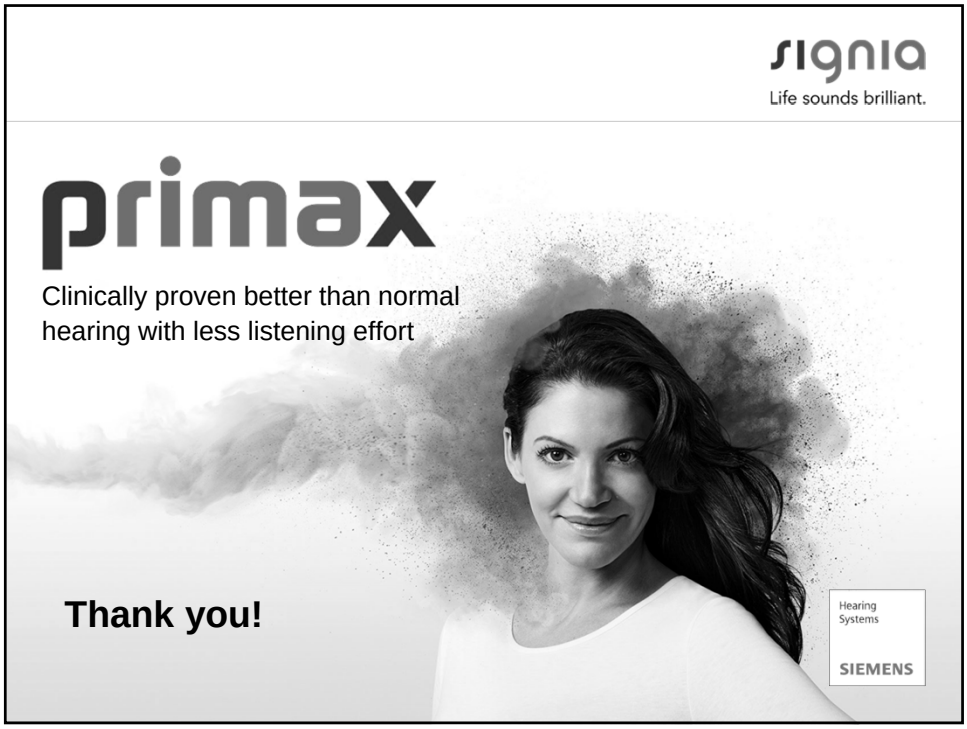
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Life sounds brilliant.
primax
Clinically proven better than normal hearing with less listening effort
Thank you!
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