

Assessing the Influence of Apple AirPods with Live Listen feature on Speech
Recognition and Memory Retention in Noise Levels Simulating Noisy Healthcare

Settings - Insights from QuickSIN

by

Mehdi Foroogozar

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Graduate Supervisory Committee:

Julie Liss, Chair
Visar Berisha
Xin Luo

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ABSTRACT

This study aimed to evaluate the efficacy of Apple AirPods pro (2nd generation) Live Listen feature in enhancing word recognition and memory retention among individuals with varying degrees of hearing loss, as determined by their Signal-to-Noise Ratio (SNR) loss. Utilizing a single-group experimental design, the research measured participants' performance on word recognition and memory retention tasks with and without the Live Listen feature. Statistical analysis, including paired t-tests and linear regression, revealed significant improvements in word recognition (from 81.8% to 94.4%) and memory retention (from 43.8% to 59.4%) scores when the Live Listen feature was activated. Moreover, a positive correlation between SNR loss and recognition score improvements suggested a greater benefit for those with higher levels of hearing loss. However, the relationship with memory retention improvements was less pronounced. These findings underscore the potential of the Live Listen feature as an effective assistive listening device, highlighting its importance in enhancing auditory experiences for individuals with hearing impairments and encouraging further research into personalized auditory assistance technologies in noisy healthcare environments.

DEDICATION

To my dearest mom,

This thesis not only stands as a testament to the hours of research, analysis, and academic pursuit but also as a symbol of your unwavering support, boundless love, and the sacrifices you've made to light my path. In every page written and every challenge overcome, I see the reflection of your strength, resilience, and the belief you've always had in me, even when I doubted myself.

As I present this work, it is with a heart full of gratitude that I dedicate it to you. Thank you for being my rock, my cheerleader, and my inspiration. This achievement is as much yours as it is mine, for without your love, guidance, and sacrifice, I would not be the person I am today.

With all my love and appreciation,

Mehdi

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INTRODUCTION

Noisy healthcare environments like hospitals are filled with a wide array of sounds, stemming from sources such as paging systems, patient call bells, and telephones (Lawson et al., 2010; MacKenzie & Galbrun, 2007; D. Pope, 2010). "Moreover, ongoing discussions and the frequent alarms from hospital equipment add to the elevated noise levels and intricacy of the sound landscape (Edworthy & Hellier, 2005, 2006). Various studies have established a connection between hospital noise and numerous adverse physiological effects, even at decibel levels well below those that cause hearing damage. These effects include disruptions to sleep, increases in blood pressure, heart rate, and respiration rate, weakened immune system responses, elevated levels of salivary cortisol, heightened sensitivity to esophageal acid reflux and the performance of cognitive tasks (Baker et al., 1993; Fass et al., 2008; Fife & Rappaport, 1976; Hu et al., 2010; Lusk et al., 2004; D. S. Pope et al., 2013).

Among cognitive tasks potentially affected by noise, speech recognition, and memory retention are more complex tasks that deteriorate substantially in the presence of noise, particularly in aged individuals (Pichora-Fuller, 2003; Pichora-Fuller et al., 1995).

Moreover, the higher prevalence of hearing loss in older populations further complicates communication in noisy environments (Schneider et al., 2002). These cognitive tasks are of particular importance in the hospital environment because patients often receive extensive healthcare education and instruction during hospitalization. The high levels of noise in hospitals, coupled with the critical role that speech recognition and memory play

for patient health outcomes during hospital stays, underscore the imperative to devise solutions that can mitigate this challenge (D. S. Pope et al., 2013).

The QuickSIN test is a speech-in-noise test that quickly and easily measures the ability to hear in background noise. The test is time efficient; the administration of it takes approximately 1 minute and gives a value called SNR loss. SNR loss is the increase in signal-to-noise ratio required by a hearing-impaired individual, to understand speech in noise, compared to a normal-hearing individual. It indicates how much separation is needed in speech from background noise (Killion et al., 2004).

This study seeks to explore the integration of the Live Listen feature with the noise cancellation capabilities of the AirPods Pro (2nd generation) to assess their potential as a cost-effective and accessible ALD in acoustically challenging healthcare settings.

Specifically, the research aims to (1) evaluate the efficacy of Apple AirPods in enhancing speech recognition and memory retention among patients, and (2) investigate the influence of patients' SNR loss on the observed improvements.

This project is being used as a deliverable for Travis Seideman, a medical student from the University of Arizona as well. This thesis project's focus will be mostly on investigating the influence of patients' SNR loss on the observed improvements.

LITERATURE REVIEW

Noisy healthcare environments

Noise is a specific category of sound defined as undesired auditory information perceived by individuals. It is commonly quantified using the A-weighted decibel (dB(A)) scale.

This scale measures the energy present in noise relative to the minimum level of energy detectable by the average human ear (Hsu et al., 2012). Hospitals are environments where

individuals are highly susceptible to noise exposure. From medical devices monitoring patients to conversations among nurses, patients are continuously subjected to various sounds. Research indicates that noise significantly disrupts patients' experiences during their hospital stays (Delaney et al., 2018). The World Health Organization (WHO), has issued guidelines for acceptable noise levels in hospitals(*What We Do*, n.d.). Despite these guidelines, numerous hospitals struggle to maintain noise levels within the recommended limits. Over time, noise pollution in hospitals has escalated into a growing concern (Morrison et al., 2003). Particularly within Intensive Care Units (ICUs), noise is identified as the primary source of stress for patients (Delaney et al., 2017). The World Health Organization (WHO) advises that the mean noise level in hospitals should not surpass 35 dB(A)(Padmakumar et al., 2013). The average noise level in the hospital consistently ranged between 59-60 dB(A) across various times, surpassing the advised limits (S.-M. Hsu et al., 2010). Consequently, patients are continually subjected to and impacted by noise.

Effect of noise on speech and cognitive processing

Noise leads to adverse effects on patients' processing abilities, including issues with clear communication and speech clarity. The clarity of speech is affected by how words are pronounced, the distance between the speakers, and the volume of background noise that interferes. Noisy environments reduce the ability to distinguish speech and as a result the Lombard effect prompts individuals to increase their vocal volume to compensate for the ambient noise. Yet, this elevation in volume can lead to a decrease in speech clarity, thereby diminishing speech quality. Typically, the sound pressure level is about 60 dB(A), and background noise levels of 45 dB(A) or higher can interfere with effective

communication (D. S. Pope et al., 2013). As many studies have shown, background noises in hospitals frequently exceed the 45 dB(A) amount (S.-M. Hsu et al., 2010). Research has shown that while noise can enhance performance on simple tasks, it tends to hinder the execution of more complex tasks. A study explored the impact of noise on speech recognition and memory through an experiment involving target speech stimuli. Participants listened to sentences ranging from high to low context, with high-context sentences enabling listeners to predict the final word, while low-context sentences did not offer such cues. These sentences were played against a backdrop of hospital noise at varying levels, from 59 dB(A) to 69 dB(A), as well as in quiet conditions and against white noise. The objective was for participants to recall the last word of each sentence. The findings indicated that noise adversely affects speech clarity and communication, with participants showing better word recall in quieter settings or at lower noise levels. Contextual cues in the sentences also played a role in word identification accuracy. This suggests that hospital noise complicates patients' ability to hear and process new information, impacting their health post-discharge. The study highlights the importance of context and familiarity in processing information, especially in noisy hospital environments where unfamiliar medical terminology is common, thus emphasizing the need for clear communication in healthcare settings(D. S. Pope et al., 2013).

Healthcare accessibility challenges, particularly around communication for individuals with hearing loss, are not just solvable but are also required to be addressed by legislation like the Americans with Disabilities Act (ADA) and the Patient Protection and Affordable Care Act (ACA). These statutes mandate that healthcare facilities must provide effective communication means to prevent discrimination and ensure

accommodation for patients with hearing impairments (*ADA Business Brief: Communicating with People Who Are Deaf or Hard of Hearing in Hospital Settings*, n.d.; *Barrier-Free Health Care Initiative*, n.d.).

Effectiveness of assistive listening devices and personal sound amplification products in noisy healthcare settings

Assistive Listening Devices (ALDs) are diverse types of amplification equipment designed to improve the communication of people to ensure optimal communication. ALDs are used to improve hearing ability for people in a variety of situations such as classrooms, theaters, places of worship, and airports. They permit greater autonomy, alleviate the daily grind, and improve the life quality of the individuals with hearing impairments. ALDs separate the sounds, particularly speech, that a person wants to hear from background noise and improve what is known as the ‘speech to noise ratio (SNR)’ rather than the ‘signal to noise ratio’ (Kim & Kim, 2014). ALDs can enhance sound in various public spaces like churches and theaters, as well as for personal use in activities involving telephones, small groups, or connecting to television and radio. They can also serve as basic alert systems for individuals with hearing loss, notifying them of events like someone knocking at the door or a baby crying. The technology behind ALDs ranges from straightforward wired microphone-amplifier setups to advanced systems capable of broadcasting signals. Typically, these devices capture sound through a microphone and then transmit it wirelessly using various methods, such as frequency modulation (FM), infrared, or induction loop transmissions, among others (Holmes et al., 2000).

A pilot study has demonstrated the practicality of offering personal amplifiers as a type of ALD to individuals with hearing loss in hospital settings. This approach has resulted in

marked enhancements in both the quality of healthcare communication and the satisfaction rates among patients and their inpatient nurses (Kimball et al., 2018). Additionally, other forms of accommodations, such as web or iPad-based captioning or interpreting services, including Video Remote Interpreting, have been identified as options that patients might favor under specific circumstances (Morrison et al., 2003).

Apple AirPods as ALDs

In 2014, Apple introduced a feature called Live Listen which turns the iPhone (or iPad) into a directional microphone, sending the sound directly to the AirPods (*Use Live Listen with AirPods or Beats*, 2023). The Apple AirPods Pro (2nd generation), was introduced in September 2022 with an improved noise cancellation feature that blocks outside noise, letting the users focus more on music or calls. While there's been no formal announcement, these features allow users to adjust AirPods Pro(2nd generation) like hearing devices, positioning AirPods Pro(2nd generation) as potential assistive listening devices(ALDs) in healthcare settings (*AirPods as Hearing Aids*, n.d.).

Based on the body of this research, it is hypothesized that Apple AirPods (2nd generation) can serve as a cost-effective and accessible ALD to enhance patients' speech comprehension and recall in acoustically challenging healthcare settings and the worse the patient's speech-in-noise understanding, the more significant the enhancement will be.

METHOD

Design and sample

The study design was prospective and within-subjects control was used. The study was approved by the institutional review board of Arizona State University (IRB 00018262)

on July 24, 2023 Inclusion criteria were adults (60-90+) with normal to mild/moderate hearing loss, self-reported American English as the first language, and no known cognitive dysfunction. Exclusion criteria were English as a second language (ESL) and non-removable hearing aids. Participants were recruited by advertisement, presentation at Mirabella retirement community, and word of mouth. Recruited participants were sent a link to a Google Form where they self-qualified. Once qualified, participants were scheduled and sent a consent form detailing the study and participant rights.

A total of 23 participants over the age of 60 were recruited at Arizona State University. 14 of the participants were female (61%), and 9 were male (39%). Recruitment strategies consist of both local (i.e., flyers) and online means (i.e., email invitations). Consent was received electronically from all participants prior to the beginning of the experiment.

Subjects were provided with a \$15 Amazon gift card for their participation.

Reimbursement acknowledgement was completed by all participants following the experiment.

Procedures

Pre-test assessments. A series of preliminary assessments were conducted. Participants underwent a pure tone audiometry test to assess their baseline hearing obtaining hearing thresholds at 500, 1000, 2000, and 4000 Hz bilaterally. Normal hearing was defined as pure-tone audiometry air-conduction thresholds in the test ear no poorer than 25 dB HL, averaged at 500, 1,000, 2,000, and 4,000 Hz. Mild to moderate sensorineural hearing loss was designated as pure-tone air-conduction thresholds ranging from 26 to 55 dB HL in the test ear, at the average of those same audiometric frequencies, based on a commonly used classification system. After that a 9-digit span test to assess working memory, and a

QuickSIN test to assess participant's SNR loss. Data was recorded in the Qualtrics survey created for the study and participants moved to the main assessment.

Study Setup. Regardless of condition, the participant sat in a sound-isolation booth into which noise could be delivered via speaker and from which evaluators could hear all noise. The participants were seated facing one speaker with another equidistant behind them. The sound level was modulated such that the volume delivered at the chair was 65 dB from the front speaker and 60 dB four-talker babble noise from the back, as measured by an SPL meter. In the AirPods condition, the sound delivered through the AirPods reached the participant's ear at 65 dB as measured by the iPhone, which equated to pressing the volume button 5 times starting from zero. Participants then had the sound delivered to them with (condition B) or without (condition A) AirPods in Live Listen. To change conditions the testers would enter the sound booth and an iPhone 15 Pro placed with the bottom/dock facing the front speaker around 4 inches away to emulate speech into it while the participant put on the AirPods and adjusted the airpods for best fit. Sound delivery at the proper level would be verified before beginning.

Block Pattern. The first block was always a non-Airpods trial block before which the participant was given the following instructions on the procedure. The trial block was run and any feedback needed was given before beginning the measured blocks. For the non-trial portion, sets of two blocks alternated between the two conditions (A&B) allowing for equal fatigue with every other participant starting on the opposite condition for further balancing (e.g. #1 A,A, B,B or #2 B,B,A,A). The blocks alternated four pairs of two, followed by a single block of each condition.

Block Creation and Participant Evaluation. After creating the QuickSIN block, “Condition” sentences ending in a noun were drawn from unused QuickSIN material and put into 10 blocks of five sentences. The noun served as the key word for the participant to remember and repeat. Within a block 2-3 seconds separated each sentence such that a participant had time to respond and pause before the next sentence was delivered. Eleven total blocks were created including a trial block (1 trial block, 5 blocks for the Live Listen condition and 5 blocks for without the Live Listen). Participants were instructed to attempt to repeat the final word (keyword), and after the block was finished, the participants would repeat as many words as they could recall. There would be a five-second pause after this recall period before the next block began within the same condition. The blocks were discrete within a Qualtrics survey and were manually started by a tester who would fill out the Qualtrics survey scale as to the number of keywords repeated and a separate one for those recalled. Keywords were listed on the screen to avoid tester-induced error.

DATA ANALYSIS AND RESULTS

This study aimed to investigate the integration of the Live Listen feature with the noise cancellation capabilities of the AirPods Pro (2nd generation) to assess their potential as a cost-effective and accessible ALD in acoustically challenging healthcare settings. In addition, the effect of the independent variable SNR loss on the performance benefits attributed to the Live Listen feature was analyzed. Three participants were excluded from the data analysis due to their reports of perceiving an echo during the utilization of the Live Listen feature. This auditory artifact was attributed to inadequate sealing of the ear canal by the Apple AirPods, permitting sound transmission not only through the device

but also via air conduction. Subsequent to identifying this issue, the experimental protocol was adjusted to incorporate the selection of appropriately sized ear tips for the AirPods, tailored to each participant's ear canal dimensions. This adjustment effectively mitigated the problem, ensuring accurate delivery of sound through the device alone.

Statistical Analysis of Recognition and Memory Retention

A paired t-test revealed significant improvements in both recognition and memory retention when using the Live Listen feature. The mean recognition score increased from 81.8% (20.47/25) without Live Listen to 94.4% (23.53/25) with Live Listen ($t = -6.758$, $p < 0.00001$). Similarly, the mean memory retention score improved from 43.8% (10.89/25) to 59.4% (14.74/25) ($t = -7.127$, $p < 0.00001$), suggesting a substantial positive effect of the Live Listen feature. Below are the descriptive statistics table and the box plot illustrating the impact of the Live Listen feature on recognition and memory retention scores.

Statistic	Recognition (No Live Listen) %	Recognition (Live Listen) %	Memory Retention (No Live Listen) %	Memory Retention (Live Listen) %
count	20.00	20.00	20.00	20.00
mean	81.80	94.40	43.80	59.40
std	16.84	12.41	16.54	16.53
min	24.00	52.00	12.00	24.00
25%	79.00	95.00	31.00	48.00
50%	86.00	100.00	40.00	66.00
75%	89.00	100.00	54.00	69.00
max	100.00	100.00	80.00	80.00

Table 1. The descriptive statistics for the recognition and memory retention scores (both with and without the Apple AirPods Live Listen feature), expressed as percentages

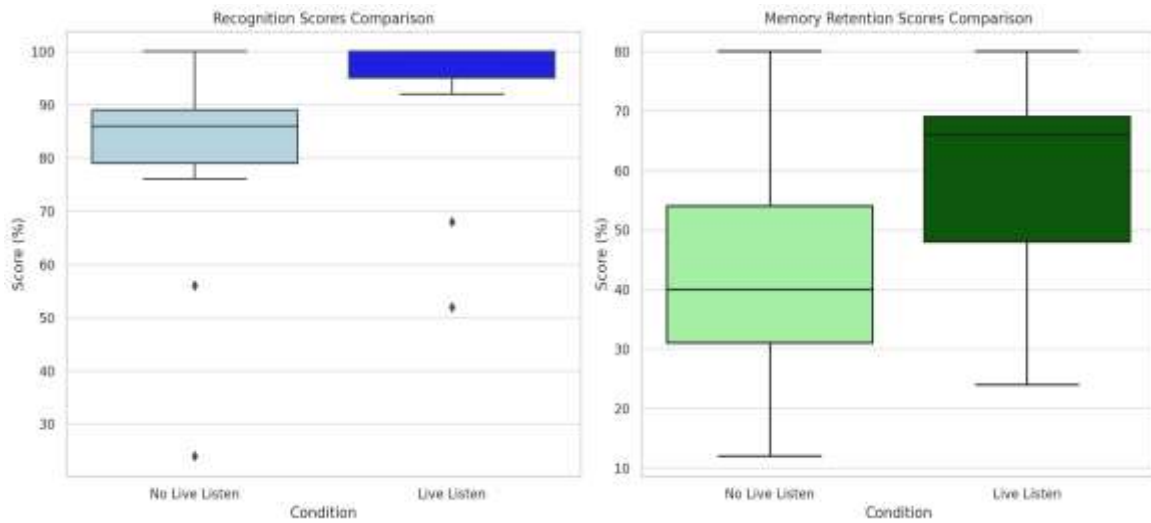


Figure 1. The impact of the Live Listen feature on recognition and memory retention scores

Regression Analysis

A simple regression analysis was conducted to explore the relationships between the independent variable SNR loss and the benefits realized from using the Live Listen feature.

Recognition Benefit. The regression model examining the impact of SNR Loss on recognition benefit (recognition with Live Listen minus recognition without Live-Listen) revealed a positive correlation. Specifically, the model estimated that for each unit increase in SNR loss is associated with a 1.095% increase in recognition score improvement due to the Live Listen feature. The model explains approximately 28.4% of the variance in recognition score improvement, indicating a moderate relationship. This positive slope indicates that individuals experiencing higher levels of SNR Loss are likely to gain more significant recognition improvements when utilizing the Live Listen feature.

Memory Benefit. Similar to the recognition benefit, the regression model for memory retention benefit (memory with Live Listen minus memory without Live-Listen) also indicated a positive relationship with SNR Loss. However, the effect size was smaller, with a coefficient of 0.055. This suggests that for each unit increase in SNR loss is associated with a 0.221% increase in memory retention score improvement due to the Live Listen feature. However, the model explains only about 0.8% of the variance in memory retention score improvement, suggesting a weak relationship.

Dependent Variable	Slope	Intercept	R-Squared
Recognition Improvement %	1.095	8.604	0.284
Memory Retention Improvement %	0.221	14.792	0.008

Table 2. Simple Linear Regression Analysis Summary Showing the Relationship Between SNR Loss and Improvement in Recognition and Memory Retention Scores Due to the Use of the Live Listen Feature.

Visualization. The regression analyses were complemented by scatter plots illustrating the relationships between SNR Loss and the respective benefits, with 95% confidence intervals providing a visual representation of the analysis's precision. These plots reinforced the positive correlations identified by the regression models, highlighting the Live Listen feature's potential to significantly aid individuals with SNR Loss in improving recognition and, to a lesser extent, memory retention.

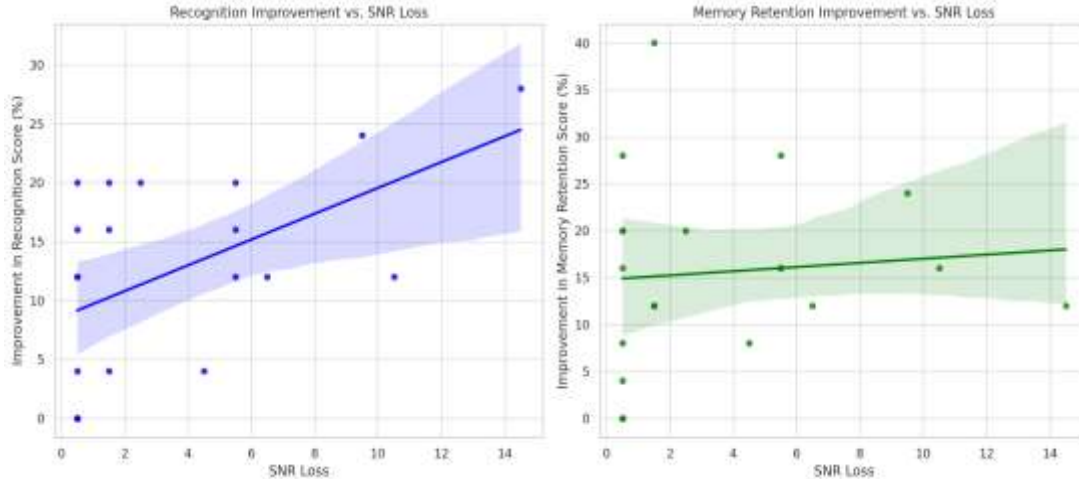


Figure 2. The impact of SNR loss on the benefits of using the Live Listen feature, with 95% confidence intervals.

DISCUSSION

This study aimed to explore the integration of the Live Listen feature with the noise cancellation capabilities of AirPods Pro (2nd generation) to assess their potential as a cost-effective and accessible Assistive Listening Device (ALD) in noise levels simulating acoustically challenging healthcare settings. The findings demonstrate significant improvements in both comprehension and memory retention among participants using the Live Listen feature, underscoring the feature's potential to enhance communication effectiveness in noisy healthcare environments.

Implications for Healthcare Communication

The results of this study have important implications for improving patient care in hospitals and other noisy healthcare settings. Enhancing speech recognition and memory retention can play a crucial role in ensuring patients accurately understand their health information and treatment plans, thereby potentially reducing readmission rates and improving health outcomes (D. S. Pope et al., 2013). The use of widely available

consumer technology, such as AirPods Pro, as an ALD presents a cost-effective solution to a pervasive problem, making it accessible to a broad population without the need for specialized equipment.

Limitations

This study has several important limitations. This study's limitations include its focus on a specific age group and hearing loss range, potentially limiting the generalizability of the findings to the broader population.

In contrast to a uniform 60 dB(A) four-talker babble noise, hospital acoustic environments are characterized by complexity and diversity of sources. These include, but are not limited to, paging systems, patient call bells, telephones, computer printers, ice machines, televisions, carts, and clipboards (Lawson et al., 2010). Research within this domain has indicated that noise levels in indoor hospital settings fluctuate significantly, registering between 37 and 88.6 dB(A) during daylight hours and ranging from 38.7 to 68.8 dB(A) throughout night times (*Environmental Noise in Hospitals: A Systematic Review - PMC*, n.d.). Therefore, utilizing a 60 dB(A) four-talker babble as a stand-in for hospital noise may lead to conclusions that do not fully encompass the potential effects of the actual, more complex, and variable, noise environment found in hospital settings.

Insufficient sample size may have played a role in the lack of significance of the association between participant's SNR loss and memory retention scores. A larger cohort could provide a more robust statistical power to detect subtle differences and associations that may not be discernible in smaller samples.

Additionally, the study's design did not account for variations in individual's familiarity with technology, which could affect the usability and effectiveness of the Live Listen feature. Future studies should consider these factors to provide a more comprehensive understanding of the potential of consumer technologies as ALDs in healthcare.

Future Research Directions

While this study provides a foundation for the use of consumer technology as ALDs in healthcare, further research is needed to explore the implementation challenges and long-term effects of such interventions. Studies could investigate the impact on patient satisfaction, recognition of more complex medical information, and the effect on healthcare provider workflows. Additionally, exploring the integration of similar technologies in other patient care settings, such as long-term care facilities and outpatient clinics, could offer insights into the versatility and scalability of these solutions. Based on the findings of this study, it is plausible to extend the potential use of the Live Listen feature as an assistive listening device to other models of AirPods, such as the AirPods Pro 1 and AirPods Pro Max. Given their advanced noise-canceling capabilities alongside the Live Listen feature, these models may offer the same benefits in improving speech recognition and memory retention for individuals. This suggests a promising avenue for further research into the use of various AirPods Pro models as personalized assistive listening technologies.

Conclusion

In conclusion, our analysis substantiates the significant benefits of the Apple AirPods Pro (2nd generation) with the Live Listen feature as an assistive listening device. Firstly, we demonstrated a notable increase in word recognition and memory retention scores with

the use of Live Listen, underscoring its effectiveness in enhancing auditory information processing. Secondly, our findings revealed a positive correlation between SNR loss and improvement in recognition scores, highlighting the particular advantage for individuals with greater hearing loss. Lastly, while the relationship between SNR loss and memory retention improvement was minimal, it emphasizes the need for further explorations. This research underscores the pivotal role of consumer technologies like AirPods Pro (2nd generation) as potential ALD improving the auditory experience for individuals, marking a significant step forward in our understanding and implementation of such tools in hearing loss management.

The positive findings of this study highlight the potential of leveraging existing consumer technology to address the challenges of noisy healthcare environments and improve patient care. As we continue to explore and integrate innovative solutions, it is crucial to prioritize accessibility, effectiveness, and the overall impact on patient care and outcomes.

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APPENDIX A
EXPERIMENT DOCUMENTS

**Conducted in a lab pertaining to
Speech and Hearing Science,
Neuroscience, and Biomedical
Engineering
Located in COOR Building**

RESEARCH PARTICIPANTS NEEDED!

**Participants will receive a \$15 Amazon gift
card.**

It will only take 1 hour of your time, *MAXIMUM!*

Candidates will be volunteering in a research study
involving measuring The Influence of Apple AirPods
LiveListen feature on information retention in Noisy
Healthcare Environments.

**Scan this QR code for
your next step!**

Contact for more information:
tseideman@arizona.edu
mforoogo@asu.edu
tkaufmann@asu.edu

**HOW CAN I
APPLY?!**



ASU ARIZONA STATE
UNIVERSITY

APPENDIX B

IRB



EXEMPTION GRANTED

Julie Liss
CHS: Health Solutions, College of
480/600-7525
JULIE.LISS@asu.edu

Dear [Julie Liss](#):

On 7/24/2023 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	The Influence of iPhone's live speech on information retention in Noisy Healthcare Environments
Investigator:	Julie Liss
IRB ID:	STUDY00018262
Funding:	Name: Arizona State University (ASU)
Grant Title:	
Grant ID:	
Documents Reviewed:	<ul style="list-style-type: none">• AirPods.pdf, Category: Recruitment Materials;• Consent_Form_iPhone's live speech feature.pdf, Category: Consent Form;• iPhone's Live Listen Feature and Information Retention - Google Forms.pdf, Category: Screening forms;• IRB Social Behavioral Protocol_final 03.03.2023 (2).docx, Category: IRB Protocol;• QuickSIN sample, Category: Technical materials/diagrams;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2)(ii) Tests, surveys, interviews, or observation (low risk), (3)(i)(B) Benign behavioral interventions (low risk) on 7/24/2023.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).



APPROVAL: MODIFICATION

[Julie Liss](#)

CHS: Health Solutions, College of
480/600-7525
JULIE.LISS@asu.edu

Dear [Julie Liss](#):

On 10/20/2023 the ASU IRB reviewed the following protocol:

Type of Review:	Modification / Update
Title:	The Influence of iPhone's live speech on information retention in Noisy Healthcare Environments
Investigator:	Julie Liss
IRB ID:	STUDY00018262
Funding:	Name: Arizona State University (ASU)
Grant Title:	None
Grant ID:	None
Documents Reviewed:	<ul style="list-style-type: none">• Consent_Form_iPhone's live speech feature.pdf, Category: Consent Form;• Digit Span Test.pdf, Category: Technical materials/diagrams;• iPhone's Live Listen Feature and Information Retention - Google Forms.pdf, Category: Screening forms;• IRB Social Behavioral Protocol_final.docx, Category: IRB Protocol;• Mirabella Recruitment Permission, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc);• Survey-live listen.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB approved the modification.