WHITEPAPER
2024

Oticon Intent™ - Clinical evidence

BrainHearing™ benefits of the 4D Sensor technology

ABSTRACT

With the introduction of the new innovative 4D Sensor technology in Oticon Intent 1 and 2, Oticon Intent can now predict users' listening intentions in any situation. Head and body movements, conversation activity around the user, as well as the acoustic complexity of the sound scene are all continuously monitored to predict the user's listening intent and steer listening support.

This whitepaper reviews the user benefits of Oticon Intent 1, following a journey along the auditory system from ear to brain. First, a technical study revealed that while traditional technology can only offer a fixed level of support within a given sound environment, Oticon Intent can offer a 5 dB span of adaptation of support based on the listening intention of the user and provide 35% more access to speech cues than Oticon Real 1. This intent-driven adaptation of support was shown to be reflected in the brain in a first clinical study. The outcomes of this brain imaging study showed that the 4D Sensor technology helps users balance their attention towards the sound sources that they intend to listen to. Furthermore, speech comprehension was evaluated in a simulated cocktail party scenario with four competing speakers placed at different locations around the user. Activating the 4D Sensor technology in Oticon Intent accounted for a 15% improvement in speech comprehension. Speech understanding was additionally measured during a group conversation and confirmed that Oticon Intent with the 4D Sensor technology delivers equally good understanding of speech originating from the front and sides of the user. Lastly, sound quality and comfort were evaluated, and showed that users preferred Oticon Intent with the new DNN 2.0 over Oticon Real 1 across a wide range of everyday listening situations.

Overall, the findings of this whitepaper show that Oticon Intent 1 with the 4D Sensor technology can provide personalised support depending on the user's listening intentions in any situation. Receiving personalised support in every moment means that users can more easily engage in conversations and in life.

EDITORS OF ISSUE

Federica Bianchi*, Kasper Eskelund*, Valentina Zapata-Rodríguez*, Raul Sanchez Lopez, and Pernille Aaby Gade

Centre for Applied Audiology Research, Oticon A/S

** Shared first authorship*

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Oticon Intent with 4D Sensor technology: supporting different listening needs within the same environment

When a hearing aid (HA) is fitted, the hearing care professional (HCP) uses all available information on the user's hearing health combined with their professional judgement to set the initial parameters of the HA, to best meet the user's needs in typical, challenging situations. After fitting, as the user moves between different sound situations, the HA adapts the level of support to changes in the acoustic environment. Thus, traditional HAs adapt their support based only on an acoustic analysis of the environment and not necessarily on what the user needs. As a result, HA users with a similar hearing loss, fitted with the same HA, and the same settings will receive the same level of support in a sound scene with a given level of acoustic complexity (Figure 1A).

Level of support in a noisy environment:

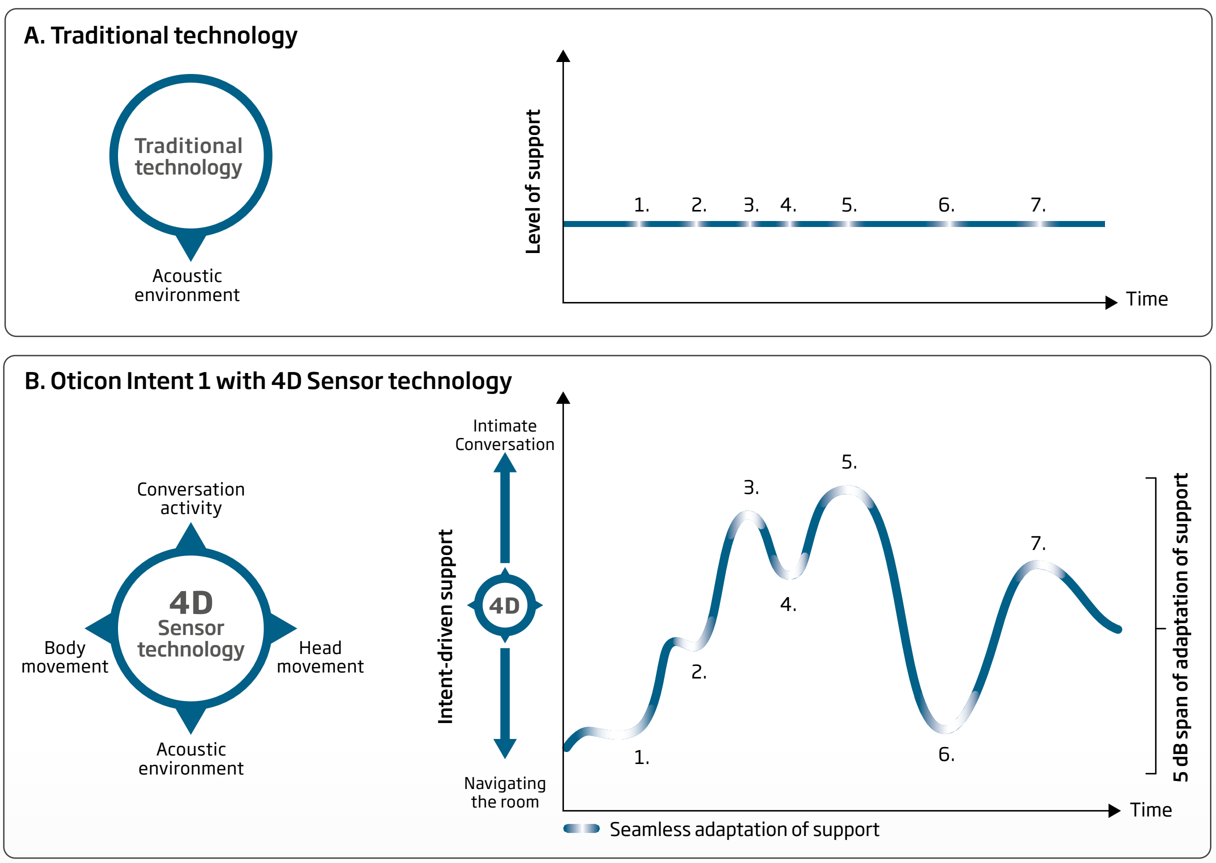


Figure 1: Illustration of the level of support that a HA user will receive in a given noisy environment A. The level of support offered by traditional technology is based on an acoustic analysis of the sound scene and will, hence, remain fixed for a given sound environment – no matter whether the user is walking in the environment (point 1) or having an intimate conversation (point 5). B. The level of support offered by Oticon Intent with 4D Sensor technology is based on information from four dimensions (head movements, body movements, conversation activity, acoustic sound scene analysis) and it will, hence, adapt based on the listener's listening intent in a given situation. Whether the user is navigating the room and needs more awareness of surrounding sounds (points 1 and 6) or whether the user is engaged in an intimate conversation (point 3 and 5), Oticon Intent offers just the right support, with a 5 dB span of adaptation within a given noisy environment (see technical measurements shown in Brændgaard/Zapata-Rodríguez et al., 2024). The seven points refer to different activities that a person might undertake at a gathering: 1. Walking in the room; 2. Conversation with a group of friends; 3. Intimate conversation; 4. Head turn towards someone waving across the room; 5. Return to intimate conversation; 6. Walk towards the buffet; 7. Exchange pleasantries with other guests at the buffet.

However, people may have different listening intentions within the same sound scene. In a busy restaurant, a guest conversing with a friend may face the same acoustic complexity as a waiter walking between tables, but their listening needs differ greatly. While the guest primarily needs support to understand what their friend is saying, the waiter may benefit from enhanced awareness of the surrounding environment (e.g., of the guests sitting at the tables). Likewise, the individual's listening needs will also naturally change over time in a given acoustic environment. In such situations, traditional hearing aids will provide the exact same level of support, which is not personalised to the users' individual listening needs. In other words, traditional HAs do not respond to the user's listening intention.

So, how do we understand and capture listening intentions? A recent study highlighted that head and body movements are key features for understanding communication intent (Higgins et al., 2023). When we are engaged in a conversation, we tend to orient our head and body towards the person talking to us (Hadley et al., 2019). As the environment complexity increases, we may lean forward, move closer, or turn our head slightly to the side to improve our hearing (Hadley et al., 2019, 2020). If we are speaking to a group of people, we tend to move our heads more, as we switch between the people we are engaging with (Hadley et al., 2020; Hadley and Culling, 2022). Furthermore, when we are physically active, walking or running, awareness of our surroundings is important to move around safely while capturing the world around us. Combined head and body movements, together with information about the acoustic environment and on conversation activity, provide fantastic insights into our intentions to engage with the world around us. Knowing this, we set out to determine if we could make hearing aids that better understand a listener's needs by incorporating how they naturally behave in different listening situations. Could we help the hearing aids respond to the user's intention and provide just the right amount of support?

Now, we introduce Oticon Intent with 4D Sensor technology. This innovative technology monitors head movements, body movements, and conversation activity, in addition to acoustic sound scene analysis, all to predict the user's listening intent and steer listening support (Figure 1B).

This whitepaper reviews the user benefits of Oticon Intent 1, as revealed by three clinical studies on experienced HA users, as well as the results of a technical study:

- **Technical Study:** quantifies the adaptation of support in Oticon Intent.
- **Clinical Study 1:** evaluates how adaptation of support to user intention balances the user's attention to surrounding sound sources.
- **Clinical Study 2:** evaluates speech comprehension in a complex sound environment.
- **Clinical Study 3:** evaluates speech understanding in a group conversation and sound quality.

How the brain processes sound: an updated BrainHearing model

One serious consequence of hearing loss is a decrease in the ability to direct and maintain listening attention in noise, which results in people with a hearing impairment becoming more disturbed by irrelevant sounds in the background (Shinn-Cunningham & Best, 2008). Current technology only partially restores the ability to focus in noise, since it steers the level of support based on the acoustic complexity of the environment and not the listening intentions of the user. But how does the brain process the sounds around us, and how does it selectively focus attention on those sounds we intend to listen to?

When processing sound, our brain works in a hierarchical way (O'Sullivan et al, 2019; Puvvada & Simon, 2017). All sounds within an environment reach the outer ear and the cochlea. These peripheral stages of the auditory pathway are referred to as **Hearing** in Figure 2.

The sounds are transformed into a **Neural code** that reaches the auditory cortex in the brain after traveling via the auditory nerve and the brainstem. Inside the auditory cortex these neural codes are translated into meaningful auditory objects, which the **Orient** and **Focus** subsystems (i.e., the **Listening** center) can further process (see Man & Ng, 2020, for an overview).

Orient subsystem: The Orient subsystem relies on receiving a good Neural Code to create an overview of all auditory objects – no matter their nature and direction – to create a full perspective of the soundscape.

Focus subsystem: The focus subsystem helps select which sounds to listen and pay attention to, while other irrelevant sounds are pushed into the background.

After listening to the sound of interest, the brain needs to extract meaning from it and comprehend what is being said **(Recognize)** and then **React**. "React" refers to a variety of processes such as planning, monitoring, evaluating, and reasoning – which guide attention and action according to the goals or intentions of a person (Miller & Cohen 2001; Lemke and Besser, 2016). In other words, **listening intentions** can steer the Focus subsystem, i.e., what we want to direct our attention to (Figure 2). This type of controlled processing is essential to remain focused and allow for the flexibility to adapt to changing circumstances.

After Hearing, Listening, Recognizing and Reacting, we may wonder how communication comes into the picture. Kiessling et al. (2003) defined four functional levels of verbal communication: Hearing, Listening, Comprehending, and Communicating. Our BrainHearing model includes the first three levels of the Kiessling et al. framework. Recognize refers to both speech understanding (i.e., being able to identify and repeat words and sentences) and speech comprehension (which includes higher level of processing, e.g., semantic processing, contextual interpretation, reception of intent). According to Kiessling et al. (2003), verbal communication requires

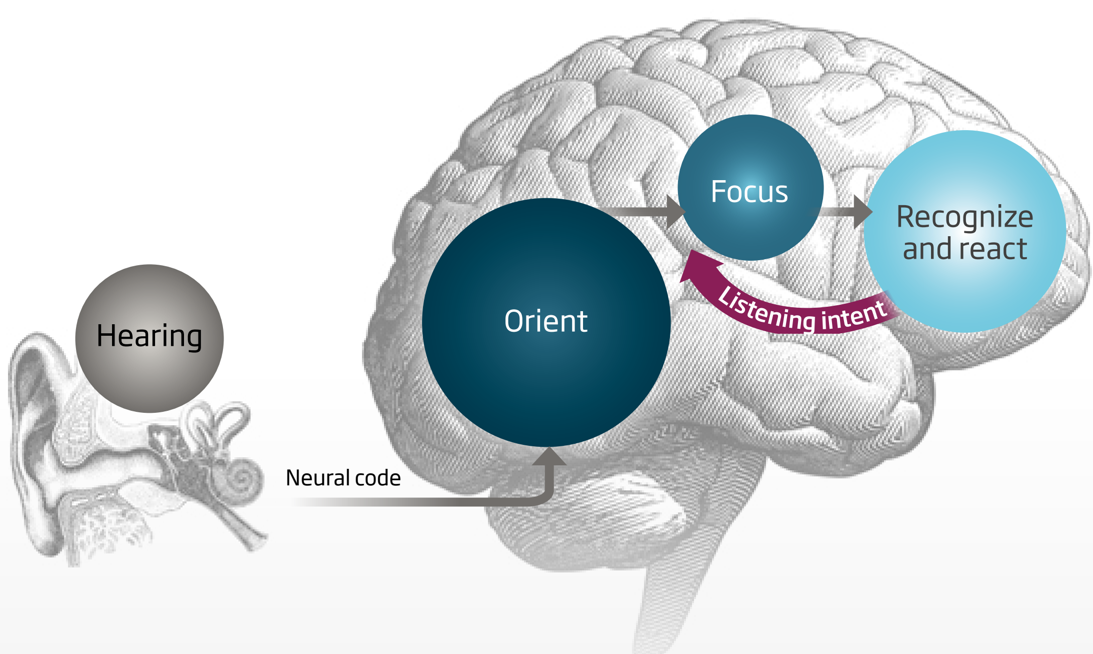


Figure 2: Illustration of how sounds are processed and interpreted from the ear to the brain (updated from Man & Ng, 2020).

that two or more people engaged in a conversation are able to Hear, Listen, and Comprehend. Besides these necessary steps, successful communication also depends on other factors, as identified by Nicoras et al. (2022). Most importantly communication depends on (1) Being able to listen easily; (2) Being spoken to in a helpful way; (3) Being engaged. This is why helping the brain to listen with ease and engagement is of essential importance in supporting successful communication. By adapting the level of support based on inferred listening intentions, Oticon Intent can support the brain's natural ability to navigate the environment and focus in noise. The evidence presented in this whitepaper follows the BrainHearing model in Figure 2. The Technical Study supports the "Hearing" stage of the peripheral auditory system, Clinical Study 1 refers to the "Focus subsystem", Clinical Study 2 and 3 refer to the "Recognize and react" stage.

Hearing: Adaptation of support evaluated via technical measurements

To investigate the adaptation of support provided by Oticon Intent 1, we measured the signal-to-noise ratio (SNR) enhancement for a given acoustic sound scene at the output of the hearing aids (Brændgaard/Zapata-Rodríguez et al., 2024). This measurement quantifies the increased contrast that the hearing aid generates between a target sound and the ambient background sounds. With Oticon Real 1, the results show that the SNR enhancement remained fixed regardless of the user's intentions changing over time (Figure 1A). However, Oticon Intent provided an adaptation of support, ranging up to 5 dB, depending on the users' intention (as shown in Figure 1B). Details about the technical study and the measurement procedure can be found in the whitepaper by Brændgaard/Zapata-Rodríguez et al.

Moreover, a 5-dB additional contrast between speech and noise was measured in Oticon Intent compared to Oticon Real – of which 3.5 dB resulted from the 4D Sensor technology, while 1.5 dB were attributed to the new embedded Deep Neural Network 2.0 (DNN 2.0) and the new Sirius platform. This 5-dB SNR benefit in Oticon Intent corresponds to a 35% better access to speech cues according to the Speech Intelligibility Index (ANSI S3.5, 1997). This illustrates the power of Oticon Intent, which ultimately provides the user with clearer and more intelligible speech.

Listening: listening intentions are mirrored in the brain (Clinical Study 1)

Background

The cutting-edge technology in Oticon Intent is capable of steering audiological help by following the listening intention of the user. It is thus interesting to investigate how this technology helps the user balance attention to different sounds.

How are we able to show that? If 4D Sensor technology can support more efficient allocation of attention to sound sources that the user intends to listen and attend to, it will be observable in neural responses driven by user attention.

In a recent study by Fiedler et al. (2023), a novel experimental paradigm was developed. It revealed how different sounds around a listener – like speech and environmental sounds - capture attention and related brain resources. The study showed that salient sounds in the environment, i.e., sounds that are meaningful for the listener, can shift a listener's attention away from the speech target to a higher degree.

To do so, they applied neural tracking methods (see Alickovic et al., 2019), capable of measuring how continuous acoustic signals such as speech or environmental sounds are represented as neural activity in the brain. The study indicated that the balance and dynamics between intended listening targets and sounds in the environment can be observed in neural responses which in turn reflect attention.

Method

We conducted a listening study closely replicating the design of Fiedler et al. (2023). Thirty experienced hearing aid users (mean age 70.5 years, range 42-84; symmetrical,mild-to-moderate sensorineural hearing loss) were attending a continuous frontal speech signal (1-minute newsclips at 65 dB SPL), while short samples of everyday, environmental sounds were played from the sides and back at random times. Simultaneously, stationary speech-shaped noise from the sides and back was presented at 0 dB SNR (see Figure 3). The environmental sounds were typical sounds that occur in households, social, or urban

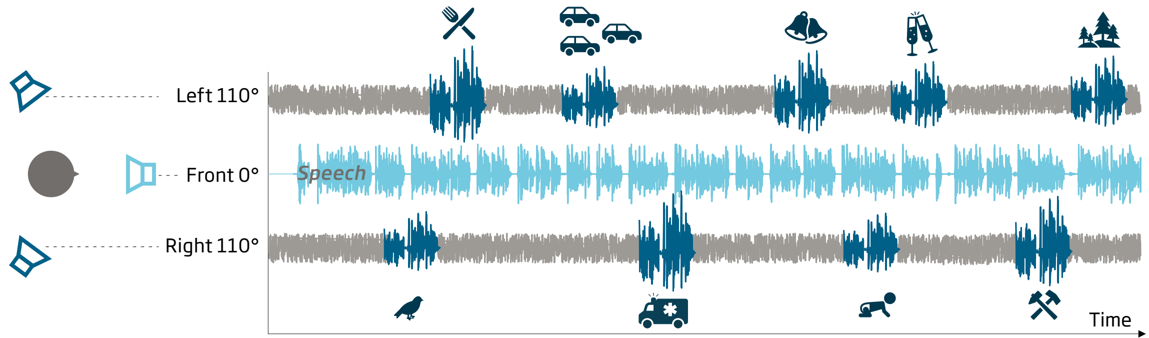


Figure 3: Stimulus presentation flow during a trial in Clinical Study 1, replicating the trial flow in Fiedler et al. (2023). Continuous speech is presented from a frontal speaker. Stationary speech-shaped noise is played from speakers placed at 110 degrees on left and right sides. Also, from the left and right back speakers, short sounds from e.g., household, urban and social activities are presented at random intervals.

situations, e.g., sounds of cutlery, children playing, tools, cars, etc.
Participants were fitted with Oticon Intent 1 based on their individual audiograms, using the VAC+ proprietary fitting rationale. Neural responses were recorded with EEG from 64 electrodes (see Figure 4). The HAs were programmed to respond as if the user intended to engage in two different communicative behaviors, all within the same complex listening situation: 1) navigating the room, or 2) having an intimate conversation with a single conversation partner. These two user intentions lie on a continuum when balancing

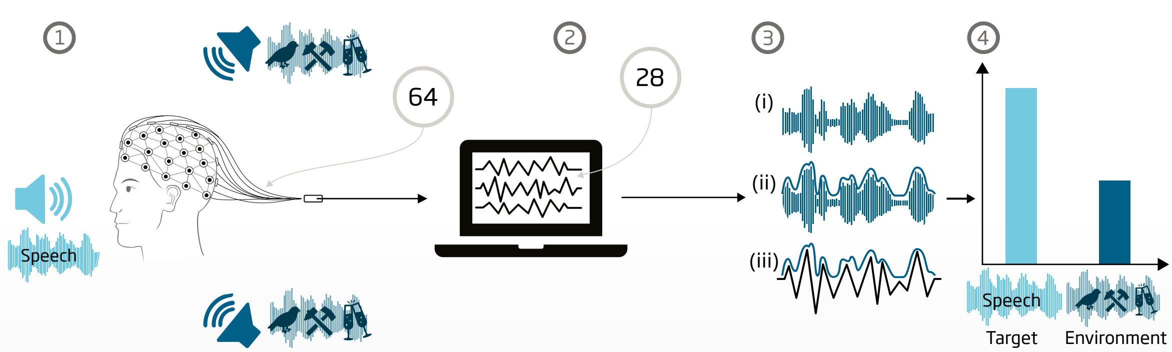


Figure 4: Schematic drawing of EEG experiment. 1. 30 hearing-impaired test participants were asked to attend to a frontal loudspeaker presenting 1-minute newsclips, while a variety of short environmental sounds were played at random intervals from loudspeakers placed at ± 110 degrees, combined with stationary speech-shaped noise. 64 channels of EEG were recorded. 2. Recorded EEG signals were cleaned for artefacts and processed offline; 28 fronto-central electrodes were selected for analysis. 3. The stimulus wave form of both speech targets and environmental sounds (i) were used to extract their envelopes (ii), which were correlated with the EEG signal (iii). 4. A transfer function accounting for the relationship between envelopes and EEG signals was derived. Attention is reflected in neural tracking of either type of stimulus, which is the correlation between EEG and a predicted EEG based on the transfer function.

the relevance of sounds in the environment.

Results

If a HA user's intention is to orient themselves in a sound scene (e.g., entering and navigating a room), the environmental sounds become increasingly relevant and should be given more attention. On the other hand, if the user is engaging in an intimate conversation, the environmental sounds do not need to capture attention to the same extent; however, they are still relevant. In both scenarios, access to speech sounds is equally important. The current study showed that this is exactly how the users experienced the sound environment using Oticon Intent. As evident in Figure 5A, the neural tracking, and thus attention capture, of target speech was uniform regardless of the listening intention, showing that listeners have the same excellent access to speech across these varied scenarios. Figure 5B, shows that the neural tracking of other sounds in the environment varied markedly between scenarios. When Oticon Intent operated as if in an intimate conversation the neural tracking of other sounds was at its lowest. When it operated as if the user was navigating the scene the neural tracking of these sounds was at its highest. Note that sounds in the environment are always tracked by neural processes, even when the user is in an intimate conversation. This shows that new sounds in the environment are still allowed access to attention, even when engaging in an intimate conversation. But Oticon Intent helps adjust the level of attention given to these sounds, based on the listening intent of the user.

This indicates that Oticon Intent not only adapts audiological processing to the user's intention as shown in the technical study, the 4D Sensor technology is also capable of allowing the brain to adapt the use of cognitive resources to the intention of the user as well. In

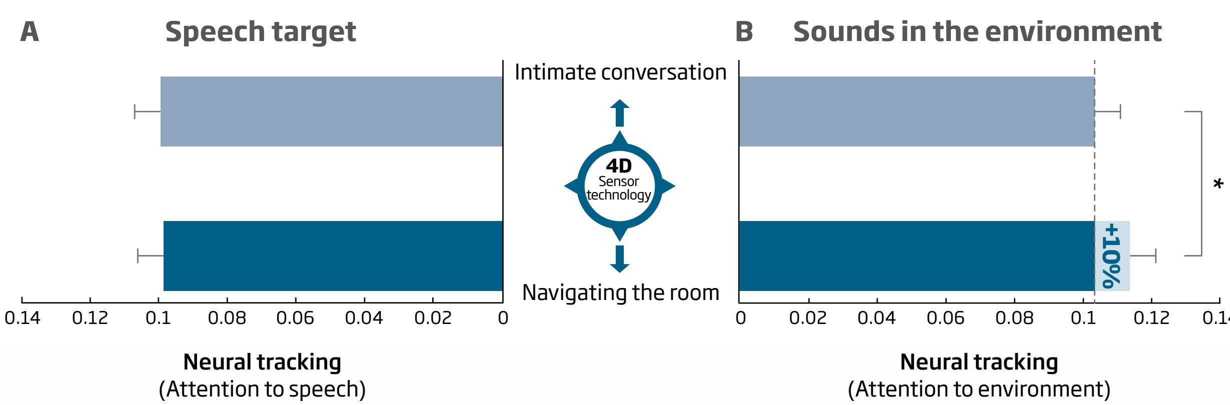


Figure 5: Neural tracking of speech target (A) and sounds in the environment (B), with Oticon Intent simulating audiological help to a user engaging in either an intimate conversation or a situation where the user navigates a room, respectively. Neural tracking of speech targets is uniform across simulated user situations. However, neural tracking of sounds in the environment is 10% higher when simulating that the user is navigating and searching a room than when simulating an intimate conversation ($p = 0.023$). Significant differences are indicated with an asterisk ($p < 0.05$). Error bars represent standard error of mean (SEM).*

this way, the user's listening intention is mirrored in the focus or capture of attention in the brain.

Recognize and react: Speech comprehension in a complex sound environment (Clinical Study 2)

In real life, users move between sound scenes and need to orient themselves within a new scene before they can focus on the speaker of interest, comprehend what is being said, and engage in a conversation. To evaluate the benefits of the 4D Sensor technology in Oticon Intent 1, we used a novel speech comprehension paradigm that adds a higher degree of listening realism than previously possible. Ahrens and Lund (2022) proposed an audiovisual scene analysis test paradigm previously tested in people with and without hearing loss (Ahrens et al., 2022). This paradigm takes advantage of the combination of a realistic acoustic simulation of a sound scene and the use of virtual reality. In this test, the participant is surrounded by 15 avatars. Up to four of the avatars can talk simultaneously in the presence of noise. Unlike traditional speech-in-noise test methods, in which participants remain still, the participants in this test may move their head to locate the target speaker. The study thus provides a much more realistic listening experience. Overall, the sound scene and task resemble a very complex cocktail-party scenario with competing talkers.

Method

Thirty experienced hearing-aid users (mean age 69.4 years, range 48-79; symmetrical, mild-to-moderate sensorineural hearing loss) participated in a study using the above paradigm at the Technical University of Denmark. The 4D Sensor technology setting in Oticon Genie 2 was either activated or deactivated. All other settings in MoreSound Intelligence 3.0 were left at their default values for each condition. The virtual audiovisual scenes consisted of 15 avatars located in the horizontal plane in a space between ± 105 degrees. At each trial, four different stories were told simultaneously by four random avatars out of the 15 possible spatial locations, while stationary noise was played from behind at 60 dB SPL. Each competing talker was also presented at 60 dB SPL. The participants first had to orient through the sound scene and find the avatar talking about a certain topic. Then, they had to focus on the identified avatar while a 30-s newsclip was played from that location. The competing talkers and background noise continued throughout the trial. Speech comprehension was tested by asking the participant to answer a yes/no question on the content of the newsclip.

Results

The average performance scores for the speech comprehension task are presented in Figure 6. Participants obtained significantly higher ($p = 0.036$) comprehension scores with the 4D Sensor technology activated, which lead to a 15% improvement relative to 4D Sensor technology off. The results suggest that the 4D Sensor technology provides an additional benefit in one-on-one

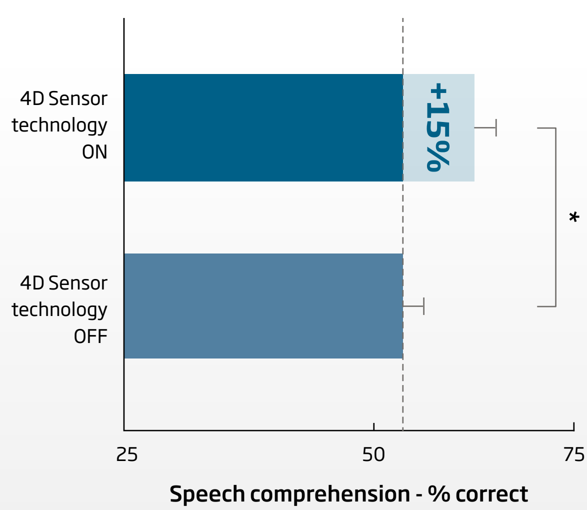


Figure 6: Speech comprehension scores (percentage correct), with 4D Sensor technology activated or deactivated. Significant differences are indicated with an asterisk (p < 0.05). Error bars indicate SEM.*

conversations while allowing the user to follow and understand conversations over a longer time in real-life complex situations.

Recognize and react: Equal access to speech from the front and sides (Clinical Study 3 – part 1)

A remarkable feature of human communication behavior is the ability to participate in the ever-changing dynamics of vivid group conversations, be it in a workplace or a lively family gathering. To enable users to successfully engage in such scenarios, we tested how Oticon Intent 1 supports users when the target of listening switches dynamically between multiple speakers surrounding the user.

To test this, we employed a novel German multi-talker speech test, the Concurrent OLSA test (CC-OLSA; Heeren et al., 2022). This test evaluates speech recognition while the participant is engaged in a group conversation with three speakers. The primary objective of this study was to explore if Oticon Intent supports speech understanding from the front as well as from the sides – even during an intimate conversation. The study was performed at an independent research center; Hörzentrum, Oldenburg (Germany).

Method

Sentences from the German matrix test (Oldenburg sentence test, OLSA, Wagener et al., 1999) were presented from three loudspeakers, positioned at the front (0°) and

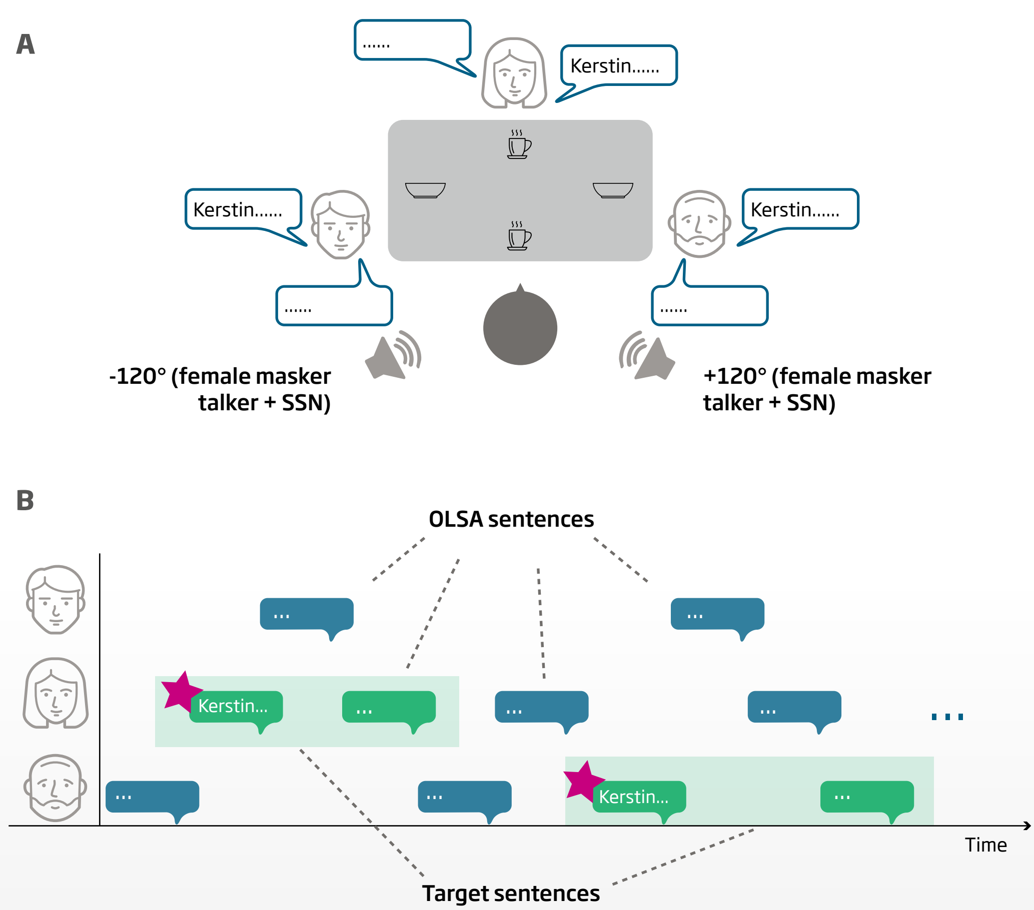


Figure 7: Illustration of the setup used for CC-OLSA. A: Loudspeaker setup, consisting of three target speakers, one at the front and two at the sides of the participant, and two noise sources behind the participant. B: Example of how the OLSA sentences alternate among the three talkers over time. The call sign "Kerstin" (denoted with a star) indicates the moment for the participant to switch attention to a different speaker while keep monitoring all the other talkers for the next call sign to appear. The participant's task is to repeat the last words of all target sentences (marked in green).

at the sides (±60°) of the participant (Figure 7A). Whenever a sentence started with the name "Kerstin" (call sign, indicated by a star in Figure 7B), the participant was instructed to repeat the last words of all sentences from that talker (target sentences), until another talker started a sentence with "Kerstin". All target words overlapped with the start of the next sentence. Overlap time between sentences was on average 1 s. The participants were instructed to keep their head still towards the front, such that speech recognition could be evaluated from the front and the sides while Oticon Intent registered that the participant was engaged in an intimate conversation.

A masker signal consisting of a mix of unmodulated speech-shaped noise (SSN) and a 2-talker babble noise was presented from the back (±120°; Figure 7A) at 70 dB SPL. The CC-OLSA was carried out at a fixed SNR for each test participant, corresponding to each participant's SRT50+5 dB, which on average, was 0.6 dB.

Twenty-five participants (mean age 73.6 years; range 63-81 years) with mild to moderately severe sensorineural hearing loss participated in the study. The test was carried out with Oticon Intent in default settings of MoreSound Intelligence 3.0 (including 4D Sensor technology and DNN 2.0), Oticon Real in default settings of MoreSound Intelligence 2.0 (including DNN), and Oticon Intent in fixed Omnidirectional setting (Omni).

After the CC-OLSA, the participants completed a questionnaire to evaluate their performance and listening experience in the three tested conditions (Intent, Real, Omni).

Results

Overall, speech recognition of the target sentences was equally good from the front and from the sides when wearing Oticon Intent in default settings (68% for both talkers at 0° and at ±60°; Figure 8) – indicating that Oticon Intent can support speech understanding in dynamic group conversations. No significant differences were found between Oticon Intent 1 and Oticon Real 1. Significantly higher speech recognition was obtained with Oticon Intent in default settings than with Oticon Intent

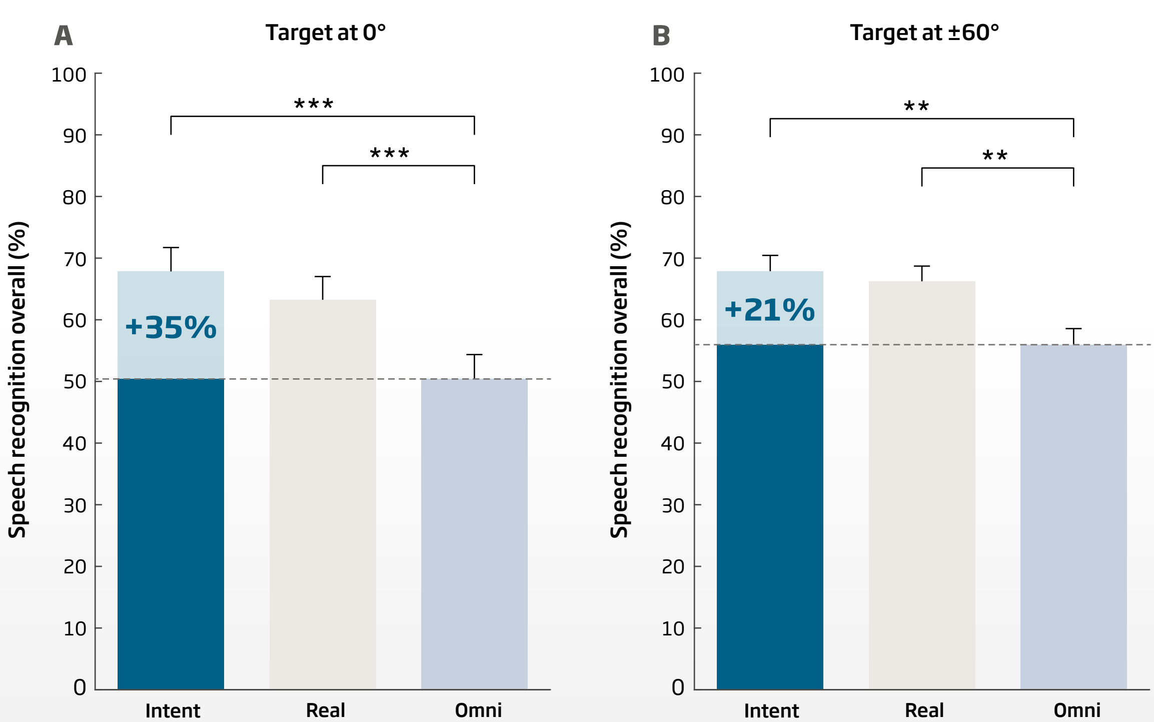


*Figure 8: Mean overall speech recognition of target sentences (last words), for target talkers positioned at the front (A) and at the sides (B), for the three tested conditions (Intent, Real, Omni). Error bars indicate SEM. Significant differences are indicated with asterisks (*** p < 0.001; ** p < 0.01).*

in Omnidirectional settings ($p < 0.0001$), resulting in a relative improvement of 25% across angles (specifically of 35% at 0° and 21% at ±60°, as shown in Figure 8). While speech recognition overall was 68% with Oticon Intent irrespective of the target direction, speech recognition net was 85%, both from the front and from the sides. In other words, when you are in a group conversation and you have correctly identified which friend is calling you, Oticon Intent allows you to understand 85% of what that person is saying, irrespective of whether the friend is positioned in front of you or at your side. Note that this was a difficult listening situation and, as a reference, young normal-hearing listeners achieved a median speech recognition net of 81% for the same time overlap of 1 s between sentences (Heeren et al., 2022).

Self-reported ratings, given after each condition of the CC-OLSA test, revealed that:

- Listening to a group conversation with Oticon Intent was rated to require significantly less effort ($p = 0.033$), offer more comfort ($p = 0.010$), and higher confidence ($p = 0.002$) than Omni, while Oticon Real was rated similarly than Omni in terms of effort, listening comfort, and confidence;

- It was significantly easier to distinguish the three talkers with Oticon Intent than Oticon Real ($p = 0.033$).

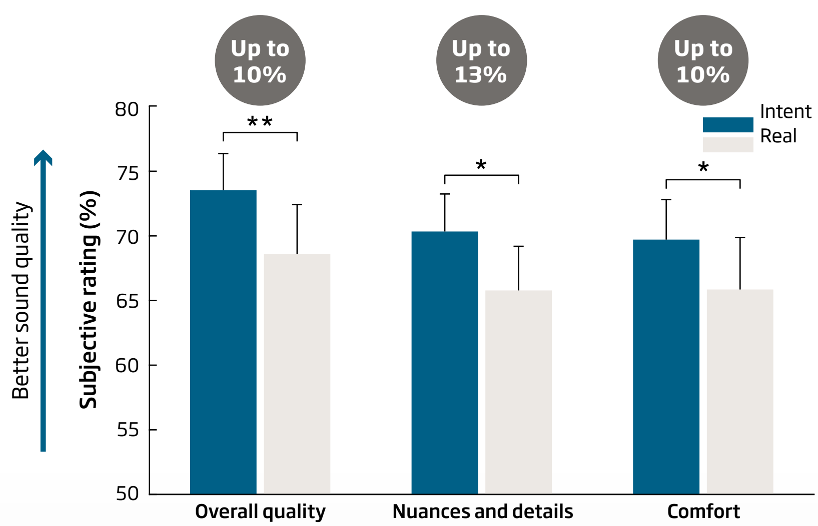
Subjective evaluation of sound quality (Study 3 – part 2)

The aim of this study was to compare the sound quality of Oticon Intent and Oticon Real. The study was performed at an independent research center, Hörzentrum, Oldenburg (Germany).

Method

Six different sound environments were realistically

A



B

Relative improvement with Oticon Intent for:	Forest	Speech in quiet	Speech in cafeteria noise	Speech in traffic noise	Speech at train station	Speech at a pub
Overall sound quality ($p = 0.003$ **)	8.4%	2.5%	10.7%	5.1%	8.0%	9.7%
Nuances and details ($p = 0.013$ *)	4.1%	2.2%	7.0%	9.7%	13.1%	8.8%
Comfort ($p = 0.027$ *)	10.1%	1.7%	8.1%	3.4%	3.6%	8.8%

*Figure 9: Mean subjective ratings for Overall sound quality, Nuances and Details in the sound scene, and Listening comfort, averaged across environments (A) and relative improvements for Oticon Intent vs. Oticon Real for each environment (B). Significant differences are indicated with asterisks (**p < 0.01; * p < 0.05). Error bars indicate SEM.*

simulated including reverberation and then reproduced using a well-established method for sound reproduction (Ambisonics) and an array of 24 loudspeakers placed in the horizontal plane. Listeners were positioned in the center of the array and thus immersed in the listening experience.

Sound quality ratings were collected via a questionnaire after the participants listened to the different sound scenarios with Oticon Intent and Oticon Real (balanced order and single blinded procedure).

The same twenty-five participants that participated in Study 3 - part 1 also participated in this Study 3 – part 2. The test was carried out with Oticon Intent 1 in default settings of MoreSound Intelligence 3.0 (incl. 4D Sensor technology and DNN 2.0) and Oticon Real in default settings of MoreSound Intelligence 2.0 (incl. DNN).

Results

The sound quality of Oticon Intent was preferred over Oticon Real across the different sound environments, in terms of overall sound quality, more nuances and details perceived in the sound scene, and listening comfort. The subjective ratings, averaged across participants and sound environments, are reported in the bar plot in Figure 9A. The table (Figure 9B) reports the relative improvements for Oticon Intent (vs. Oticon Real) for each sound environment. Significantly better ratings were reported for Oticon Intent in environments where understanding speech was important, such as a cafeteria, and also for environments where awareness of surrounding sounds was most important, such as a forest.

Conclusions and clinical implications

This whitepaper reviews the user benefits of Oticon Intent, following a journey along the auditory system from ear to brain.

The technical study revealed that Oticon Intent can adapt the level of support based on listening intentions, providing a 5-dB span of adaptation *within* the same sound environment. *Clinically, this means providing a clearer and more balanced sound scene to clients.* By intelligently adapting the level of support at the Hearing stage of the auditory system, Oticon Intent supports the brain's natural ability to process sounds – all depending on user intentions in a given situation. Using EEG, the second study showed that this adaptation of support was reflected in the brain, at the Focus stage of the auditory system. Here, attention to surrounding sounds significantly varied depending on listening intentions, while attention to speech remained robust across situations. *Clinically, this means that the hearing care professional can confidently fit the user knowing that Oticon Intent helps the brain allocate attention to the sounds that matter - in any listening situation.*

When moving up to higher stages of the auditory system, where meaning of speech is retrieved (Recognize and react), 4D Sensor technology was responsible for a 15% increase in speech comprehension. All while remaining open and offering similarly good speech understanding no matter where the speaker was located - in front of the user or to their side. *Clinically, these results demonstrate how 4D Sensor technology provides an additional benefit in one-on-one conversations, while remaining open to the full sound scene. They also demonstrate that the commonly used counselling strategy of strictly looking directly at the conversation partner may be outdated, as modest head turns will neither challenge speech understanding of multiple conversation partners nor lip reading.*

Finally, the 4D Sensor technology, in combination with the new DNN 2.0, significantly improved the perceived sound quality of Oticon Intent - as reported by users across different sound environments. *The clinical implication is higher user satisfaction with the high-quality sound that Oticon Intent provides.*

Overall, the findings of this whitepaper show that Oticon Intent 1, with its 4D Sensor technology, can provide the user with personalised support depending on their listening intentions in every situation. Receiving personalised support at every moment means that the user can more easily engage in conversation and in life.

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