

Signia AX HandsFree and CallControl: A dream to stream

White Paper

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November 2022



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Abstract

This paper presents the outcome of a study investigating the Signia Augmented Xperience (AX) HandsFree for iOS and CallControl functionality that allows wearers to conduct hands-free phone calls. In the study, 20 participants with hearing loss and 20 with normal hearing assessed the wearer and conversation partner experience, respectively. In test calls conducted in different listening environments, wearers reported a high level of satisfaction with call quality (in quiet as well as background noise) and usability. In a listening test evaluating the call quality on the receiving conversation partner's side when communicating with a wearer situated in a noisy environment, the normal hearing participants provided high ratings for the speech clarity and ease of listening provided by Signia AX HandsFree. Additionally, in a comparison with three other hearing aid brands, which offer hands-free technology, Signia AX was rated significantly higher. The study demonstrated HandsFree and CallControl provided a highly satisfying phone experience for the wearer and conversation partner alike.

Introduction

Streaming sound directly from a smartphone to hearing aids using Bluetooth® wireless protocols has been an integral part of modern hearing aid technology for several years. The technology has allowed hearing aid wearers to stream phone calls directly into their hearing aids, resulting in better sound quality and a substantial reduction of problems with acoustic feedback and other artifacts. These problems have traditionally caused challenges and limited satisfaction when wearers are talking on the phone while wearing hearing aids (e.g. Wong et al., 2009). Signia strives to provide an optimal telephone streaming experience and has offered several streaming solutions, resulting in high levels of wearer benefit and satisfaction (e.g. Froehlich et al., 2017; Froehlich, 2019).

With the introduction of HandsFree for iOS, Signia has taken the next step to improve the phone experience for hearing aid wearers. It is now possible for wearers of Signia Augmented Xperience (AX) hearing aids to use their hearing aids as a headset and have hands-free phone calls, allowing them to conduct other activities while talking on the phone. This hands-free experience is achieved by streaming sound from the smartphone to the hearing aids, and conversely, from the hearing aids to the smartphone. By using the hearing aids' microphones to pick up the voice of the wearer, this hands-free system no longer relies on the smartphone's microphone. Thus, the smartphone no longer must be held close to the mouth of the talker.

The wearer's experience is further enhanced by CallControl, which allows the wearer to accept or reject an incoming call and end a call by simply touching the hearing aids.

In this paper, we present the results of a study conducted at the University of Northern Colorado (UNC), in which the call quality and usability of the HandsFree and CallControl features were assessed.

However, first we provide a short description of the functionality of these features.

How it works

The technology for streaming phone calls to hearing aids has been around for more than a decade. The HandsFree for iOS feature, now available in Signia AX, is based on well-known Made for iPhone (MFi) technology. Now, MFi technology has been further

developed to support streaming of sound the other way – from hearing aids to smartphone.

A key characteristic of HandsFree functionality is that it uses the hearing aid microphones to pick up the wearer’s voice. A major challenge associated with the HandsFree feature is maintaining the sound quality of the wearer’s voice as heard by the conversation partner during a call in which the wearer is situated in background noise. To optimize the sound of the wearer’s voice, Signia has implemented its state-of-the-art directionality and noise reduction technology into the Handsfree feature. One of the hearing aids is used to pick up the sound of the wearers’ voice, and the sound is optimized by pointing the directional-microphone beam in the direction of the mouth of the wearer and by applying noise reduction to the signal before streaming it to the smartphone. This approach results in a clear, high-quality phone call for both parties, even when the wearer is talking in challenging environments with background noise.

The implementation of the original streaming path – from smartphone to hearing aids – has been refined in Signia AX using two innovative approaches. First, AX split processing (Branda, 2021; Taylor & Jensen, 2022) reduces interference from ambient noise. Second, Signia AX offers different streaming gain offsets for different types of streaming. The default settings of the gain offsets have been optimized for Audio, TV, and HandsFree phone streaming, respectively, but the Hearing Care Professional (HCP) has the option to adjust all gain offsets individually and thereby accommodate the individual preferences of the wearer.

Another major addition for phone use is the CallControl option. For Signia AX hearing aids with a push button or rocker switch, the wearer can accept an incoming call by applying a short press and end or reject a call by applying a long press. For the Styletto form factor, where no button is available, calls can be accepted and ended by double-tapping either of the hearing aids. Thus, incoming calls can be handled without having to touch the smartphone at all. Together, the HandsFree and CallControl features provide exceptional wearer phone call functionality that can be tailored by the HCP to the individual needs of the wearer.

The HandsFree feature is automatically activated when the hearing aids are paired with a smartphone, but the feature can be deactivated in the iOS menu. For further details on the HandsFree and CallControl functionality in Signia AX, please see Signia (2022).

Wearers’ assessment of call quality and usability

To assess the wearer experience using HandsFree and CallControl, a study was conducted at UNC.

Methods

Twenty people with mild- to-moderate sensorineural hearing loss participated in the study. The participants (10 female, 10 male) had a mean age of 68 years (range: 23-85 years), and their average audiogram is shown in Figure 1. All participants were experienced hearing aid wearers, but they were not required to have (or use) streaming options in their own hearing aids.

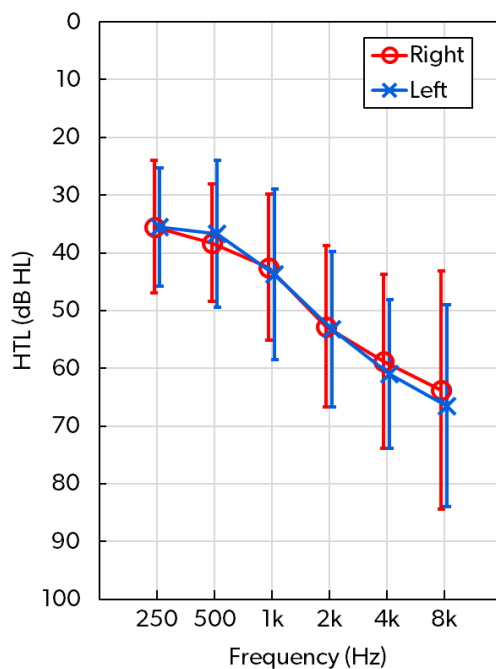


Figure 1. Mean audiogram of the 20 participants. Error bars indicate \pm one standard deviation.

Participants were asked a series of questions about their phone use with their own hearing aids. Questions were presented in a Likert-style scale to indicate usage and preferences with streaming of phone calls to their hearing aids. Participants were also asked about their preferences for using hearing aids to answer and end calls. The questions/statements follow:

- In the phone calls you make with your smartphone, how often do you use the streaming function in your hearing aids?
- I like the idea of being able to make a handsfree phone call using my hearing aids, not having to hold my smartphone while talking.
- I like the idea of being able to answer and end phone calls by pressing a button on my hearing aids, not having to touch the smartphone.
- I like the idea of being able to answer and end phone calls by tapping my hearing aids, not having to touch the smartphone.

Prior to testing, the participants were fitted bilaterally with Signia Pure Charge&Go AX (RIC) hearing aids. The proprietary First Fit rationale was used, Own Voice Processing 2.0 training was completed, and standard closed domes were used for the ear coupling. Fine-tuning of the master gain was allowed as needed, but that was not requested by any of the participants. The participants were also fitted with a set of Styletto AX (SLIM-RIC) hearing aids to allow the usability of its tapping control functionality to be assessed.

To assess the call quality offered by HandsFree in different acoustic scenarios, a simple test was established. Each participant was equipped with an iPhone 13 smartphone that was paired with their Pure hearing aids, and they were instructed on how to make an outgoing call (using the smartphone) and how to accept and end an incoming call (using CallControl).

After instructions had been completed, the wearer was seated at a desk with the smartphone in front of them. The task was then to conduct several short test calls with the test leader (situated in another room) acting as the conversation partner. The participant and the test leader took turns in calling each other. This task was designed so the participant tested making outgoing calls as well as accepting incoming calls. CallControl was always used to accept and end calls. To reduce variability in cellular service, all calls were established as Wi-Fi calls using the Facetime app, but with video deactivated on both phones.

The test calls were completed in four acoustic scenarios: 1.) Quiet, 2.) a rather quiet restaurant environment (54 dBA), 3.) a louder restaurant environment (63 dBA), and 4.) traffic noise (63 dBA). The three latter scenarios were established by playing sound samples from two loudspeakers positioned behind the participant.

After completing the test calls in each of the four scenarios, the participant was asked to answer four questions relating to the call quality in that specific environment:

- How satisfied were you with the clarity of your conversation partner's voice?
- How easy was it to understand what was being said?
- How satisfied were you with the sound of your own voice?
- How satisfied were you, all in all, with the quality of the phone call?

The participant stated the answers on a seven-point Likert-type scale, going from "very dissatisfied/difficult" to "very satisfied/easy."

When all test calls had been completed, the participant was asked to answer five questions on the usability of the HandsFree and CallControl functionality when using the Pure hearing aids:

- How easy was it to make an outgoing phone call?
- How easy was it to answer an incoming phone call?
- How easy was it to end a phone call?
- How satisfied were you with the option to answer and end phone calls by pressing a button on the hearing aid?
- How satisfied were you, all in all, with the hands-free functionality?

When the usability questions had been answered for Pure, the participants switched to the Styletto hearing aids. After instructions in the CallControl functionality using tapping had been provided, a few test calls were completed, focusing only on the usability of CallControl and not on the sound quality. The usability was assessed by allowing the participant to answer the last four of the usability questions, which were already answered for the Pure device. The first question on the ease of making an outgoing call was not asked, as this was not dependent on the hearing aid but only on the smartphone and the phone app.

Results

The ratings for the four streaming preference questions are presented in Figure 2. Ratings of phone use and streaming preferences are highly variable. This result is not surprising, since many individuals today prefer alternatives for communicating with friends and family (e.g., text messages), which are likely to influence phone use. As seen in Panel A, only half the respondents used a smartphone streaming option, while 40% reported that they did not know whether their hearing aids allowed streaming (as indicated by N/A in

the plot). It is therefore not surprising to see that for the questions related to hands-free usage (Panels B-D), only about half the total participants indicated a positive interest in the availability of hands-free phone calls and the push-button or tapping function for answering/ending phone calls.

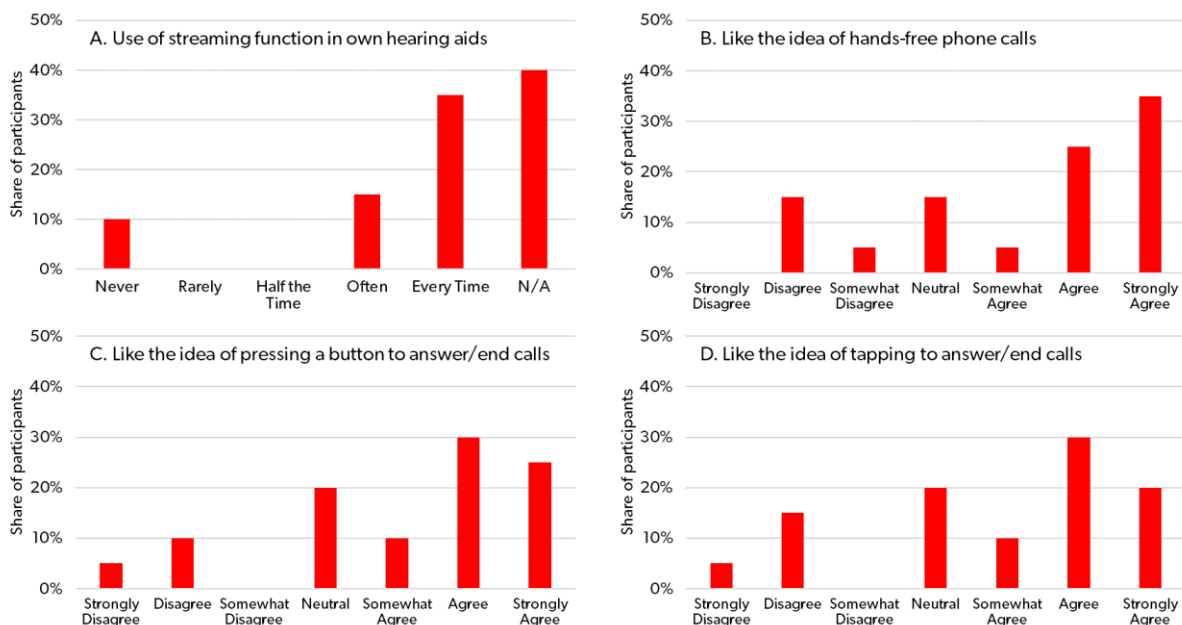


Figure 2. Distribution of ratings in the four questions about the participants' current use of phone streaming in own hearing aids (Panels A) and their attitude toward hands-free functionality (Panels B-D).

The ratings of the four call quality questions are shown in Figure 3. The four panels in the Figure show the distribution of ratings made in each of the four background scenarios.

The general trend, shown in Figure 3, indicates high levels of satisfaction for all four questions. For the three questions pertaining to speech clarity, speech understanding and overall satisfaction, all ratings were in the upper half of the rating scale (predominantly at the two highest ratings), indicating that all participants were satisfied with the sound quality when listening to the conversation partner.

For the question querying participants about their own voice, a few ratings were below the midpoint of the scale, indicating some level of dissatisfaction. A likely explanation is that all participants were fitted with closed domes and perhaps were not given ample time to get acclimated to the sound of their own voice with this new coupling system. In some cases, an open dome would have been more appropriate and perhaps would have improved the own-voice perception. However, the fact that 80%-90% of the participants expressed satisfaction with the sound of their own voices across the different sound scenarios – immediately after being fitted with new hearing aids – is quite remarkable.

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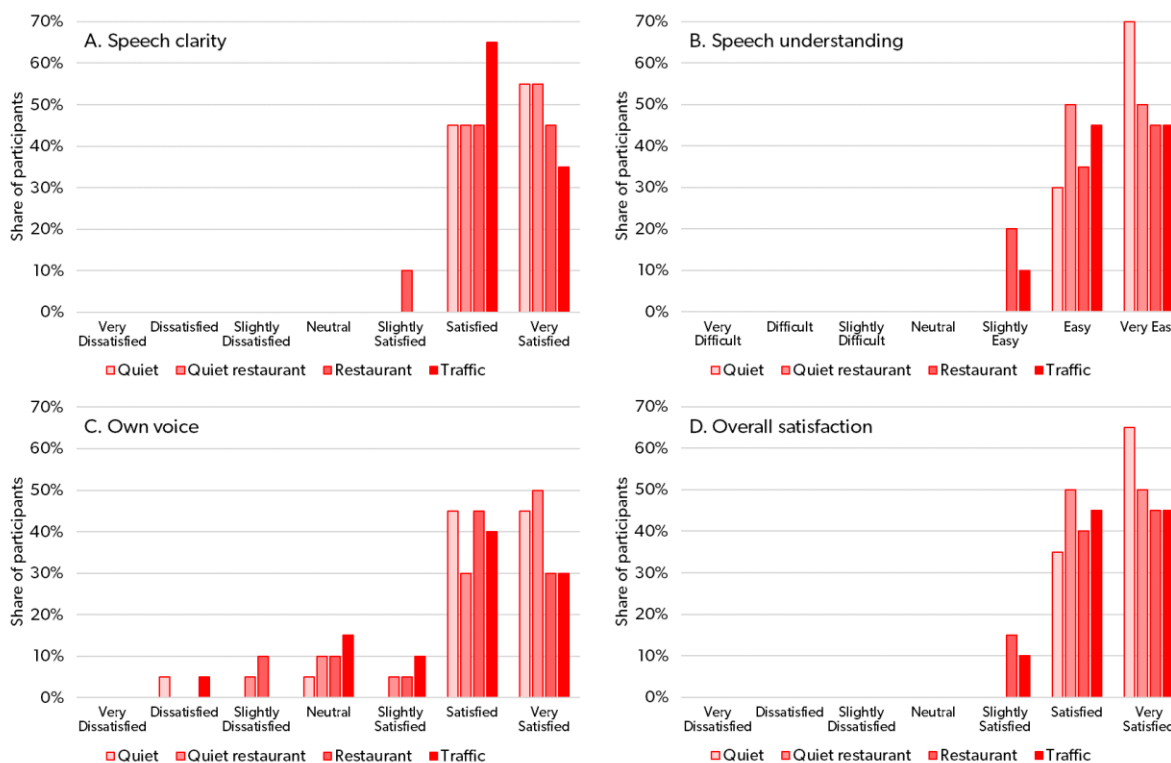


Figure 3. Call quality perceived by wearers. Distribution of the ratings in the four test scenarios (four shades of red) for each of the four call-quality-related questions (Panels A-D).

Not surprisingly, another general trend in Figure 3 is that the highest ratings are observed in the two quiet scenarios with no or soft background noise, while the number of “very satisfied” ratings drop when the background sound becomes louder in the restaurant and traffic scenarios. However, the drop is not large, and even in the noisy backgrounds, 45% of participants continue to be “very satisfied” when asked about their overall satisfaction, while 40%-45% state they are “satisfied.”

Turning to the usability questions, the first question asked was ease of making an outgoing call. Since the Bluetooth connection between smartphone and hearing aids is established automatically, it is – unless the connection fails –

the smartphone and the interface of the phone app (in this case Facetime) that drives the user experience, and thereby, the rating of this question. Results of this question were as follows: 60% reported it was “very easy,” 25% reported it was “easy” or “slightly easy,” while 15% answered “neutral.” No participants reported that it was difficult to make a call. These results suggest that no major problems occurred for the participants when making an outgoing call – even when using an unfamiliar smartphone and phone app.

The remaining four questions on usability pertained to Signia Pure C&G AX (with CallControl implemented using button control) and Signia Styletto AX (with CallControl implemented using tapping control). The distribution of ratings of the usability of HandsFree and CallControl – with each of the two form factors – are presented in Figure 4.

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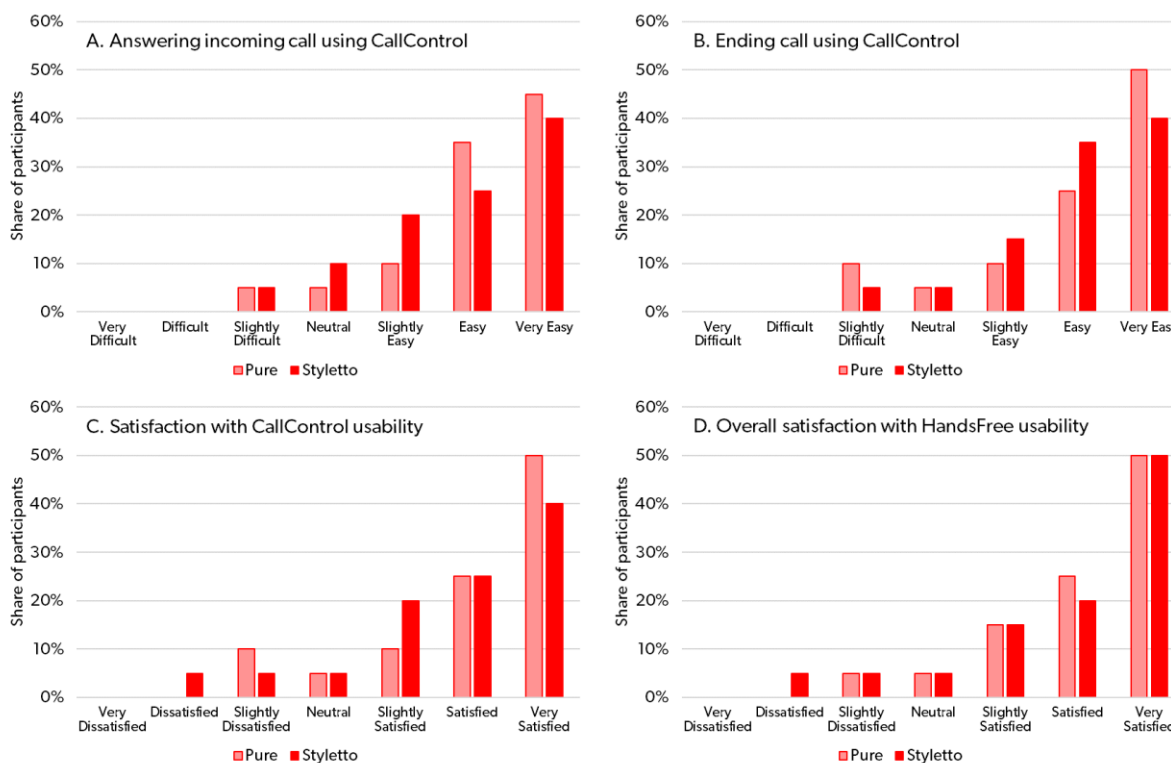


Figure 4. Usability perceived by wearers. Distribution of the ratings of the two form factors (Pure and Styletto) for each of the four questions on the usability of HandsFree and CallControl (Panels A-D).

A similar response pattern was observed for all four usability questions. The ratings were predominantly in the upper end of the scale, with the highest ratings (“very easy” and “very satisfied”) being the most frequently used, indicating that it was straightforward to accept and end phone calls, and that participants were satisfied with the CallControl and HandsFree functionality in general.

The response patterns were also quite similar for Pure and Styletto. In the first three questions (Panels A-C), the number of maximum ratings provided was slightly higher for Pure, but in the fourth question on overall satisfaction, the response patterns were almost identical, indicating that both form factors’ implementation of the HandsFree feature with CallControl offer a high level of wearer satisfaction.

Conversation partners’ assessment of call quality

In the second part of the UNC study, the experience of the person having a phone conversation with the Signia AX wearer using HandsFree for iOS in a noisy environment was assessed.

Methods

In this part of the study, 20 young people with no history of hearing loss participated. The participants (18 female, 2 male) were all graduate students in the audiology program at UNC. Since all 20 participants were audiology students, they were familiar with listening tests and the evaluation of sound quality used in this study.

The assessment of the conversation partner experience was conducted by listening to pre-recorded sound samples presented via headphones. The setup for the recordings included a pair of Signia Pure C&G AX hearing aids positioned on the ears of a KEMAR manikin. Since only recordings on the conversation partner side of the hearing aid microphone signal transmission were made, the parameter settings of the hearing aids played no role in the recordings. Speech produced by a female speaker was presented from the KEMAR mouth simulator (a loudspeaker positioned in the KEMAR mouth to simulate the sound field close the mouth created when a person is speaking). Two different acoustic scenarios were included, restaurant and traffic (similar to the sound scenarios used in wearer assessments done in the first part of the study). The two noise scenarios were created by playing sound from five loudspeakers positioned around the KEMAR manikin.

With HandsFree activated, the Signia AX hearing aids picked up and processed the sound signal and streamed it to an iPhone. Via a Facetime call using a Wi-Fi network, the phone call sound was transmitted to another iPhone, where the sound, as it would be perceived by a conversation partner, was recorded.

Along with Signia AX, recordings in the two noise scenarios were made using RIC-style hearing aids from three main competitor brands that offer the same type of hands-free functionality. Thus, the conversation partner experience was assessed for four different sets of hearing aids. The hearing aid models included were the premium models of the different brands. The brands will be referred to as Brands A, B and C, respectively.

The test procedure was fully automated and administered by a PC with a RME Fireface UC soundcard and running the SenseLabOnline test software. The participant was equipped with a set of AKG K712 Pro headphones and placed in front of a monitor. The task of the participant was to rate the perceived ease of listening and speech clarity when listening to each combination of hearing aid condition and background scenario. For each noise scenario, the participant could switch between all four hearing aid conditions and rate each hearing aid by placing a slider on a continuous 0 to 100 scale in which higher ratings indicated better performance. The two attributes were rated in separate trials, and each combination of hearing aid condition and background scenario was rated twice.

Results

All 20 normal hearing participants completed the ratings. The mean ratings observed in the two noisy scenarios are shown in the two panels in Figure 5. The results are shown for each sound attribute. The mean ratings of Signia AX are shown as red bars, while different shades of gray represent the three competitor brands.

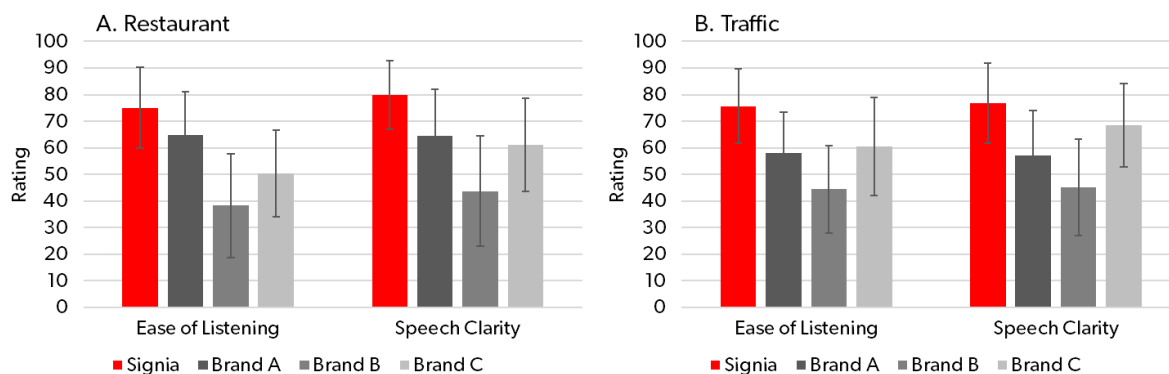


Figure 5. Call quality perceived by conversation partners. Mean ratings of ease of listening and speech clarity provided for Signia AX with HandsFree and three competitor brands (A-C) offering hands-free phone conversations. Results are shown for the restaurant scenario (Panel A) and the traffic scenario (Panel B). Error bars indicate \pm one standard deviation.

Figure 5 shows that the response patterns in noise were almost alike for the two sound attributes, ease of listening and speech clarity. For both attributes, the highest mean ratings, in both noise scenarios, were observed for Signia AX with HandsFree. All Signia AX mean ratings were 75 or higher on the 100-point scale, while none of the competitor mean ratings exceeded 70, indicating a higher call quality offered by Signia AX. Among the competitor devices, Brand B consistently received the lowest ratings across scenarios and attributes. Brand A was rated higher than Brand C in the restaurant scenario, while the opposite was the case in the traffic scenario.

The ratings were analyzed using a mixed-model ANOVA. The analysis showed a highly significant main effect of hearing aid brand ($p < .00001$), and Tukey HSD post-hoc tests showed that the mean rating of Signia AX was significantly higher than the mean ratings for all three competitor brands in both scenarios, and for both attributes (all $p < .05$). Thus, the analysis shows statistically significant benefits in call quality offered to the conversation partner by Signia AX HandsFree, compared to the hands-free solutions offered by the three competitors.

While Signia AX in the implementation of HandsFree for iOS relies on some of the same underlying MFi technology that is used in the competitor's devices, there are some unique characteristics of the Signia AX technology that explain the superior experience reported by the conversation partner. One is the directional microphone technology that is used to pick up the wearer's voice. By steering the microphone beam toward the direction of the signal of interest (i.e., the voice originating from the wearer's mouth) it is possible to maintain the vocal quality of the talker – even in the presence of background noise. The quality is further enhanced by Signia AX's advanced noise reduction technology before the signal is streamed to the smartphone. The overall result is a clear and easy-to-understand speech signal transmitted to the smartphone after it has been processed by the Signia AX hearing aids. As the results of this study demonstrate, this implementation of advanced signal processing as part of the HandsFree feature results in improved ease of phone communication for the conversation partner and the wearer.

Discussion

The results of the study indicate use of the Signia HandsFree generates high satisfaction levels in two ways. One, for the wearer, high ratings of call quality and usability were

recorded. Two, for the conversational partner, the call quality was rated significantly higher than the quality offered by three other hearing aid brands. These results demonstrate how the signal processing available in Signia AX leads to superior phone use outcomes for the wearer and conversation partner using HandsFree for iOS.

Interestingly, if one considers the initial questions about usage prior to the study, only half the participants reported using smartphones for streaming. Further, only half of the participants indicated an interest in hands-free phone capabilities. However, the quality and usage ratings suggest a more favorable attitude toward hands-free streaming. Consequently, it would not be surprising to find that improvements in connectivity, speech-in-noise management, and usability could motivate hearing aid wearers to further use streaming functionality with their hearing aids.

We speculated at the beginning of the study that the usability ratings of Styletto would be lower than the ratings of Pure because the double tapping required to activate the CallControl functions may take more practice to learn than pushing a button, as done on the Pure hearing aids. However, the brief training provided in this study was adequate for participants to handle the tapping reliably when using the Styletto. Some participants preferred Pure over Styletto, but interestingly, there were also participants who had the opposite preference. For example, a few participants with reduced sensitivity of their fingertips stated that they found the tapping for the Styletto was easier than having to find and push the button on the Pure hearing aid. This is a relevant finding, considering the relatively large number of wearers with finger dexterity issues.

While the test conditions in the study were meant to simulate use in real life, there are external conditions that may affect the performance of the HandsFree feature. The call quality, of course, depends on the quality of the wireless communication between the wearer's smartphone and the other phone involved in the conversation. This connection may be established in numerous ways, based on Wi-Fi or cellular networks of varying quality and strengths. This (sometimes very complex) connection between the two phones is not stronger than its weakest link. Thus, moving from a strong Wi-Fi network to a weak cellular connection will have a negative impact on the perceived quality. This holds true for all types of phone calls, including phone calls conducted using HandsFree.

The connection between hearing aids and the wearer's smartphone is another factor that can impact call quality. Bluetooth has a limited transmission range, and while it is possible to move around in a room and talk while the smartphone is placed on a table, it is not possible to move far away from the phone without affecting the call quality. It may also affect the call quality to place the phone in a back pocket, even though a phone conversation can still be carried out (Froehlich, 2019). Finally, the quality of the phones involved in the conversation may also affect the call quality, and in turn, the total user experience.

Summary

In a study performed at the University of Northern Colorado, the wearer's and conversation partner's experiences of phone calls using the HandsFree for iOS and CallControl features in Signia AX were assessed. The results showed:

- High levels of wearer satisfaction with call quality. All participants were satisfied with speech clarity and found it easy to understand the conversation partner – in quiet as well as in background noise.

- High levels of wearer satisfaction with usability. Eighty-five percent of participants were satisfied with the usability of CallControl (for both button and tapping control), and 90% were satisfied with the overall usability of HandsFree.
- High levels of conversation partner satisfaction with call quality. Mean ratings of speech clarity and ease of listening were above 70 (on a 100-point scale) when listening to a talker situated in a noisy background.
- Significantly higher conversation partner satisfaction with Signia AX with HandsFree than with three main competitor products with hands-free phone functionality.

In conclusion, the study demonstrated that HandsFree and CallControl in Signia AX deliver a great phone experience for the wearer and the conversation partner.

Acknowledgements

We would like to thank Diane Erdbruegger and Erinn Jimmerson, faculty at UNC, who assisted in recruiting the participants, fitting the test hearing aids, and running the experiments. Furthermore, we would like to thank all the participants for their efforts.

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