



nuance audio

in tune with life

Nuance Audio™ Glasses: Scientific Evidence Report

SCIENTIFIC PAPER

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Managing Hearing & Vision

Hearing and vision are two of our most vital senses, essential for awareness, independence, and communication. Loss of hearing and vision has a negative impact on quality of life. Yet, they are often addressed separately in healthcare and technology. Today, EssilorLuxottica introduces Nuance Audio™ Glasses – an innovative open-ear hearing solution embedded in a glasses frame. This white paper presents a groundbreaking approach that merges advanced auditory technology with everyday eyewear. By combining expertise in engineering, design, audiology, vision science and ophthalmic glasses, we have developed a product that empowers users to engage more deeply with their surroundings.

As the Chief of Audiology and as the Head of Medical Affairs, we are excited to share the research and innovation behind this product. This paper outlines the technology, clinical insights, and user benefits that define this new category of wearable devices. We believe this advancement marks a significant step toward more holistic sensory healthcare, and we look forward to its positive impact on users' daily lives.

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“Enabling ease of understanding in challenging communication situations (noise, foreign language hurdle) through the use of Nuance Audio™ Glasses to improve acceptance of amplification in mild to moderate hearing impairment”

Prof. Dr. Anke Lesinski Schiedat

“I’m pleased to share this evidence-based work on Nuance Audio™ Glasses. They offer a discreet, user-friendly solution that may finally bridge the gap between clinical needs and everyday use—an important step forward in hearing care”

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1. Executive Summary

Hearing impairment and difficulty understanding speech in noisy environments are widespread global challenges. Although hearing aids are a common form of treatment, adoption remains low due to social stigma and challenges users may experience in complex listening environments. Nuance Audio™ Glasses offer an innovative hearing solution, seamlessly integrated into eyeglasses. This design reduces the stigma often associated with traditional hearing aids and enhances the listening experience, especially in challenging listening environments.

A series of research studies assessed the effectiveness of Nuance Audio™ Glasses for individuals with mild to moderate hearing impairment. Results demonstrated that Nuance Audio™ Glasses significantly improve speech understanding in noise and effectively reduce listening effort. Users also self-reported noticeable improvements in daily communication and overall quality of life while using the device. This novel form factor plays a crucial role in encouraging individuals with mild to moderate hearing impairment to begin their hearing rehabilitation journey.

Although HI can occur at any age, its prevalence increases with age. Around 10% of individuals between 30 and 40 years old experience some degree of HI, with this number rising to 50% in individuals over 50 (2). Mild-to-moderate HI constitutes a significant proportion of cases, yet individuals in this category are the least likely to seek treatment (3).

Hearing impairment refers to a reduced ability to hear sounds compared to normal hearing levels. Hearing impairment is classified by severity level:

Mild - Difficulty hearing soft sounds or following speech in noisy environments.

Moderate - Challenging to follow conversations even in quiet settings.

Severe - Only able to hear very loud sounds; most speech sounds are not detected.

Please note: The specific decibel (dB) thresholds used to define each level of hearing impairment may vary across countries and professional guidelines.

2. Introduction

2.1 HEARING IMPAIRMENT DEMOGRAPHICS

Hearing impairment (HI) is a widespread global issue, affecting over 1.5 billion people, with projections estimating an increase to 2.5 billion by 2050 (1).

The most common cause of HI is sensorineural, which results from damage to the cochlea's hair cells. This damage not only reduces audibility but also distorts sound, impairing frequency selectivity and temporal processing. Consequently, understanding speech becomes particularly challenging in complex and noisy environments (4).

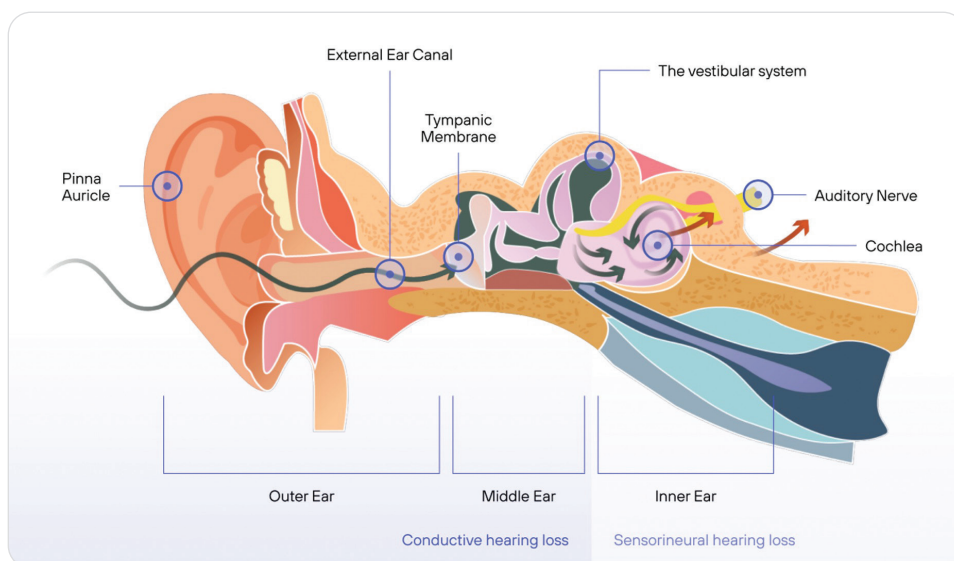


Image 1 – The Auditory Pathway

2.2 SPEECH IN NOISE DIFFICULTIES

One of the most significant challenges for individuals with hearing impairment (HI) is understanding speech in noisy environments (SIN). Background noise degrades the auditory signal, diminishing speech clarity and increasing the risk of misinterpretation (5). Even individuals with near-normal hearing or early-stage high-frequency hearing impairment—including extended high-frequency deficits—often struggle in such environments (6). More broadly, SIN difficulties are prevalent across the general population, affecting a significant portion of individuals regardless of their measured hearing thresholds (7).

2.3 IMPACT OF HEARING IMPAIRMENT ON QUALITY OF LIFE AND COGNITIVE ABILITY

Hearing impairment (HI), even at mild to moderate levels, can have substantial consequences for daily functioning. When left untreated, it often leads to social withdrawal, diminishing an individual's ability to maintain relationships and engage in meaningful interactions (8). HI is also associated with lower educational attainment and reduced career success, as it is independently linked to higher rates of unemployment and underemployment (9).

Beyond social and professional impacts, HI increases cognitive load due to the need to compensate for degraded auditory input. Research has identified a correlation between HI and cognitive decline, with proposed mechanisms including sensory deprivation and information degradation (10). HI is estimated to account for approximately 7% of potentially modifiable dementia cases, according to the Lancet report (11).

Furthermore, untreated HI has been associated with an increased risk of depression, as individuals frequently face communication challenges that can lead to social and familial withdrawal, as well as feelings of loneliness and isolation (12).

2.4 THE ROLE OF HEARING AIDS IN ENHANCING COMMUNICATION AND WELL-BEING

Hearing aids are advanced amplification devices designed to improve audibility and, in turn, enhance speech understanding. The use of hearing aids can mitigate the negative effects of hearing impairment by facilitating communication, improving quality of life, reducing symptoms of depression, and promoting greater social and economic participation (13). Adults with HI have reported improved overall health and enhanced social functioning following the adoption of hearing aids (14). Nevertheless, a significant number of individuals continue to avoid using hearing aids due to various barriers, limiting their ability to fully benefit from available technological solutions.

2.5 BARRIERS TO ADOPTION AND THE NEED FOR ADVANCED SOLUTIONS

Although hearing aids offer substantial benefits, adoption rates remain low. Only 14.4% of individuals with mild HI use hearing aids, and while adoption increases with severity, it still falls short of its full potential (3). Even among those who acquire hearing aids, consistent use is not guaranteed (15). Barriers to adoption include cosmetic concerns, poor fit and comfort, difficulties in managing the device, limited effectiveness in noisy environments, a lack of perceived need or benefit, and the influence of others' negative experiences with hearing aids (16). The visibility of hearing aids also contributes to stigma, as they are often culturally associated with aging and cognitive decline (17), which can deter younger individuals and first-time users.

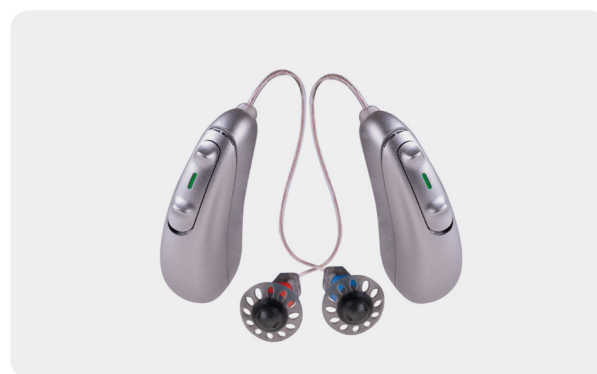


Image 2 – Traditional Form Factors of Hearing Aid

Unlike vision correction with glasses, hearing correction is limited by the physiological nature of inner ear damage, making it difficult to fully restore speech understanding in noisy environments. Research shows that limited benefit in such conditions is a major reason for hearing aid non-use, with speech-in-noise (SIN) difficulties often cited as a cause for discontinuation (18). This contributes to lower adoption among individuals with mild to moderate hearing impairment, who may continue to face communication challenges in everyday situations, including social, public, and work settings.

To meet the needs of people with mild to moderate hearing impairment, new hearing solutions must provide effective speech-in-noise (SIN) enhancement, while also ensuring comfort, ease of use, and an aesthetically acceptable design. By integrating advanced microphone arrays and optimizing signal processing, it is possible to develop hearing technologies that meaningfully improve communication in noise. This approach offers the potential to increase hearing aid adoption and improve quality of life for individuals with HI.

3. Nuance Audio™ Glasses

Nuance Audio™ Glasses are a new invisible open-ear hearing solution designed for individuals with mild to moderate hearing impairment. The product is approved for use in the European Union (CE marked) and cleared by the U.S. Food and Drug Administration (FDA). Sound is captured by an array of directional microphones located on the temples of the glasses, then processed by a digital sound processor and transmitted to the ears via open-ear speakers.

Innovative beamforming algorithms enable the listener to focus intuitively on desired sounds. The microphone array amplifies speech from the front while avoiding amplification of background noise, thus enhancing speech-in-noise (SIN) performance in complex environments. The principle “what you see is what you hear” reflects how the system prioritizes sound from the direction the user is facing.



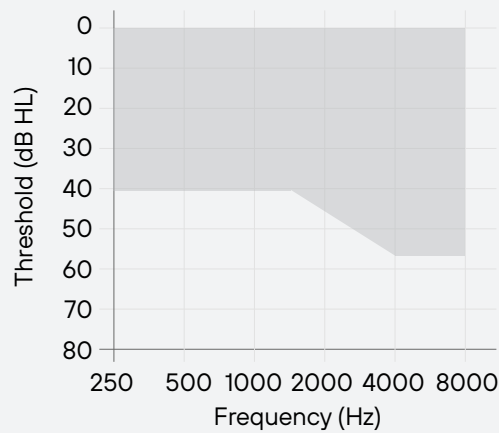
Image 3 – Nuance Audio™ Glasses

At the same time, the ears remain fully open, allowing natural sound processing through the auditory system. The lightweight, open-ear speakers provide comfort, preserve spatial hearing, and support all-day wearability.

Nuance Audio™ Glasses deliver amplification through one of four pre-configured gain settings, referred to as presets. These presets correspond to a range of typical hearing impairment profiles and are designed to meet the needs of most individuals with mild to moderate hearing impairment (up to 55 dB HL, as defined by the American Speech-Language-Hearing

Association, ASHA (19)). Amplification, volume, directionality, and noise reduction settings can be adjusted via a dedicated mobile app. In addition to app-based control, Nuance Audio™ Glasses can be operated directly from the glasses using a touch interface and volume button, or through an optional remote control.

Nuance Audio™ Glasses are designed as a pair of stylish glasses, providing a comprehensive solution addressing both vision and hearing needs in one elegant device.



Electroacoustic characteristics (ANSI S3.22:2014 & CTA 2051:2017)

Frequency Band	Standard Band Device
Frequency Response Bandwidth	200Hz - 5000Hz
Equivalent Input Noise	31,2 dB
Total Harmonic Distortion	<1%
Maximum OSPL90	110,5 dB
HFA OSPL90	100,1 dB
Maximum Full-On-Gain	20,3 dB
HFA Full-On-Gain	9,8 dB
Input Distortion at 80 dB SPL	1%
Latency	8,8 ms

Image 4 - Technical Data Sheet

4. Scientific Evidence

This section reviews the scientific evidence gathered from several research studies evaluating the performance and user experience of Nuance Audio™ Glasses. Through a combination of controlled experiments and real-world assessments, these studies examined the device's effectiveness in improving speech-in-noise comprehension, reducing listening effort, and enhancing overall quality of life.

4.1 IMPROVING SPEECH PERCEPTION IN NOISE

Understanding speech in noisy environments poses a significant challenge, particularly for individuals with HI. Assessing speech perception in noise is therefore critical for both diagnosing hearing difficulties and optimizing hearing aid performance. One widely used tool for this purpose is the Oldenburg Sentence Test (OLSA, also known as Matrix test (20)). This standardized test determines the signal-to-noise ratio (SNR) at which a listener can correctly recognize 50% of spoken words.

The test consists of five-word sentences presented against a background of steady noise. Each sentence follows a fixed syntactic structure—noun, verb, number, adjective, and object noun—such as “Peter buys five green hats.” Words are drawn randomly from a closed set, reducing predictability and supporting consistency across sessions. This design allows for repeated measurements with reliable results (21).

The Matrix Test employs an adaptive paradigm: correct responses lead to a decrease in signal

amplification, while incorrect responses trigger an increase. The test is fully automated, time-efficient, and frequently used in clinical research (22). Versions of the Matrix Test have been developed in multiple languages, enabling cross-linguistic comparisons and facilitating its use in international clinical settings (20).

A research study was conducted to evaluate the effectiveness of Nuance Audio™ Glasses in improving the SNR-50 compared to the unaided condition (23).

Forty-three adults (18 females, 25 males) with perceived mild-to-moderate hearing impairment (HI) participated in the study. Their average age was 68 years, with a range from 30 to 87 years. All participants reported difficulties in understanding speech in challenging situations, such as environments with background noise or group conversations.

Speech-in-noise performance was assessed using the Hebrew version of the Matrix Test. The test setup included three loudspeakers: the target speech was delivered from a front-facing speaker positioned one meter from the participant, while two additional speakers, located at 90° and 270° (left and right), emitted speech-shaped noise (SSN) at 65dB SPL, simulating a realistic noisy listening scenario.

Participants were evaluated in two conditions, randomized in order: unaided, and aided with Nuance Audio™ Glasses. Each participant was fitted with Nuance Audio™ Glasses, using the preset that best matched their audiometric profile. The primary outcome measure was the signal-to-noise ratio required for 50% word recognition (SNR-50), with lower values indicating better performance.

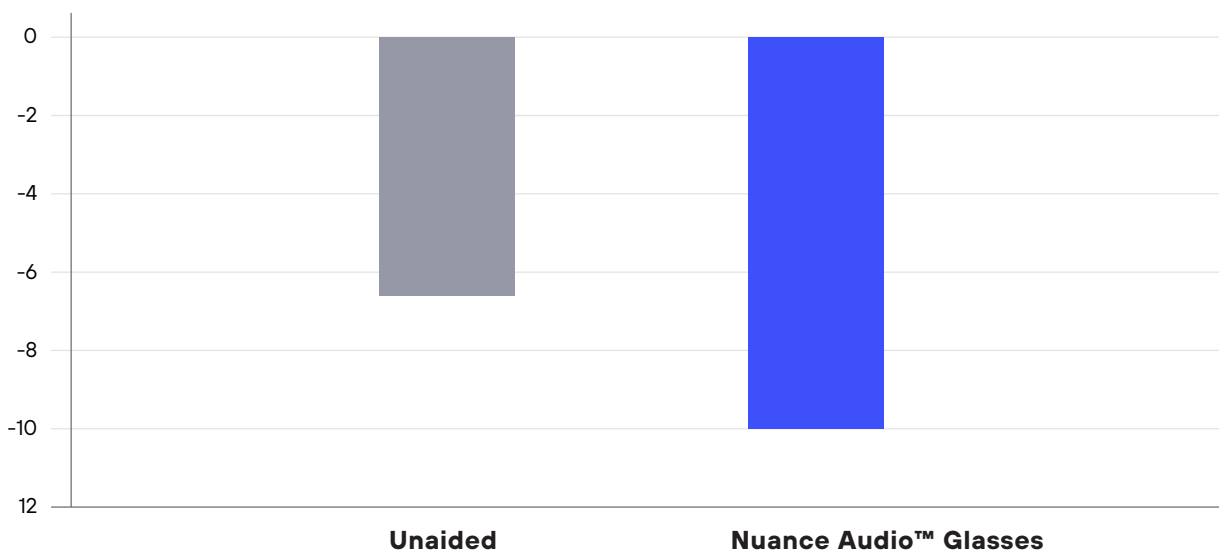


Image 5 – SNR-50 Score for the Aided vs. Unaided Matrix Test

Results showed that in the aided condition, participants were able to recognize speech in worse signal to noise ratio than in the unaided condition, indicating that Nuance Audio™ Glasses improved speech perception in noise. A paired-sample t-test revealed a significant improvement between conditions, $t(42) = 15.89$, $p < .001$, with a large effect size (Cohen's $d = 2.42$). The high statistical power (1.0) supports that the Nuance Audio™ Glasses significantly improved speech-in-noise performance in the Matrix test compared to the unaided condition.

These findings underscore the effectiveness of Nuance Audio™ Glasses in enhancing speech comprehension in noisy environments, providing improved speech clarity for the listeners.

4.2 REDUCING LISTENING EFFORT

Listening effort refers to the mental exertion required to understand spoken language (24). It relies on cognitive resources—particularly working memory and attention—and is influenced by external factors such as background noise, rapid speech, and unfamiliar accents, as well as internal factors like hearing status, fatigue, prior knowledge, and the perceived importance of the conversation (25; 26). Assessing listening effort is essential because it provides a more comprehensive understanding of auditory performance beyond accuracy and intelligibility alone. While performance metrics such as speech recognition scores are valuable, they do not capture the cognitive and mental resources required to achieve that performance. Listening effort reflects

the underlying cost of performance, offering insight into the cognitive load and fatigue experienced by the listener.

One widely used method to evaluate listening effort is subjective self-report through questionnaires. This approach provides valuable insights into perceived difficulty across various listening environments (26; 27) and is particularly useful for assessing hearing aid benefit under real-world conditions.

Forty-three participants with perceived mild to moderate hearing impairment (mean age: 67 years) participated in a research study (23). After being fitted with Nuance Audio™ Glasses at a comfortable amplification level, they engaged in a conversation with an audiologist in a simulated noisy environment featuring speech noise and music from multiple directions. During the session, participants were instructed to alternately switch Nuance Audio™ Glasses on and off. They then rated how their perceived listening effort changed using a 5-point Likert scale ranging from 1 (worse) to 5 (much better). The average rating was 4.13 out of 5. A statistical analysis yielded a t-value of 14.51 ($p < 0.001$), indicating a highly significant reduction in perceived listening effort when using Nuance Audio™ Glasses.

These findings suggest that participants experienced a noticeable reduction in listening difficulty and found it easier to follow speech when using Nuance Audio™ Glasses.

DID YOU FEEL A DIFFERENCE IN THE LISTENING EFFORT WITH NUANCE AUDIO™ GLASSES?

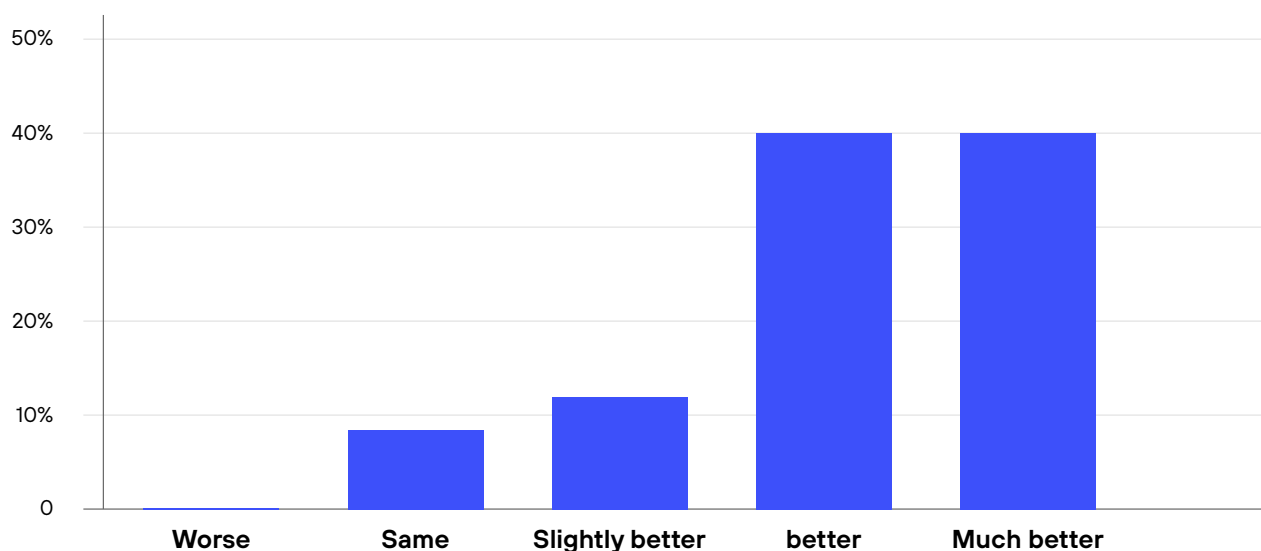


Image 6 – Listening Effort Question Responses

4.3 IMPROVING QUALITY OF LIFE

Beyond improving speech-in-noise performance and facilitating speech comprehension, it is equally important to assess the broader impact of hearing solutions on users' daily lives and overall listening experiences. The International Outcome Inventory for Hearing Aids (IOI-HA) is a widely used tool for evaluating hearing aid outcomes. It measures seven key domains: usage, benefit, residual activity limitations, satisfaction, participation restrictions, impact on others, and quality of life. Each item is rated on a five-point scale, providing a comprehensive and reliable measure of hearing aid effectiveness (28).

The IOI-HA is commonly used in both clinical and research settings to monitor hearing aid performance, compare devices, and assess user satisfaction. Research has shown that higher IOI-HA scores are associated with greater comfort, improved sound

clarity, and reduced listening effort—making it a valuable tool for evaluating the real-world success of hearing aids (28; 29; 30).

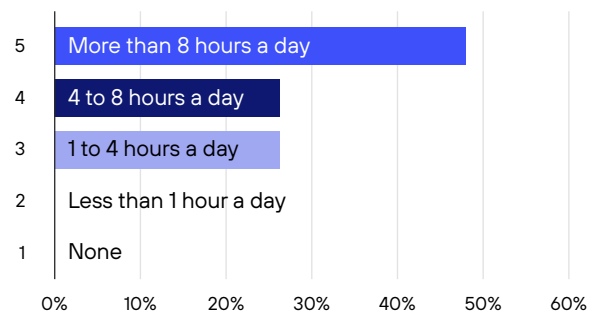
To assess the real-life benefit of Nuance Audio™ Glasses, a study was conducted with 23 adults aged 55 to 82 who with mild-to-moderate hearing impairment (31). All participants were habitual eyeglass wearers with no prior experience using hearing aids who led active social lives. Each participant replaced their regular glasses with Nuance Audio™ Glasses, individually fitted with their personal prescription lenses, and wore the device daily for 14 days.

At the conclusion of the trial, participants completed the IOI-HA questionnaire. The following graphs present their scores across the seven key areas evaluated in the questionnaire:

QUESTION 1

USE

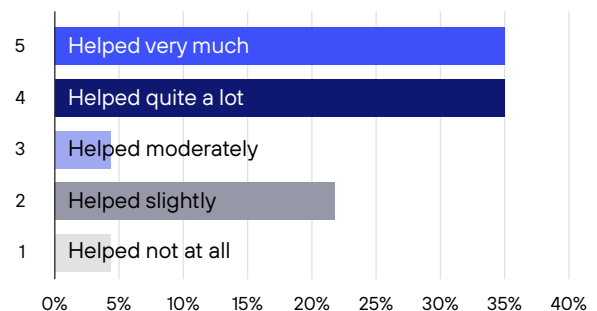
This graph illustrates the average daily usage reported by participants, indicating that the integrated, glasses-based design of Nuance Audio™ Glasses encouraged consistent use throughout the day.



QUESTION 2

BENEFIT

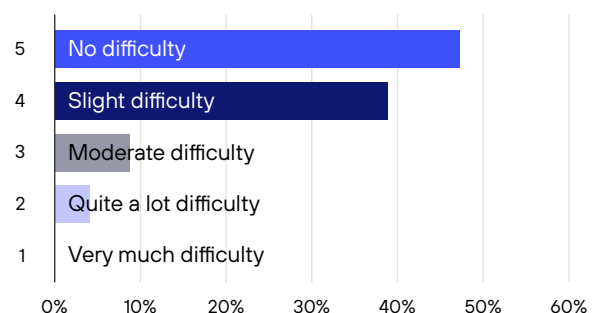
This graph illustrates participants' perceived benefit from their hearing devices, indicating that Nuance Audio™ Glasses effectively support users' daily listening needs.



QUESTION 3

RESIDUAL ACTIVITY LIMITATION

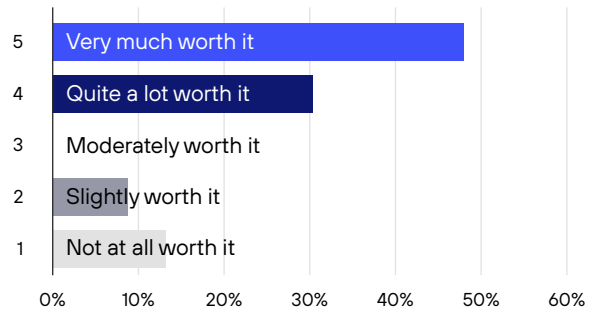
This graph represents the residual listening difficulty experienced by participants while using the device. Nuance Audio™ Glasses users reported less difficulty in listening situations with the device, suggesting improved ease of listening in everyday environments.



QUESTION 4

SATISFACTION

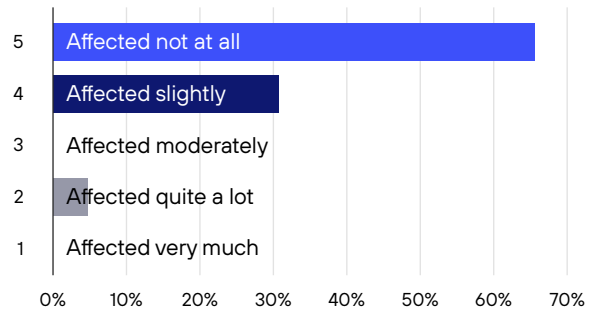
This graph reflects overall user satisfaction with their hearing devices. Nuance Audio™ Glasses users reported high satisfaction, suggesting a positive user experience and strong acceptance of the device.



QUESTION 5

RESIDUAL PARTICIPATION RESTRICTION

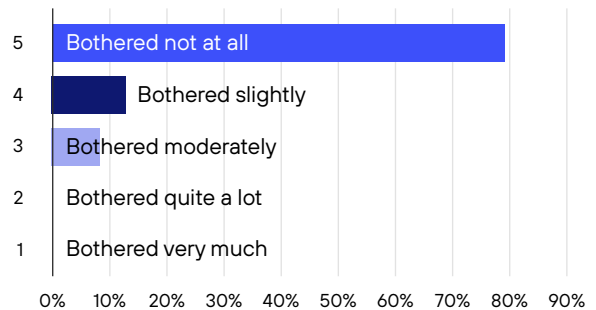
This graph shows the extent to which hearing difficulties continued to limit daily activities. Nuance Audio™ Glasses users reported fewer participation restrictions with the device, indicating improved social engagement with Nuance Audio™ Glasses.



QUESTION 6

IMPACT ON OTHERS

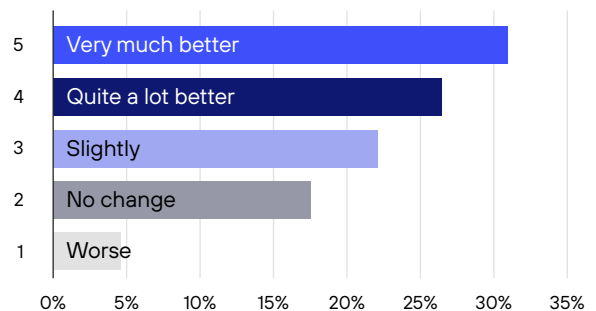
This graph illustrates the extent to which others noticed participants' hearing difficulties while they were using the device. Nuance Audio™ Glasses users reported that their residual hearing difficulties had less impact on others when they used the device.



QUESTION 7

QUALITY OF LIFE

This graph demonstrates the extent to which participants felt their hearing device improved their overall enjoyment of life. The results highlight the device's positive impact on well-being and daily life.



To summarize, these results indicate that Nuance Audio™ Glasses led to positive outcomes in the seven IOI-HA domains. These findings suggest that users experienced meaningful improvements in their daily lives, with high satisfaction, reduced listening difficulties, and greater ease in social participation..

4.4 FACILITATING USE OF HEARING ASSISTANCE

Beyond their clear audiological benefits, Nuance Audio™ Glasses help overcome one of the most persistent barriers to hearing aid adoption: social stigma. Many individuals avoid traditional hearing aids due to concerns about visibility, associations with aging, or fear of being perceived as disabled. In this section, we present testimonials from participants in our studies that illustrate how Nuance Audio™ Glasses help overcome these psychological barriers.

Nuance Audio™ Glasses offer a discreet and stylish alternative, seamlessly integrating hearing assistance into eyeglasses—an item already worn by millions daily. User feedback reflects this shift in perception: “This is interesting! It’s not a big change for me... no one would even know since I have my glasses on anyway.” Another participant expressed relief in not having to worry about visibility: “There’s nothing visible anymore, it’s in the glasses—it’s magic!” The glasses were also praised for their design and comfort: “Excellent! Beautiful! They speak of freedom, comfort, discretion—exactly what I am looking for!”

Another advantage provided by Nuance Audio™ Glasses is the comfort. Nuance Audio™ Glasses rest externally on the face, avoiding the need for anything to be placed in the ear canal. Participants appreciated the effortless experience—no manual adjustments, no invasive sensation, and nothing visibly signaling a hearing device. Its discreet and comfortable design makes hearing assistance feel seamless, approachable, and easy to incorporate into daily life.

5. Conclusion

Nuance Audio™ Glasses are an innovative invisible open-ear, glasses-integrated hearing solution for individuals with mild to moderate hearing impairment. Designed to improve speech understanding in complex listening environments, it incorporates advanced microphone arrays and beamforming algorithms that capture sounds from all directions and help the listener focus on what matters most.

The findings presented in this white paper demonstrate that Nuance Audio™ Glasses significantly improve speech comprehension in noisy environments and reduce listening effort, making conversations easier to follow. Users reported increased comfort in communication, greater participation in daily activities, and a strong sense of overall satisfaction with their listening experience.

By offering discreet and socially acceptable hearing assistance, Nuance Audio™ Glasses help eliminate the stigma and discomfort that are commonly associated with traditional hearing aids. By integrating hearing support into a familiar, visually discreet accessory that fits naturally into users’ everyday appearance, it empowers users—including first-time wearers—to embrace better hearing with confidence, while also providing vision correction when needed.

Overall, the findings suggest that Nuance Audio™ Glasses deliver both audiological improvements and psychosocial benefits, serving as a promising alternative for individuals seeking subtle, effective, and user-friendly hearing support in real-world environments.

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