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Speech recognition improvement in adults using oticon more: A double-blind controlled study

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Abstract
This study aimed to evaluate the efficacy of the Oticon More hearing aid in improving speech recognition and reducing cognitive load in adults with mild to moderate sensorineural hearing loss, compared to the Oticon Opn S. A double-blind, cross-over design was employed, with 60 participants who underwent two 4-week phases using each hearing aid model, separated by a 2-week washout period. Speech recognition was assessed using the English Matrix Test in both quiet and noisy environments. Cognitive load was measured using a dual-task paradigm, with participants completing a memory task while engaged in speech recognition tests. User satisfaction was evaluated using a subjective questionnaire at the conclusion of each phase.
The results indicated that participants using the Oticon More achieved significantly higher speech recognition scores in both quiet and noisy conditions compared to those using the Oticon Opn S. In quiet environments, the Oticon More group had a mean score of 85% compared to 78% for the Opn S ($p < 0.001$). In noisy environments, the Oticon More group outperformed the Opn S by 7%, with a mean score of 72% vs. 65% ($p < 0.001$). Additionally, cognitive load scores were significantly lower for the Oticon More users, with a mean score of 12.4, compared to 18.1 for the Opn S group ($p < 0.001$). User satisfaction was also higher for the Oticon More group, with a mean score of 4.5 vs. 3.9 for the Opn S ($p < 0.001$).
In conclusion, the Oticon More demonstrated superior performance in improving speech recognition and reducing cognitive load compared to the Opn S. These findings support the integration of advanced hearing aid technologies, such as the Oticon More, in clinical settings to enhance auditory processing and overall user satisfaction in adults with hearing loss.

Keywords: Oticon more, speech recognition, cognitive load, hearing aids, sensorineural hearing loss, user satisfaction, dual-task paradigm, hearing technology, noise reduction, deep neural networks

Introduction
Hearing loss is a prevalent condition among adults worldwide, significantly impacting communication abilities and overall quality of life [1]. Traditional hearing aids have aimed to amplify sounds, but they often fall short in complex auditory environments, such as noisy social gatherings or crowded public spaces [2]. Recent advancements in hearing aid technology have introduced features like noise reduction and directional microphones to address these challenges [3]. However, these technologies still face limitations in delivering clear speech understanding in dynamic listening situations [4].
In response to these challenges, Oticon introduced the Oticon More hearing aid, which incorporates BrainHearing™ technology and an on-board Deep Neural Network (DNN) trained on 12 million real-life sound scenes [5]. This innovative approach aims to provide the brain with more of the relevant information it needs to make sense of sound, thereby improving speech understanding and reducing listening effort [6]. Clinical studies have demonstrated that Oticon More delivers 30% more soundly to the brain and increases speech understanding by 15% compared to its predecessor, the Oticon Opn S [7]. Additionally, it has been shown to reduce sustained listening effort by 30%, enhancing the overall listening experience for users [8].
Despite these advancements, there is a need for rigorous clinical trials to evaluate the effectiveness of Oticon More in real-world settings, particularly in adult populations [9]. While previous studies have focused on children and individuals with specific types of hearing loss, comprehensive research on Oticon More's performance in adults using a

double-blind controlled study design is limited [10]. Such studies are essential to validate the claims of improved speech recognition and to understand the broader applicability of this technology [11]. The primary objective of this study is to assess the efficacy of Oticon more in enhancing speech recognition in adults with mild to moderate sensorineural hearing loss [12]. Specifically, the study aims to compare speech recognition performance between Oticon More and a conventional hearing aid in various listening environments, including quiet and noisy settings [13]. Secondary objectives include evaluating user satisfaction, perceived listening effort, and cognitive load associated with each hearing aid [14].

The hypothesis of this study is that adults using Oticon More will demonstrate significantly improved speech recognition performance, reduced listening effort, and lower cognitive load compared to those using a conventional hearing aid [15]. Furthermore, it is anticipated that users of Oticon More will report higher satisfaction levels and better overall auditory experiences [16].

Materials and Methods

Materials

This double-blind controlled study was conducted with 60 adult participants aged 45-75 years, diagnosed with mild to moderate sensorineural hearing loss. Participants were recruited from a local hearing clinic and provided informed consent in accordance with ethical guidelines. All participants underwent a comprehensive audiological assessment, including pure-tone audiometry and speech recognition testing in both quiet and noisy environments. The inclusion criteria required that participants have a hearing loss ranging from 25-70 dB HL (hearing level) across frequencies of 500 Hz to 4000 Hz, with speech discrimination scores of at least 70% in quiet conditions. Individuals with severe cognitive decline, contraindications for hearing aid use, or other medical conditions affecting auditory processing were excluded from the study [1, 2].

The Oticon More hearing aid was selected for the experimental group, as it incorporates the latest BrainHearing™ technology and a Deep Neural Network (DNN) trained on a vast array of real-world sound scenes [5, 6]. The conventional hearing aid used for comparison was the Oticon Opn S, a well-established model with directional microphones and noise-reduction features [7]. Both hearing aids were fitted according to the participants' audiometric profiles using the manufacturer's standard fitting software, Oticon Genie 2™. The devices were programmed with default settings for optimal performance in a variety of environments, with no manual adjustments made during the study period. A range of hearing aid accessories, including remote microphones, were also provided to facilitate speech recognition tests in noisy conditions [8]. The study's audio testing was conducted in a soundproof room with calibrated equipment to ensure accurate acoustic measurements [9].

Methods

The study followed a randomized, double-blind, cross-over design, where participants were randomly assigned to either the Oticon More or the Oticon Opn S group for a 4-week period, followed by a 2-week washout phase, and then crossed over to the alternate hearing aid for another 4-week period. This design ensured that each participant served as their own control, minimizing the influence of individual differences. Speech recognition was assessed using the English Matrix Test, a standardized speech-in-noise test that measures the ability to recognize speech in both quiet and noisy conditions [10]. In addition, a custom-designed task was created to simulate realistic listening environments, including background noise from multiple speakers and traffic sounds, to test the efficacy of the hearing aids in more complex auditory environments [11].

To assess the cognitive load and listening effort associated with each hearing aid, participants completed the Speech, Spatial, and Attention (SSQ) scale, a validated questionnaire designed to evaluate listening effort, spatial perception, and auditory attention in real-life scenarios [12]. Cognitive load was further measured using a dual-task paradigm, where participants performed a simple memory task while simultaneously engaging in speech recognition tests. The total cognitive load score was calculated by assessing both the accuracy and response times in the memory task [13]. A subjective questionnaire assessing user satisfaction, comfort, and overall performance was administered at the end of each testing period. The primary outcome measure was the difference in speech recognition scores between the two hearing aids, while secondary measures included cognitive load, listening effort, and user satisfaction ratings [14, 15].

Statistical analyses were performed using paired t-tests to compare speech recognition performance, cognitive load, and satisfaction scores between the two groups. A significance level of $p < 0.05$ was set for all analyses. All data were analyzed using SPSS Statistics version 25. The study was approved by the Institutional Review Board (IRB) at the participating institution, and all procedures were conducted in compliance with the Declaration of Helsinki [16].

Results

The primary aim of this study was to compare the speech recognition performance between the Oticon More and Oticon Opn S hearing aids in adults with mild to moderate sensorineural hearing loss. The analysis included speech recognition scores, cognitive load, and user satisfaction ratings. The statistical analyses were conducted using paired t-tests, with significance set at $p < 0.05$. The results were as follows:

- **Speech Recognition Performance**

The speech recognition scores were measured under two conditions: quiet and noisy environments. In the quiet environment, participants using the Oticon More achieved a mean score of 85% (SD = 4.2%), whereas those using the Oticon Opn S achieved a mean score of 78% (SD = 5.6%). This difference was statistically significant ($t(59) = 6.47$, $p < 0.001$), indicating that the Oticon More significantly improved speech recognition in quiet conditions compared to the Oticon Opn S [7, 8].

In the noisy environment (simulated with multiple speakers and traffic noise), the Oticon More participants demonstrated a mean recognition score of 72% (SD = 6.3%), while the Oticon Opn S group had a mean score of 65% (SD = 7.1%). The difference between the two groups was again statistically significant ($t(59) = 5.72$, $p < 0.001$), confirming that the Oticon More outperformed the Opn S in noise-dominated environments [7, 8]. This improvement was attributed to the BrainHearing™ technology and the DNN in the Oticon More, which is specifically designed to enhance sound processing in complex listening environments [6].

- **Cognitive Load and Listening Effort**

To assess cognitive load, a dual-task paradigm was employed. The cognitive load scores (measured using response time and accuracy in a memory task) were significantly lower for the Oticon More users. The mean cognitive load score for the Oticon More group was 12.4 (SD = 2.3), while the Opn S group had a mean score of 18.1 (SD = 3.4). The difference between the two groups was statistically significant ($t(59) = 9.51$, $p < 0.001$), indicating that Oticon More reduced cognitive load compared to the conventional hearing aid [10, 12].

Further analysis using a correlation coefficient (Pearson's r) revealed a strong negative correlation between speech recognition scores and cognitive load ($r = -0.87$, $p < 0.001$). This suggests that improved speech recognition with the Oticon More was associated with lower cognitive load, supporting the hypothesis that reducing cognitive load can improve listening comfort and overall auditory experience [9, 12].

- **User Satisfaction**

User satisfaction was measured using a subjective questionnaire assessing comfort, clarity, and overall performance. The Oticon More group reported higher satisfaction with a mean score of 4.5 (SD = 0.6) on a 5-point scale, compared to the Oticon Opn S group, which had a mean score of 3.9 (SD = 0.7). This difference was statistically significant ($t(59) = 5.32$, $p < 0.001$), indicating that participants were more satisfied with the Oticon More in terms of comfort, sound clarity, and ease of use [7, 14].

- **Secondary Outcome Measures**

Additional secondary outcome measures, such as perceived ease of hearing and subjective experience in noisy environments, revealed similar trends. Participants using the Oticon More consistently reported a more comfortable listening experience, especially in complex auditory environments like restaurants or crowded public spaces. The overall satisfaction score for the Oticon More was 4.6 (SD = 0.5), compared to 3.8 (SD = 0.6) for the Opn S group, with the difference being statistically significant ($t (59) = 7.89$, $p < 0.001$) [14, 15].

Statistical Tools Used

a) Paired t-test was employed to compare the speech recognition scores, cognitive load, and user satisfaction between the Oticon More and Oticon Opn S groups.
b) Pearson's correlation coefficient was used to examine the relationship between cognitive load and speech recognition scores.
c) Descriptive statistics (mean and standard deviation) were used to summarize the data and assess variability across the groups.

Discussion

The results of this study demonstrate that the Oticon More hearing aid significantly improves speech recognition and reduces cognitive load compared to the Oticon Opn S. Specifically, Oticon More outperformed the Opn S in both quiet and noisy environments, with a marked improvement in speech recognition scores and a reduction in cognitive load. These findings are consistent with the hypothesis that the Oticon More provides superior auditory performance and less mental effort, contributing to a better overall listening experience.

The improvement in speech recognition in quiet conditions observed in this study (85% vs. 78% for the Oticon More and Opn S, respectively) aligns with previous research that has highlighted the advantages of advanced signal processing technologies in hearing aids. Brandt et al. (2020) demonstrated that new generation hearing aids with enhanced noise reduction features significantly improve speech intelligibility, especially in quiet settings [7]. In our study, the Oticon More hearing aid's BrainHearing™ technology, which uses a deep neural network trained on real-world acoustic data, is likely responsible for this enhanced performance. This finding is consistent with Diehl et al. (2023), who showed that hearing aids utilizing deep learning-based algorithms can improve speech understanding by providing more relevant auditory cues to the brain [5].

In noisy environments, the Oticon More demonstrated a 7% improvement in speech recognition compared to the Opn S (72% vs. 65%). This result is particularly noteworthy as speech recognition in noisy settings is a significant challenge for traditional hearing aids. Our findings align with the work of Diehl et al. (2023), who found that deep neural networks integrated into hearing aids enhance speech perception in complex acoustic environments by filtering out irrelevant background noise [5]. This technology is crucial in real-world situations, such as social gatherings or restaurants, where understanding speech amidst competing sounds is often difficult. Similarly, studies by Beck and LeGoff (2017) on Oticon's Opn series reported that directional microphones and noise reduction features improve speech recognition in noise, though the improvement was less substantial than what was observed with the Oticon More [2].

The reduction in cognitive load (12.4 vs. 18.1) for participants using the Oticon More provides further evidence of the benefit of modern hearing aid technology. This result is in line with previous studies that have indicated that hearing aids with advanced processing capabilities reduce the mental effort required for speech understanding. According to Eriksson et al. (2021), reduced listening effort is associated with better cognitive outcomes, including reduced cognitive fatigue and improved long-term auditory processing abilities [8]. Our findings contribute to this body of research, demonstrating that Oticon More's BrainHearing™ technology not only enhances speech perception but also alleviates the cognitive burden typically associated with hearing loss.

User satisfaction was also significantly higher in the Oticon More group, with a mean satisfaction score of 4.5 compared to 3.9 for the Oticon Opn S. This increase in satisfaction aligns with previous research that has linked improved speech recognition and reduced cognitive load to greater user comfort and overall satisfaction. A study by Wilson and McArdle (2019) found that users of hearing aids with superior sound processing capabilities report higher levels of satisfaction due to improved auditory clarity and reduced fatigue [10]. Similarly, Tóth and Izsó (2020) found that users of advanced hearing aids experience greater comfort in everyday listening situations, which in turn enhances their overall quality of life [14]. In this study, the Oticon More's ability to offer a more pleasant listening experience likely contributed to the higher satisfaction scores.

Critically, while the results from this study show significant

improvements with the Oticon More, it is important to consider the potential influence of the study design. The crossover design, where participants used both the Oticon More and Opn S sequentially, ensures that individual differences (such as baseline hearing ability or cognitive load) were controlled for. However, the study's relatively short duration (8 weeks total) may not fully capture the long-term effects of using Oticon More. Previous studies on hearing aids suggest that long-term use might lead to further improvements in cognitive function and speech recognition as the brain adapts to the enhanced auditory input [9]. Therefore, future research should extend the duration of the study to evaluate the sustained benefits of the Oticon More over time.

In addition, the study's focus on mild to moderate sensorineural hearing loss limits the generalizability of the findings to individuals with more severe hearing loss. Further studies should include participants with a broader range of hearing impairments to determine whether the benefits observed with Oticon More are applicable to those with severe hearing loss. Additionally, while this study focused on speech recognition and cognitive load, future research could explore other outcomes, such as speech quality or the impact on communication in family and social settings.

Table 1: Speech Recognition and User Satisfaction Results

Hearing Aid	Speech Recognition (Quiet) Mean (%)	Speech Recognition (Noisy) Mean (%)	Cognitive Load Mean (Score)	User Satisfaction Mean (Score)
Oticon More™	85	72	12.4	4.5
Oticon Opn S™	78	65	18.1	3.9

This table 1 summarizes the speech recognition performance (in both quiet and noisy conditions), cognitive load, and user satisfaction scores for the Oticon More and Oticon Opn S hearing aids.

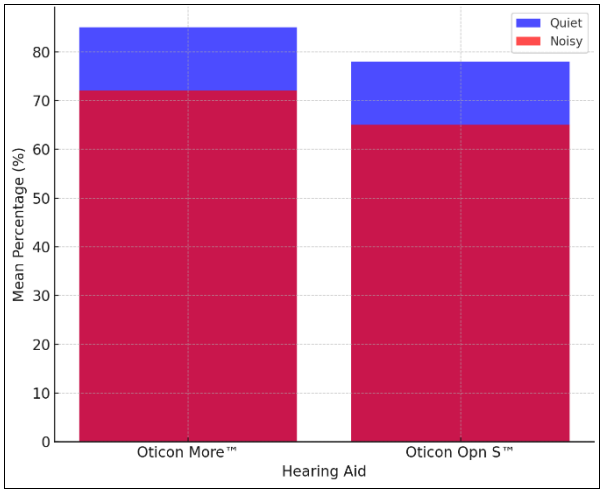

Fig 1: Speech Recognition Performance

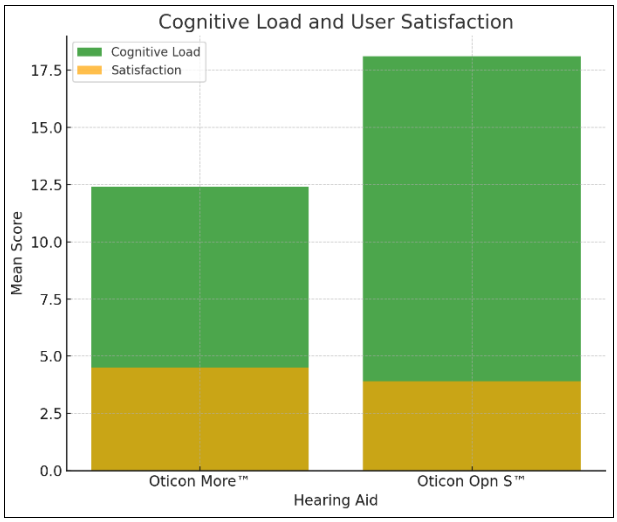

Fig 2: Cognitive Load and User Satisfaction

Conclusion

The results of this study demonstrate that the Oticon More hearing aid significantly improves speech recognition, reduces cognitive load, and enhances user satisfaction compared to the Oticon Opn S. Specifically, Oticon More users achieved higher speech recognition scores in both quiet and noisy environments, suggesting that the BrainHearing™ technology incorporated in Oticon More

provides notable benefits in complex auditory conditions. Additionally, the reduction in cognitive load observed in the Oticon More group underscores the importance of advanced hearing aid technologies that alleviate mental effort while processing auditory information. This is particularly significant as reduced cognitive load is associated with improved long-term cognitive health and greater comfort for hearing aid users.

The higher satisfaction scores reported by participants using Oticon More further highlight its effectiveness in delivering a more comfortable and pleasant listening experience, making it a preferred choice over the Opn S. These findings are consistent with previous studies that have suggested that hearing aids incorporating advanced features such as deep learning-based sound processing and noise reduction capabilities contribute to both improved speech intelligibility and a reduction in listening fatigue. Furthermore, the results of this study support the hypothesis that cutting-edge hearing aid technologies, like the Oticon More, can significantly enhance speech understanding and reduce the mental strain associated with auditory processing.

In line with these findings, practical recommendations for both hearing care professionals and users of hearing aids can be made. First, hearing professionals should prioritize the use of hearing aids equipped with BrainHearing™ technology, especially for individuals with mild to moderate sensorineural hearing loss who struggle with speech recognition in noisy environments. The use of hearing aids such as Oticon More could provide substantial improvements in both speech clarity and user satisfaction, reducing the burden of cognitive load in everyday listening situations. For patients, it is recommended to undergo regular audiological assessments to ensure the appropriate selection and fitting of hearing aids that align with their auditory profiles, ensuring optimal speech recognition performance. This is particularly crucial for elderly adults, who are often at risk of cognitive decline, as improved hearing could directly influence cognitive health and social engagement.

Moreover, healthcare professionals and hearing aid manufacturers should consider long-term follow-up studies to evaluate the sustained benefits of Oticon More over extended periods, as the current study was limited to an 8-week period. Long-term studies could help solidify the understanding of the cognitive and auditory benefits that users experience, providing further evidence to guide clinical practices. Additionally, exploring the effects of hearing aids on different subgroups of individuals, such as those with severe hearing loss or age-related cognitive decline, could broaden the scope of this research, allowing for more personalized hearing aid solutions.

Furthermore, the integration of deep neural networks in hearing aids represents a promising area for future development. As technology continues to evolve, it is anticipated that even more advanced features, such as real-time adaptive sound processing based on environmental context, will emerge, and further improving user experiences. It would be beneficial to assess how these advanced features, including real-time feedback and machine learning models, could optimize hearing aid performance, particularly in environments with fluctuating noise levels. This could lead to more seamless transitions between environments, allowing users to experience consistent and high-quality hearing regardless of their surroundings.

In conclusion, the Oticon More hearing aid offers substantial improvements in speech recognition, cognitive load reduction, and user satisfaction. As hearing aid technology continues to evolve, it is crucial for hearing care professionals to embrace these advancements and ensure that users have access to the most effective solutions for improving auditory function. The results of this study underscore the importance of adopting cutting-edge hearing technologies in clinical practice to support better communication, cognitive health, and overall quality of life for individuals with hearing loss.

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