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Artificial Intelligence in Hearing Aid Processing

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Thank you so much, Anna. My name is Rachel Lamb. I am a clinical trainer with Phonak, and we are going to be talking today about artificial intelligence and hearing aid processing. Just a review of how it is used in everyday life, healthcare, and in hearing care. These are our learning objectives today.

We want to first define what is artificial intelligence, how current hearing aids employ AI, and how Phonak's autosense uses artificial intelligence in our hearing aids today.

As always, my disclosure is that I'm employed by Phonak, but I wanted to also let you know that we've been talking about artificial intelligence in, especially in movies for a long time. If you didn't know, there was a movie in 1927 called Metropolis. It was about a dystopian utopia that highlighted the full and terrifying capabilities of this technology. It depicted a robot fully assimilating with humans and wreaking havoc, which really says a lot about how the public perceived this developing technology at the time. And we've continued to talk about it in movies.

If you think about 2001 A Space Odyssey or the Matrix, and even on television with Doctor who and Star Trek, artificial intelligence has been around for a long time and has been talking, been talked about for a long time. The rapid advancement of artificial intelligence technology is poised to dramatically reshape the modern workplace and herald in a new era of unprecedented change. You might have recently read this headline, where OpenAI's chatbot chat GPT has managed to pass the US's medical licensing exam, a test that all us physicians need to take, and obtain a score of 60%. It has also passed a common study exam used by physicians preparing for board certification in ophthalmology, a college level microbiology quiz created by science journalist Alex Berezaio with a score of 95%, a Stanford, California medical school clinical reasoning final exam with a score of 72%. And now even radiologists say it can pass their specialist board exam.

But before we get too carried away, chat GPT still makes many illogical and inaccurate assertions, and it can't read an x ray, so it's not completely ready to take over the role of your personal physician for

now.

Artificial intelligence offers many advantages. AI can automate tasks that are traditionally performed by humans, and that leads to increased efficiency and productivity for problem solving. AI can assist in those intricate problems across various fields, from medical diagnosis to financial analysis. And artificial intelligence has significantly transformed human computer interactions by enabling more intuitive and personalized experiences in a manner that resembles human speech. Artificial intelligence systems can learn from experience and adapt to new situations.

And this capability is crucial for autonomous systems like self driving cars, and while the AI has received a lot of publicity in the last twelve months, it is important to realize and remember that AI is featured in many aspects of your current everyday life, and you might not have even noticed it in today's modern homes. Artificial intelligence plays a pivotal role in automating tasks, enhancing convenience, efficiency and security. AI technology enables the automation of things such as lighting tasks such as temperature control and appliance usage. Through smart sensors and algorithms, AI systems can learn user preferences and adjust settings accordingly, creating a personalized and comfortable environment in our vehicles. Many modern cars feature AI powered functions that use sensors placed around the car.

These include lane departure warnings, line spot detection, adaptive cruise control, and real time driver assistance. And our smartphones have emerged as a hub for AI powered technologies and functionalities. Personal assistants such as Siri, Google Assistant Alexa are now important parts of your phone's function. Smartphones operating systems also include many AI powered features such as facial recognition and security features, text message word predictions, assistive accessibility functions such as image recognition for low vision users and it can automatically contact health services if you're in a car accident or have another type of a health based incident such as a fall. But let's take a look at

how AI is being used in healthcare applications.

AI is getting increasingly sophisticated at doing what humans do, but more efficiently, more quickly, and at a lower cost. The potential for both AI and robotics in healthcare is vast. Just like in our everyday lives, AI and robotics are increasingly a part of our healthcare ecosystem. AI allows those in training to go through naturalistic simulations in a way that a simple, computer driven algorithm can't, and training can be done anywhere. With the power of AI embedded on a smartphone, you can have a quick catch up session after a tricky case in clinic while traveling, and this is all possible even now.

One of AI's biggest potential benefits is to help people stay healthy so they don't need a physician, or at least not as often in research. Drug research and discovery is a more recent application for AI and healthcare. By directing the latest advances in AI to streamline the drug discovery and drug repurposing processes, there is the potential to significantly cut both time to market for new drugs and their costs. AI is already being used to detect diseases such as cancer more accurately and in its early stages, and IBM's Watson for health is helping healthcare organizations apply cognitive technology to unlock vast amounts of health data and power diagnosis. Beyond just scanning the health records, though, AI can help providers identify chronically ill individuals who might be at risk of an adverse episode.

AI can help clinicians take a more comprehensive approach for disease management, better coordinate care plans, and help patients manage their disease processes, and comply with long term treatment programs. Using available big health data and machine learning, AI can use pattern recognition to help patients identify patients who are at risk for developing a condition or seeing that condition deteriorate due to lifestyle, environmental, genomic, or other factors. All of these areas are where AI is beginning to take a hold in healthcare. It really is used in five main ways. Artificial intelligence can be integrated at various stages, with some of these aspects already implemented and others remaining theoretical or in

the process of being evaluated.

It's transforming healthcare across various domains, from early detection and diagnosis to personalized treatment and planning, surgery, virtual assistants, and research support. So let's look a little bit closer at how AI is being integrated into these aspects. Early detection of disease is paramount for timely treatment and improved outcomes. AI powered diagnostics revolutionizes healthcare by analyzing vast amounts of data with significant and impressive speed and accuracy, enabling early detection and personalized treatment approaches. AI powered diagnostics harness the power of machine learning algorithms to analyze diverse data sources, including medical records, genetic information, imaging, and test results.

By processing this wealth of data, AI systems can detect subtle patterns and markers indicative of disease, facilitating early intervention and detection of rare diseases. And unlike the traditional diagnostic method, artificial intelligence can analyze large datasets rapidly and with high accuracy, allowing healthcare providers to identify potential health issues sooner, enabling prompt action for better outcomes. AI goes beyond the standard diagnostic approach and integrates personalized variables into its analysis. Factors such as a genetic predisposition, lifestyle choices, and existing health conditions are considered, allowing for a more tailored and targeted intervention to address that patient's specific needs. By leveraging AI powered diagnostics, healthcare professionals can adopt a precision medicine approach.

This involves customizing treatment plans based on an individual's unique genetic makeup, lifestyle, and disease characteristics to maximize therapeutic efficacy and minimize side effects.

Diagnosis only marks the beginning of a patient's healthcare journey, though, and AI holds an immense potential to advance clinical decision making and personalized treatment planning. AI powered technologies excel in pattern recognition. By analyzing those vast amounts of medical data from

diverse sources, it enables the healthcare professional to identify subtle correlations and trends that might identify or influence treatment decisions for that patient. AI can enhance communication between providers and patients by simplifying complexity, medical concepts, and terminology. By leveraging natural language processing and machine learning algorithms, AI facilitates clear and understandable expectations, fostering patient understanding and engagement.

It can also enable the development of a personalized treatment plan that considers that patient's unique characteristics, including their lifestyle, genomics, and cultural factors. By integrating all of these personalized variables, the healthcare professional can tailor a treatment approach to address individual needs preferences and maximize therapeutic efficacy and patient outcomes. But it doesn't stop there. The integration of AI and robotics in rehabilitation has ushered in a new era of possibilities, offering numerous benefits to patients and healthcare professionals. By harnessing the power of intelligent machines, rehabilitation techniques are becoming more personalized, efficient, and effective.

AI algorithms can analyze those vast amounts of patient data like we've talked about before, and enable the tailoring of a rehabilitation program specifically for that patient. It can provide continuous monitoring of their movement in progress and introduce interactive and immersive experiences into rehabilitation therapy. Additionally, robotic devices offer precise control over movements, enabling patients to perform intense and repetitive exercises. This repetition plays a critical role in neuroplasticity, facilitating the rewiring of neural connections and promoting functional recovery. AI and robotics have the potential to democratize access to rehabilitation services.

Telerehabilitation platforms allow patients to receive therapy remotely, eliminating geographical barriers and reducing the need for frequent visits to healthcare facilities.

And in one of AI's most significant potential benefits, it lies in its ability to prevent healthcare issues through the use of apps, virtual assistants, and chatbots. By leveraging this technology, individuals can

take a proactive measure to maintain a healthy lifestyle and minimize the need for frequent medical interventions. These AI powered apps, assistants, and chatbots provide personalized recommendations and reminders for preventative health measures, medication adherence, scheduling, preventative screenings, or adopting a healthier lifestyle habit such as nutrition and exercise. With AI based technologies, individuals can proactively manage their health and well being, potentially reducing their need for frequent visits to healthcare providers. By staying informed and engaged in their own health, individuals may experience better outcomes and lower healthcare costs over time.

AI technology is integrated into smartphones and various wearable devices, making it easily accessible to users. These devices can track health metrics such as our steps, physical activity, sleep patterns, heart rate, and provide real time feedback to patients, giving them insight into their health status. By leveraging AI for health prevention and wellness, consumers are empowered to take control of their own health and well being with access to personalized recommendations and proactive management tools so individuals can make informed decisions about their health and pursue a healthier lifestyle choice with confidence and medical training is really highly complicated and stressful. It's a stream of education where the stakes are extremely high high, and the learning curve is very steep. However, AI based medical training can revolutionize this process by offering highly immersive and personalized learning experiences.

These systems leverage AI to adapt delivery methods based on individual preferences and learning styles, detect errors, and provide tailored feedback to the student. This personalized learning process can be modulated can be modulating its delivery based on preferences and learning styles, ensuring that a student receives content in a format that best suits their need, comprehension and retention of information. AI systems can detect errors made by medical students during training, assist in resolving gaps in their understanding by figuring out where that gap is by analyzing the student performance, providing targeted feedback, and additional resources to address areas of weakness, and foster

continuous improvement. AI based learning systems are used to train medical professionals on identifying and diagnosing clinical problems for virtual patients. These patients are developed by using AI by AI using real patient data, providing learners with realistic scenarios to practice those decision making processes and their diagnostic skills in a safe and controlled environment.

There are numerous benefits already being researched, trialled, and or being put into action. Medication dosage optimization enhancing population health management establishing and optimizing health guidelines virtual health assistance robotics that can improve the accuracy of surgery and effectiveness of rehabilitation improved patient education and patient physician trust. Artificial intelligence has the potential to save governments hundreds of billions of dollars annually if widely adopted. With this revolution in personalized healthcare, it's really important to consider the patient's attitudes in all of this, and studies have shown that patients can see the potential benefits to using AI in healthcare. In a recent study of american patient perspectives of AI in healthcare, a large share of respondents think the use of AI in healthcare in medicine would reduce the number of mistakes made by healthcare providers, and in another study, the majority of survey participants felt that AI would make healthcare much better or somewhat better.

These studies also show that there are some reservations about the use of AI. 60% reported being uncomfortable if their provider relied on AI for their medical care, and participants indicated that they strongly that they want to be informed when AI is being used.

When you put this information together, we see that patients recognize the potential benefits of using AI, but they want it to be provider led and to be informed in the process.

But before we jump too far into AI and hearing aids, review in more detail, what exactly is artificial intelligence? Artificial intelligence AI is the ability of a machine to imitate human behavior, and machine learning is a subset of AI in which a system learns automatically and enhances its performance through

the analysis of provided data and then deep learning. This is an advanced subset of machine learning that employs intricate algorithms such as a deep neural network, to closely emulate the human brain, enabling the system to learn and respond to information with increased complexity and precision. In other words, think back to the examples we discussed earlier. Artificial intelligence when you imagine a chess playing robot, that robot isn't sentient.

It can think strategically based on an algorithm and past games, and adapt its move based on the opponent's actions. This simulates intelligent behavior, even if it's not truly thinking. Machine learning is more like a spam filter. In your email, it learns from examples of what you mark as spam, automatically identifying similar emails in the future. It improves over time without explicit programming.

Showcasing the core of machine learning, however, deep learning imagine you're developing a self driving car. It needs to interpret complex visual information from its cameras in real time, like recognizing objects, cars, pedestrians, traffic signs and their distances. A deep neural network with multiple layers can process this visual data effectively. Each layer extracts increasingly intricate features from the image, eventually enabling the car to understand the scene and react appropriately. This multilayered approach is what sets deep learning apart from machine learning algorithms, making it particularly powerful for handling intricate tasks like autonomous driving.

So let's take a look at how machine learning is different from deep learning and deep neural networks to understand how each is used in the application of AIH hearing aid technology today. Machine learning is a process whereby an algorithm is trained by being provided substantial sets of information, and then is given an opportunity to learn patterns and sequences to make the information make sense for a particular purpose. In this case, the machine learning algorithm is being provided many visual examples of two types of animals in order for it to learn to which one is a dog and which one is a cat. After some time, the algorithms can start to detect patterns and sequences and provide suggested

outputs based on probability if incorrect answers are provided. Depending on the situation, a machine learning algorithm may be able to learn autonomously.

However, in most situations and cases it will need retraining via the programmer or the data input engineer.

Machine learning can have limitations as well if the input is outside of the training model that it was provided, like this. Here is our input signal, and the algorithm uses its classifications to choose a from the available options. Regular machine learning algorithm can still attempt to apply its learning model to the picture of a bear and locate identifying features that are consistent with a cat, such as a black nose, claws, two ears. However, as its operating parameters are only programmed to understand dog and cat, it will not provide the complete correct outcome.

And this is where a deep neural network system has advantages. It's able to identify analyze far more deeply from a greater data set, and it can also learn autonomously individual variables or outputs. Maybe it identifies the fur, color and texture, paw size, and the fact that the animal is outside in a forest being able to analyze from a grid greater data set, it can come up with grizzly bear. A deep neural network is a network of complex hidden layer structures within a wide variety of different layers. These additional layers help the model to understand problems better and provide optimal solutions to complex projects.

A deep neural network has more layers or depth, and each layer adds complexity to the model while enabling the model to process the inputs concisely for outputting the ideal solution. Here we can see deep neural networks are composed of layers of nodes. Each node is designed to behave similarly to a neuron in the brain. The first layer of a neural network is called the input layer, followed by the hidden layers and finally the output layer. Each node in the neural network performs some type of a calculation, which is important for the correct outcome.

But imagine if the system was able to integrate hundreds of animal encyclopedias in a library. It could analyze every detail, from fur color and texture to paw size, to location, and make incredibly accurate guesses based on that massive amount of knowledge. So let's talk a little bit more about how artificial intelligence is used in hearing healthcare. AI integration also lives in the hearing healthcare space. The three areas where AI is used are early detection and diagnosis.

For example, atypical tympanometric results in diagnosing ear infections based on otoscopic images. This really can be helpful in rural or regional areas in developing countries. Tinnitus support chatbot based tinnitus management applications allow for those who experience tinnitus to access management and relief strategies and support any time of day and hearing aid technology. And that's what we're going to focus on today as we discuss AI and today's hearing aids. It is worth highlighting some of the pros and cons of machine learning versus deep neural networks.

Machine learning can be very a very efficient system. It requires less input information and processing power and can enhance and learn over time. One potential limitation is that machine learning is only as good as the human input and training that is used during its development.

When we look at deep neural networks, there is potential for greater simulation of humanity through patterns. The trade off is, though, that a true full DNN requires significantly more information and processing power to function. In fact, the required processing power to run a full DNN is not available in a hearing aid package at this time. But we're going to come back to this hearing aid. Automatic systems can be developed or trained using AI.

Common features that are trained by AI include environmental classification and program steering. This automatic behavior offers patients convenience, and optimized hearing to make sure that the behavior of the hearing aid is accurate and optimal in key ways through environmental classification and

program steering. AI powered algorithms classifier environmental sounds in real time automatically adjusting hearing aid settings to optimize performance in different listening environments. Environment classification includes identifying speech, noise, music, and other background sounds to enhance speech intelligibility and comfort. Program steering AI driven program steering technology adapts the hearing aid settings based on the user's location, movement, and activity.

By continuously monitoring the user's auditory environment, the hearing aids can seamlessly transition between different listening programs to provide optimal hearing assistance throughout the day.

First environment environmental classifications our ears pick up a blend of sounds from various sources at once, which overlap and mix together. Despite this overlap, our hearing system can accurately group different sound sources in terms of timing, space, and frequency into a coherent sound stream, referred to as auditory scene analysis. This ability of grouping and streaming different scenes is one of the theoretical basis for environmental classification in hearing aids, namely Phonak's autosense OS.

Program steering refers to the way a hearing aid adapts its features based on external input. This input could be environmental classification sensor input and, for example, a movement based sensor that tracks the wearer's activity, a wireless signal that is connected to a hearing aid, for example, a Bluetooth audio signal from a smartphone or a proprietary wireless signal from an accessory.

Autosense scans the environment 700 times per second for 20 seconds. It identifies a loud, noisy environment based on the frequencies, space, and timing of the different sounds at the same time, input from the motion sensor shows the wearer is currently walking. Based on this information, the hearing aids go into motion sensor hearing, opening the directionality and giving your patients an awareness of their environment, all without any input from the patient themselves.

In addition, another example could be from a patient going from a quiet environment. Perhaps the hearing aid is in calm, and then a phone call comes in because the environment doesn't matter. Here, the hearing aid switches its input to the bluetooth, streaming from the phone.

Hearing aid processor chips are built for efficiency and are heavily optimized. This efficiency focuses results and current processor chips lacking processing power required from some AI tasks. The current AI technologies found in hearing aids are either efficient machine learning algorithms, small deep neural networks, or utilizing cloud based servers for heavier AI processing through an app. Today, we're going to focus on what's available in the hearing aids themselves, instead of through an app. Phonak has successfully employed machine learning for over two decades in its autosense operating system, ensuring accuracy, performance, and patient satisfaction to ensure performance and efficiency, our AI algorithms are optimized for computing power so they can run on the form factors we have available today.

The system was trained by experts during the learning process, then uses those algorithms to classify the environment.

So, autosense OS, how does it use AI exactly? Let's go step by step and learn what? Take a look at the process of training autosense OS with AI machine based learning.

First, we need to gather a diverse set of real world recordings. This is important because the variety and number of real world recordings help us to better diversify the systems reference to various environments, allowing for better identification of those environments. Because we're not just identifying cat and dog. Fun act relies on the use of thousands of real world recordings.

So let's listen to program number one and make sure you can hear it.

Rachel, I think we forgot to share the sound on your computer when we were setting up today. If you want to go up to the top and share sounds. I did that. Okay, I'm hearing it now. I'll replay it.

Thank you. I was doing that as we talked.

Morning, no? Right. Juicy. Today, everybody recording two together and try out eight and four.

So which autosense or environment would you classify for each of these recordings?

We then label the recordings with the relevant labels that indicate the environments that they represent. And as you can see now, the recordings we listen to are now labeled with those environments. The labeling of a sound file is also very important, because if you have collected a ton of recordings, either on your own or in a database on the Internet, it's not guaranteed that all of these labels are correct or labeled the way we think they should be. This is a huge amount of effort we at Phonak put into the training process, because we want to ensure that we have the correct label for different situations. How close were you in each of these?

So then we train the algorithm, and we want to make sure that the algorithm learns to accurately recognize a different environment based on the labels. So, for example, if we play music, then we have cardinal, we need to make sure that the machine learning analysis is correct. So if the machine learning analysis incorrectly identifies the situation, it is retrained at that point.

So then we analyze and the signals that are coming in from the different recordings and break them down into their features, such as spectral or temporal characteristics. The system now automatically learns the features that best represent the different situations.

During the use of autosense, the features of the live environment are calculated and compared to the machine learning environments, allowing autosense OS 5.0 to determine the live situation accurately.

The DNNs found in hearing aids today are considered to be small. In other words, small DNNs are used in situations where available computational resources necessitate a more compact model, and this is the case with hearing aids using DNNs today. Today's small DNNs perform the same functions of feature extraction and classification. For context, it is well known that AI based technologies, or smartphones, require substantially more power than other typical computational processes. As AI technologies continue to expand, their power demands are already considerable and projected to increase dramatically.

AI processing requires substantially more processing power and therefore requires a larger power source. Integrating the next generation of AI capabilities into hearing aids will increase power consumption of hearing aids.

So dnnns hold immense potential for managing speech and noise, as shown by the blue line on this graph when you look at but when, as we've explained, they require substantially more processing power than current hearing aids can offer. That means that the currently implemented small dnnns and hearing aids available today, illustrated by the gray and blue circles on that blue curve, are not providing the true benefits of DNN processing because they're limited by physical size and available processing power. At Phonak, we believe a good classical algorithm combined with machine learning scene classification found in our lumity product line, the green dot on the gray machine learning curve can match and or outperform the small DNN offerings seen in the market available from other manufacturers. While machine learning approaches require more development and human involvement to train the automatic system due to the current state of hearing aid processing power, machine learning and small DNN approaches can be considered to provide equivalent computational

complexity. What matters is what you do with it.

Phonak is not new to the world of AI. As early as 2000, Phonak saw the potential of using AI to improve its sound processing technology. Phonak's core platform was the first to utilize a form of AI within its groundbreaking automatic system. Over the past 24 years, we've integrated, consistently integrated AI into our sound classification and noise reduction steering strategies using machine learning in real world audio recordings. This ensures that our hearing aids and accessories not only perform accurately and reliably, but most importantly, deliver unparalleled speech understanding, all without the need for manual button presses.

As with previous generations, our latest operating system, Autosense OS 5.0, has been developed with AI via machine learning, and this is where we're going to focus next on Phonak's 24 years of experience with AI based machine learning and dig into the details and benefits of what Autosense OS 5.0 has to offer you and your patients. Phonak hearing aids are continually developed with cutting edge technology. Autosense is our most recent application of machine learning. Trained with thousands of real world sound recordings, it constantly scans and analyzes the sound environment and automatically adjusts the parameters to create over 200 unique setting combinations. This results in a truly personalized hearing experience, meaning that the patient is in the right setting in every situation.

The core of Autosense OS is based on the classifier structure of non exclusive blended programs, calm speech and noise, comfort and echo, comfort and noise and exclusive programs, speech and loud noise, music and speech and car. But the sounds of life don't always conveniently fall into seven buckets, which is why Autosense OS, trained through machine learning, blends programs based on the unique environment, the unique identification of the environment, so we don't just classify easy or hard, and we don't classify and then only use those structured preset parameters. The blending allows the device to classify but also pull in features as needed in the moment from other classifications to provide

the best response. In that environment. Features are engaged truly based on the environment and the patient's movement.

Autosense OS also incorporates streamed inputs into the automatic classification process. Thus, our devices can tell the difference between an acoustic signal versus a stream signal. Autosense OS automatically classifies streamed input for an enhanced listening experience, where sound is optimized for speech clarity during streaming of dominantly dialogue heavy programs, and sound quality when music rich programs are recognized. Furthermore, it applies event loss compensation automatically based on decoupling so that there's no loss in low frequency input.

Autosense OS 5.0 also provides numerous benefits to both patients and hearing care professionals during the use of autosense. OS the features of the live environment are calculated and compared to machine learning environments, allowing autosense OS 5.0 to determine the live situation accurately. The AI based automatic program selection of autosense means program activation and deactivation is accurate, reliable, and consistent without any input from the wearer at all. This results in a truly personalized hearing experience, meaning the patient is in the right setting in every situation. There's no need for complicated manual hearing aid program structures during a hearing aid setup, so the fitting process is also streamlined and simple.

Autosense 5.0 provides unparalleled access to functional parameters, so customized hearing aid performance for hearing aid wearers is easy and effective and can be done via remote support. With the growth of AI, we are very excited to see what the future holds when we think about AI in the hearing care space. Rest assured that you as the provider are still key to that care. Remember that patients want to be informed when AI is being used, and they don't want a clinician that solely relies upon AIH. As the audiology and hearing healthcare industry begins to see more AI solutions, you can expect that your patients still need and want your support, and they want you to form a strong relationship and

develop rapport with them.

Your patients want to see you combine your experience with AI, not have you rely on AI alone.

We only discuss AI and hearing aids today, but it certainly has applications in other areas of the field.

As the audiology and hearing healthcare industry begins to see more solutions using artificial intelligence, we can expect new approaches to diagnostic assessments that are more reliable and sensitive to hearing loss, improved techniques for hearing aid verification and calibration, and new innovations in the way hearing aids and their digital ecosystem apps, virtual assistants, etcetera work to perform 24/7 patient support. Machine learning is evolving in exciting ways and is positively impacting the audiology industry. Machine learning algorithms can create customized settings based on each user's specific needs and degree of hearing loss, resulting in more personalized hearing aid solutions. For example, AI and machine learning can accurately analyze a user's listening habits and preferences and use that information to optimize their hearing aid settings.

High performance chips will become more common moving forward. This will make it quick and easy to accurately create customized amplification and connectivity settings, resulting in a better and more precise experience for each user. We will continue to see hearing aid features that push boundaries in automatic performance, environmental classification and performance and noise. We know that performance and noise can make a huge difference for patients user satisfaction. Fortunately, we're seeing improvements in this area and market track ten when looking at satisfaction with sound quality, we saw 68% of owners were satisfied with following conversation in noise.

A large number of owners were also satisfied with conversations in large groups when watching tv, and in small groups. But that doesn't mean we don't have more work to do. So what can be done to drive satisfaction further? At first glance, there's really nothing revolutionary about any of this. These are the core needs of your clients.

But sometimes persistent challenges call for revolutionary solutions. We need to meet the unmet expectations of all patients, maximize speech understanding in all situations, connect wirelessly via Bluetooth protocols, old and new, and provide easy and intuitive management and ease of use for your patients.

We believe the next great leap in satisfaction will be provided by AI. Currently, there are no commercially available processor chip options that could enable higher level AI processing in a package that is small enough, powerful enough, power, efficient enough, and not reliant on a smartphone or cloud based processing. But what could it be like if we had more access to more processing power?

I want to share some examples of AI driven denoising speech enhancement that works well, but is reliant on the processing of a smartphone. This is a sample. How's that? It's great. Also just moved there in December, so.

And here's an example with at the other side of the train station, there is a barn with horses and then the dogs and barbers. How's that? It's great. Also, Jeff moved there in December, so.

And here is another one without at the other side of the train station, there is a barn with horses and dogs and Barnsley. And that same example with at the other side of there is a barn with horses and dogs and farmers. It's pretty impressive.

Tomorrow's AI enabled hearing aids may even find a way to leverage both machine learning and DNN algorithms together for different tasks, making the most of both similar to that of a modern day processor for a PC or smartphone, which has processing cores optimized for efficiency and cores optimized for power. Perhaps an ideal architecture of a future AI hearing aid will involve a chip capable

of high performance AI features via DNN and efficient functions via machine learning. And time will tell.

Considering the future, we believe that it will be a combination of innovative new technology focusing on leveraging the opportunities artificial intelligence provides with the audiological intelligence you have to offer your clients. You cannot have one without the other. It is the combination of the two that will provide the best outcome. Now is the time for you to understand how AI can work for you and your clients, and a partner with Phonak who can provide 75 years of experience of innovation, 30 years of hearing instrument innovation, and 24 years of AI development. We also have a proven track record of rising to the occasion when a challenge presents itself.

We look forward to taking this journey with you because we recognize that together we change lives.

Thank you very much.