

Integrated Intelligence without Compromise



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Key takeaways:

- The impact of deep neural network (DNN) technology depends not just on algorithms, but on how they are integrated. Compared to multi-chip solutions, a unified platform architecture that is end-to-end optimized enables more synchronized and efficient processing, enhanced feature performance, and reduced audio processing delays. All of which can lead to improved patient satisfaction.
- Reduced processing delay may help minimize artifacts particularly in open-fit designs where clarity is most critical.
- Starkey's unified performance architecture demonstrated faster processing compared to other DNN-enabled hearing aids evaluated and up to 2.7x faster DNN processing than the slowest competitor..

Introduction

The evolution of hearing aids from basic analog amplification to sophisticated, digitally optimized systems mirror the broader advancement of audio technology. Early analog devices, while essential in establishing audibility, amplified all incoming sounds uniformly. This limited approach often made it challenging to separate speech from background noise, particularly in complex listening environments.

The transition to digital hearing aids marked a significant inflection point in the industry. By converting sound into data, digital platforms enable more precise analysis and processing, introducing programmable signal processing capabilities that allow clinicians to tailor amplification across frequencies to an individual's unique hearing profile. This shift delivered more targeted performance, improved sound clarity, and greater adaptability across a range of listening conditions.

Building on this digital foundation, subsequent innovations introduced advanced features such as noise reduction, feedback management, and directional microphones. Together, these capabilities elevate both speech understanding and overall listening experience, inevitably transforming hearing aids from simple amplification tools into personalized, responsive hearing solutions.

The next inflection point in hearing technology is driven by the emergence of deep neural networks (DNNs), enabling hearing aids to evolve from advanced devices into truly intelligent systems. However, the true step-change lies not just in the introduction of DNN algorithms, but in how they are integrated into the underlying system architecture. Today, hearing technology continues to progress along this trajectory, integrating increasingly advanced processing capabilities designed to address real-world listening demands.

This evolution from analog simplicity to digital precision, and now to intelligent systems, provides critical context for the next generation of innovation where intelligent processing, system efficiency, and seamless performance are becoming as central as sound processing itself.

The importance of a solid core

As hearing technology advances, the effectiveness of artificial intelligence is increasingly defined not only by the sophistication of the algorithms, but by how they are implemented within the device architecture. Integrated Deep Neural Network (DNN) co-processing represents a strategic evolution away from traditional multi-chip designs toward a more unified, system-level approach to intelligent signal processing.

In conventional architectures that rely on separate chips for AI or DNN processing, audio signals must travel between components for analyses and adjustment. This introduces additional system overhead, including latency, power demands, and bandwidth constraints that can limit processing efficiency and real-time responsiveness.

By contrast, Starkey's integrated DNN co-processor (Neural Processing Unit) was designed from the ground up and embeds neural network capabilities directly within the core signal processing framework (*Figure 1*). This unified design is end-to-end optimized and enables faster data exchange, reduces the need for inter-chip communication, and allows for tighter synchronization between acoustic input and AI-driven processing.

The result is a more streamlined and efficient platform capable of supporting multiple DNN-driven features (Always-on DNN Noise Reduction, DNN 360, Edge Mode, and DNN Dual Compressor), demonstrated in the Omega AI+ product line (*Heuermann et. al., 2026*), without

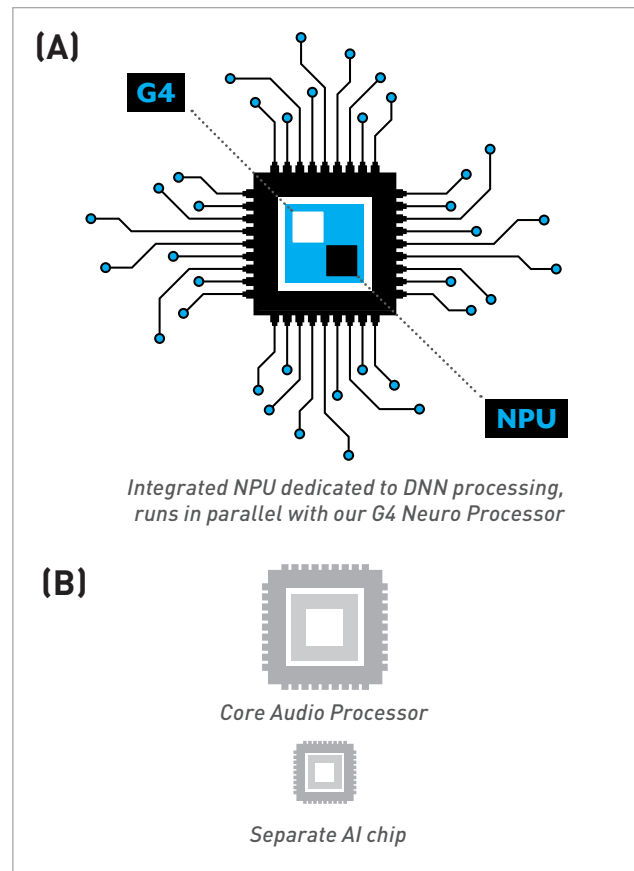


Figure 1: (A) Starkey's integrated Neural Processing Unit (NPU) dedicated to DNN processing. (B) An example of a hearing aid with an AI chip separate to its core audio processor.

the typical trade-offs associated with discrete architectures. Furthermore, the embedded neural architecture enables continuous expansion of DNN capabilities into additional features with no impact on latency or power.

This integration typically delivers meaningful advantages, including reduced signal transfer delays, improved power efficiency, and more coordinated operation across core features. By eliminating the divide between traditional digital signal processing and AI computation, the system can operate more cohesively, enabling continuous and responsive performance in dynamic listening environments.

For hearing care professionals, this architectural approach translates into a more consistent and scalable solution and one that is designed to deliver intelligent, real-time performance while supporting the increasing complexity of modern hearing technology.

No compromises to speed

A comparative evaluation was conducted to assess audio processing delays among flagship hearing aids incorporating DNN-based speech-in-noise technologies available at the time of testing. All devices were programmed to a flat 50 dB hearing loss using each manufacturer’s proprietary fitting rationale, using each product’s flagship ‘speech in noise’ memory, and tested under standardized conditions with an occluded coupling (Power Dome). To ensure consistency across devices, features such as feedback management were disabled, and directionality was set to omnidirectional mode. Processing delay was quantified using a white noise burst stimulus, with cross-correlation analysis applied to estimate latency.

Table 1: A list of hearing aids evaluated in the delay processing study. The sequence of the devices listed does not correspond to the alphabetical sequence referred to later in the results.

Brand	Model
Starkey	Omega AI+ 24 RIC RT
Oticon	Intent 1 miniRITE
Phonak	Audeo Infinio (Ultra) Sphere 90
ReSound	Vivia 9 microRIE
Widex	Allure AI

As seen in Figure 2, Omega AI+ demonstrated the lowest audio processing delay at approximately 5 ms, outperforming all evaluated flagship devices that were marketing with DNN-powered noise reduction at the time the comparison was made.

Competing devices exhibited higher delays, with Brand C and D measuring approximately 8 ms, Brand B around 10 ms, and Brand A exceeding 13 ms. When compared with the slowest-performing device evaluated, Omega AI+ demonstrated up to 2.7 times faster processing.

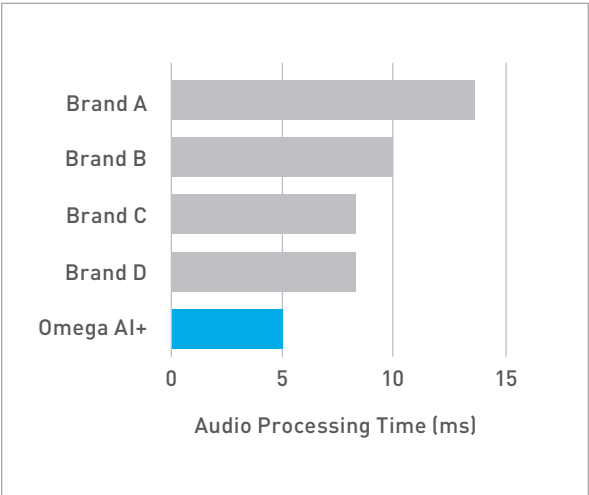


Figure 2: Results of the audio processing delay study demonstrating Starkey’s superior latency compared to other brands evaluated.

The results underscore Omega AI+’s ability to deliver advanced DNN-based processing with minimal latency. Reduced processing delay is an important contributor to maintaining temporal alignment between acoustic input and amplified output, supporting a more seamless and natural listening experience in real-world environments.

Although not evaluated in this study, previous research has demonstrated the importance of audio processing delay with perceived sound quality particularly in devices designed for open or vented fittings. Foundational research (Agnew & Thorton, 2000) has shown that even relatively short delays can become perceptible when amplified sound combines with direct acoustic input. As delay increases, this temporal misalignment can introduce audible artifacts, such as echo effects or smearing, that detract from the naturalness of sound. While some individuals with hearing loss may exhibit some tolerance for slightly longer delay, particularly

in more occluded fittings where there is heavier reliance on the amplified signal than the combination of direct and processed paths, maintaining low delays remains critical to optimizing sound quality and ensuring consistent performance across a wide range of listening environments and fitting configurations.

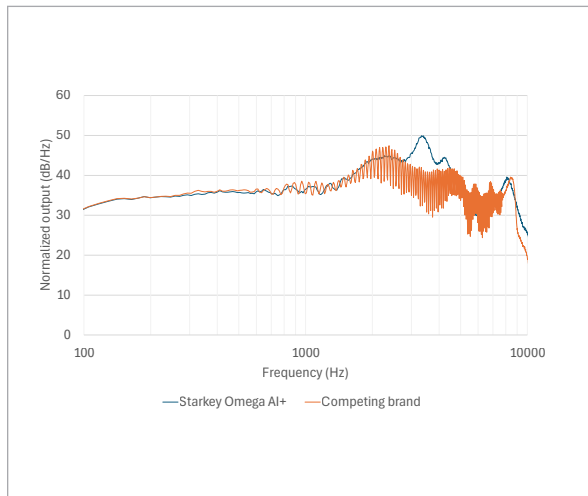


Figure 3: An example of comb-filtering measured with an open-fit device using the Omega AI+ (blue line) and a competing brand (orange line).

Figure 3 above demonstrates the effect of a system with comparably longer delays (orange line) in an open fitting. In open-fit hearing aids typically used for mild to moderate hearing losses, venting allows direct sound to reach the ear alongside amplified output. Timing mismatches between the direct and amplified paths can lead to comb-filtering, which is an interference pattern that creates peaks and nulls across frequencies. The comb filtering effect can potentially distort the spectral balance of sound, resulting in hollow or swirly quality that is unnatural sounding. Longer delays can exacerbate these artifacts, particularly in speech, where fine temporal and spectral cues are essential. Minimizing processing delay is therefore essential in open fittings to reduce comb filtering effects, preserve sound fidelity, and maintain a more seamless integration between direct and amplified sound.

Engineered for efficiency

Battery efficiency is a critical consideration in modern hearing aid design, particularly as devices incorporate increasingly sophisticated always-on DNN-driven processing. In architectures that rely on a separate chip, continuous data transfer between the core signal processor and the dedicated DNN processor can introduce additional power demands. These inefficiencies can be driven by inter-chip communication requirements, increased data movement, and duplicated processing overheads, all of which can place additional strain on battery performance.

In contrast, the Omega AI+ platform leverages an integrated DNN co-processor, consolidating signal processing and AI computation within a single, unified system. This architecture is designed to reduce the need for data movement across components, enabling more efficient use of computational resources and overall power consumption.

As a result, integrated architectures like that implemented in the Omega AI+ platform, can support multiple, advanced, always-on DNN-powered features with optimal battery performance.

Comparative data obtained from published materials (*Table 2 on the next page*) shows suggested battery life information across different brands and hearing models that have DNN technology at the time of evaluation. While a direct comparison is limited in the absence of a standardized testing framework, the results demonstrate high confidence in the Omega AI+ product line in being able to support patients throughout their day.

Author Biographies



Amit Shahar, is the Senior Vice President of Advanced Development at Starkey, where he leads global engineering and established the company's advanced R&D center in Tel Aviv. Drawing on his previous experience as a Senior Director at Intel, Shahar has driven Starkey's transition from traditional audio amplification to AI-powered health tech. Under his leadership, his team pioneered integrating Deep Neural Networks directly onto hearing aid silicon chips for real-time sound processing, while also introducing other groundbreaking hearing aid features.



Heike Heuermann, Ph.D. is the Vice President of Product Integration at Starkey, where she bridges complex hearing aid technology with patient-driven goals. Holding a Ph.D. in Cognitive Psychology and a Master's in Physics, she previously spent years in senior leadership at WS Audiology and Siemens/Sivantos, directing global R&D and platform strategies. Today, she leverages her extensive background in audiology and product development to help advance Starkey's established vision of delivering patient-centric, personalized hearing aid features.



Christine Tan, Ph.D. is a Senior Market Analyst at Starkey, with a unique, multidisciplinary background that spans a BEng. in Electronics and Electrical Engineering, an MSc. in Audiology, and a Ph.D. in Psychology. As a second-generation audiologist with a deep-rooted passion for industry, she has extensive experience across research and product management. In the current role, she supports the business through streamlining processes, strategic competitive and market insights, and compelling technical storytelling.