JOURNAL OF COMMUNICATION DISORDERS AND ASSISTIVE TECHNOLOGY

Aster Publications Research ISSN: 2576-3997

The Effect of Voice Gender and Spoken Messages in Augmented Interactions

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Received: Sep 18, 2017; Accepted: July 31, 2018; Published: Aug 03, 2018

Competing interests: The authors have declared that no competing interests exist.

Cite as: Lapham K, Seale J. The Effect of Voice Gender and Spoken Messages in Augmented Interactions. J Commun Disorder Assist Technol. 2018;2:1-13.

ABSTRACT

A speech-generating device is often implemented to aid communication for those with limited ability to produce mouth speech. Although these devices have come a long way since their initial development, there are still pervasive problems regarding augmentative and alternative communication (AAC) technology. These problems include communication rate, intelligibility of the synthesized voice, and the effectiveness of the synthesized speech to transfer information for a variety of interactions. Additionally, the device is responsible for portraying unique information about the augmented speaker, including their competence, individuality and identity. This study investigated the impact of computer-generated voice output in routine social interactions. Using an AAC application and an iPad, the primary investigator approached 6 novel communication partners under 3 speech output conditions: female, male, and speech-off. Findings suggest a minimal effect on gendered speech output. Interestingly, results indicate that the speech-off condition may be more efficient for information seeking interactions. More research is needed on synthesized voices to address these issues and determine future directions for AAC technology. .

Key Words: Augmentative and Alternative Communication

INTRODUCTION

Over 4 million Americans have complex communication needs and can benefit from the use of augmentative and/or alternative communication (AAC) [1]. Technological advancements have produced communication aids that are increasingly more customizable in terms of voice selection, speech generating features, and vocabulary [2]. Additionally, mobile applications that facilitate communication as an alternative to specialized devices have become more available, often at lower cost and smaller size in comparison to specialized AAC devices [2,3]. Communication apps are becoming increasingly available for use on iPads and smartphones, making widely used, multi-purpose devices viable options for AAC solutions.

Despite advancing technology, problems surrounding AAC devices continue to persist. Specifically, its availability, and usability in the AAC community [2,4]. Problems commonly discussed are related to the message presentation affordances offered by AAC devices. Individuals who use AAC have suggested that communication rate, intelligibility, and lack of personalization of synthesized voices are problematic when interacting in face-to-face contexts [1,2,5,6]. Interestingly, message length and observer background has also been shown to influence perceptions of AAC users' social competence [8,9].

Augmented speakers also report other's perceptions of them change in the presence/absence of AAC use for communication. Oftentimes, potential communication partners perceive an AAC user to possess more independence when a communication device is present. Although the physical presence of AAC changes communication partner perceptions, AAC users suggest that the software has room for improvement to achieve the goal of supporting communication in typical interaction settings [5].

One pervasive and well-documented problem that contributes to perceived competence in augmented interactions is that of communication rate. It often takes more time to compose messages externally, on an AAC device in comparison to mouth speech [1,9,10]. Mouth speaker speech rates can range from 150 to 250 words per minute (WPM), while augmented communication ranges 15 to 25 times slower (i.e., 2-25 WPM) [1,10]. This slow communication rate influences the perception and comprehension of the synthesized speech in part due to processing demands, which are greater for synthesized speech in comparison to mouth speech [11]. Increased processing demands and slow rate of speech sometimes leads to communication breakdowns, which influences the perception of the augmented speaker [4,6,10].

As an AAC user, Colin Portnuff referred to email as "the great leveler" in the communication arena. The rate of typing during e-mail is of little concern because it is composed on the speaker's own time [5]. In addition, elements that often contribute information during face-to-face interactions such as mutual gaze, body positioning, and gesture, are no longer at play when communication is via email [12]. Continued research on the impact of text-based communication in various interaction contexts is needed to explore how email communication affects augmented speakers.

In addition to communication rate, message relevance also contributes to perceived AAC user competence. Using pre-stored messages is often a strategy employed by augmented speakers to reduce the communication rate gap [1]. However, there are trade-offs if the saved messages do not exactly match the interaction at hand [13].

Results from Bedrosian and colleagues' [9,10] study, showed a mouth speaker preference for augmented speakers using a slowly delivered message with a conversational floor holder. In natural interactions, it may benefit the augmented speaker to use a combination of both pre-stored and generative messages. The current investigation will utilize this combination strategy in a structured task that reflects a common everyday interaction. preference for augmented speakers using a slowly delivered message with a conversational floor holder. In natural interactions, it may benefit the augmented speaker to use a combination of both pre-stored and generative messages. The current investigation will utilize this combination strategy in a structured task that reflects a common everyday interaction.

Intelligibility

The research suggests that mouth speech is only slightly more intelligible than synthesized speech. Intelligibility of AAC devices is comparable to mouth speech in quiet environments, but noisy and/or distracting environments lead to the decreased intelligibility of synthesized speech [4,11,14]. In noisy environments, it may be beneficial for augmented speakers to forgo the use of the voice function and share information through text messages displayed on their device display screen. This strategy would also circumvent the perceptions that result from intelligibility of synthesized speech. Additionally, text-based information exchange may reduce the need for repetition of an uncomprehended message [5,15].

Offering contextualized information is another strategy that may increase comprehension of synthesized speech [16]. Research shows that establishing context may make up for the processing demands of synthesized speech and would require fewer resources to comprehend the message. Context builds throughout an information-seeking interaction, as each communicative contribution prepares the communication partner for understanding content provided in later contributions [13,16-19]. As context builds, the need for additional resources decreases (i.e., processing, attention) and ultimately increases intelligibility [16].

Many AAC users work around user attention demands by storing frequently used messages on their devices. Pre-stored phrases allow the AAC user to produce utterances at a faster rate and maintain eye contact. When pre-stored messages are not relevant, feedback offered in the form of audible beeps while the AAC user types a generative message could indicate to the communication partner that a message is being constructed. After the AAC user has shared their message, they may resume eye contact in order to signal communication turns and better prepare the communication partner to receive a message.

Identity & Voice

The issue of identity and individuality is another area that has received more attention in recent years and continues to require more research [20]. Synthesized speech has been reported to lack "naturalness" when compared with mouth speech, and is devoid of individual variations in voice quality, tone, volume and emotional prosody [4,5,21,22]. Oftentimes, a classroom with multiple students who use AAC devices use the same adult synthesized voice [20,21]. This mismatch may limit the adoption of the device as an extension of the individual, both by the

user and communication partners. Although there are more options for voice selection than in the past, the vast majority of synthesized voices are not representative of the user's individual vocal qualities or personality [21]. Limited research has been done to determine how vocal qualities impact communication.

Anecdotal evidence suggests the gender of the synthesized speech may affect intelligibility. In some instances, AAC devices were found to be more intelligible when using the male voice rather than female or child voice. Many people develop a hearing loss in the higher frequencies as they age [23]. Women's voices are typically a higher frequency than male voices, leading to a decreased ability to understand female speech in comparison to male speech in the case of a hearing loss. In situations where an AAC user will be frequently communicating with a person with even a mild hearing loss, a male voice may suit their needs better even if they are female [5,24].

SUMMARY

The development of synthesized speech has a long way to go in emulating mouth speech. Adjusting communication rate to resemble mouth speech may be difficult or impossible when communicating through a computer. However, voice quality is a solvable obstacle that could lower processing demands, enhance comprehension and offer AAC users a greater sense of individuality through their AAC device. Presentation style, both in terms of message formatting and voice selection, should be studied to determine which styles are most successful in various situations. AAC users, practitioners, and product developers should be aware of strategies that have been successful such as using a conversational floor holder or combining prestored and generative messages. This investigation seeks to contribute to efforts aimed at understanding the impact of manipulating computer-generated voice output features in routine social interactions. Specifically, this project aims to address the following questions:

1. To what extent does interaction duration, message repetition, or repair frequency change relative to the gender of the voice output, and/or absence of speech output, during an interaction between an augmented speaker and a library clerk?

2. To what extent do library clerk's perceptions of interaction success and augmented speaker's performance change relative to gendered voice output or speech-off conditions?

METHODS

To address the previous questions, structured interactions involving the primary participant acting as an augmented speaker were analyzed. The independent variables in this study included three voice conditions: female speech output, male speech output, and speech off. The dependent variables included: duration of interaction, augmented speaker contributions, need for repetitions, whether partner's read off the iPad screen, abandoned utterances and perceptual data collected from survey results. Each independent variable was tested two separate times during scripted interactions with novel communication partners. Data was collected throughout the interaction using screen-recording technology; following the interaction participants completed a survey.

Participants

The primary investigator was the main participant, who represented herself as a student who used AAC and was

seeking information for a research project. In this role, the primary investigator communicated as an augmented speaker, using only the AAC device to request information. When the interaction was complete, the primary investigator returned to her natural communication modality as a mouth speaker to debrief communication partners and collect survey data.

Communication partners in this study were information desk clerks in three public libraries. For the purposes of this study, partner's age, gender and familiarity with AAC was not recorded. No interaction data was recorded for communication partners (i.e., number of turn contributions), but they did offer perceptual ratings of their experiences interacting with AAC technology. Data analyzed in this study was collected from six interactions with seven different communication partners; one interaction involved two desk clerks. Hearing and vision of the information desk clerks were judged to be functional for conversational speech in quiet environments.

MATERIALS

Data for this analysis were collected through a structured communication task with unfamiliar communication partners using an iPad Pro with Predictable Speech application (version 5.0.3) and attached Logitech case which provided access via keyboard input. The augmented speaker used the Predictable Speech application, and implemented two pre-stored phrases. When pre-stored phrases were exhausted, she used the keyboard to generate the unprepared, or novel, responses.

A Likert scale survey was adapted from the surveys used by Bedrosian and colleagues [8,9] to collect follow-up data after the interaction. The survey aimed to evaluate the communication partner's assessment of the interaction. Questions prompted responses about computerized voice quality, the speed of communication, voice volume, font size, and the success of the interaction overall (Table 1).

Procedure

In order to prepare for the experimental interactions, the primary investigator practiced communicating via AAC in private (5 hours) and public settings several times (i.e., 3-5 different times) prior to the study. Operational proficiency was gained through four weeks (6-8 cumulative hours) of practice with different device settings both at home and in public settings.

Prior to data collection, the primary investigator entered the library and connected to Wi-Fi in order to access the screen capturing application (AirShou). Additionally, the speech output condition (male/female, or speech-off) was selected, and the volume was adjusted to an appropriate level. Next, recording the iPad display was initiated with the screen capturing application. In the role of augmented speaker, the primary investigator approached an information desk clerk. The interaction was initiated by the primary investigator issuing two pre-stored messages; one introducing the device and requesting assistance, the second specifying the assistance needed. If the conversation about the desired book required less than three contributions from the augmented speaker, additional questions were asked such as, additional assistance in finding related research articles, and/or clarifying the library's

	Strongly Disagree	Disagree	Slightly Disagree	Neither Agree nor Disagree	Slightly Agree	Agree	Strongly Agree
Katrina expressed herself today	1	2	3	4	5	6	7
Katrina was easy to understand	1	2	3	4	5	6	7
The speed of communication was just right(Neither too fast nor too slow)	1	2	3	4	5	6	7
Katrina's computer voice was easy to hear	1	2	3	4	5	6	7
Katrina's text/font size was easy to read	1	2	3	4	5	6	7
	Strongly Disagree	**Disagree**	**Slightly Disagree**	**Neither Agree nor Disagree**	**Slightly Agree**	**Agree**	**Strongly Agree**
Katrina was succesful in getting her point across	1	2	3	4	5	6	7
The way katrina communicated resulted in some misunderstandings; I needed her to clarify her message	1	2	3	4	5	6	7
Katrina was very easy to talk to	1	2	3	4	5	6	7

Table 1: A survey distributed to participants following the interaction

business hours. After the interaction was complete, the primary investigator "broke character," and debriefed the communication partner. The investigator requested that the participants complete the Likert scale survey; survey data was obtained from 6 of 6 experimental sessions.

The entire experimental session, beginning with entering the library and ending with the survey collection, averaged 5-7 minutes per session. Immediately following the experimental session, screen recordings were exported from the application to the iPad photo album, and subsequently downloaded to a laboratory computer for transcription and further analysis.

Data Analysis

The analysis consisted of the number of turns the AAC user took in the typical interaction, the repairs or repetitions provided, and the duration of the interaction; recording and transcription of the responses from the communication partner was beyond the scope of this investigation.

The screen capturing software recorded interaction time and augmented speaker contributions; abandoned utterances were deduced from the message displayed on the iPad screen. The video recordings were transcribed to examine the number of turn exchanges, generative phrases, and abandoned utterances. Survey results were analyzed to determine if gendered output or text-only communication influenced partner's perceptions of: intelligibility, speech rate, text size, and overall success of the interaction. Raw counts of participant ratings for the individual questions obtained from the survey data were analyzed.

Interaction duration was determined as the time from which the primary participant approached the information desk clerk to when the primary investigator broke "character." Augmented speaker contributions were recorded as the number of times the augmented speaker shared a message. Abandoned utterances were not counted towards this total. For the purpose of this study, an abandoned utterance symbolized an instance when the augmented speaker would write a message, and then choose not to share the message with the communication partner. These objective measures were visually inspected for differences across conditions.

RESULTS

Results recorded from the structured interactions are reported in Figure 1, Table 2, and Table 3. Variables reported in this investigation include: interaction time, augmented speaker contributions, repetitions, abandoned utterances, and survey responses. Due to the small sample size, results reported below reflect observations from inspection of raw data; no statistical analyses were performed.

The recorded interaction duration averaged three minutes across conditions. Interactions were longest with the female voice with an average of 215.5 seconds (3.6 minutes) (Figure 1). The second longest interaction time was the male condition with an average interaction time of 187 seconds (3.1 minutes). Shortest was the speech off condition with an average interaction time of 170.5 seconds (2.8 minutes).

The number of contributions from the augmented speaker revealed that the male and female voice conditions averaged the most contributions (6 and 5.5, respectively). The speech off condition had the fewest amount at an average of 5 (Table 2). Repetition did not occur in any of the structured interactions, and communication partners appeared to read the screen regardless of the voice condition.

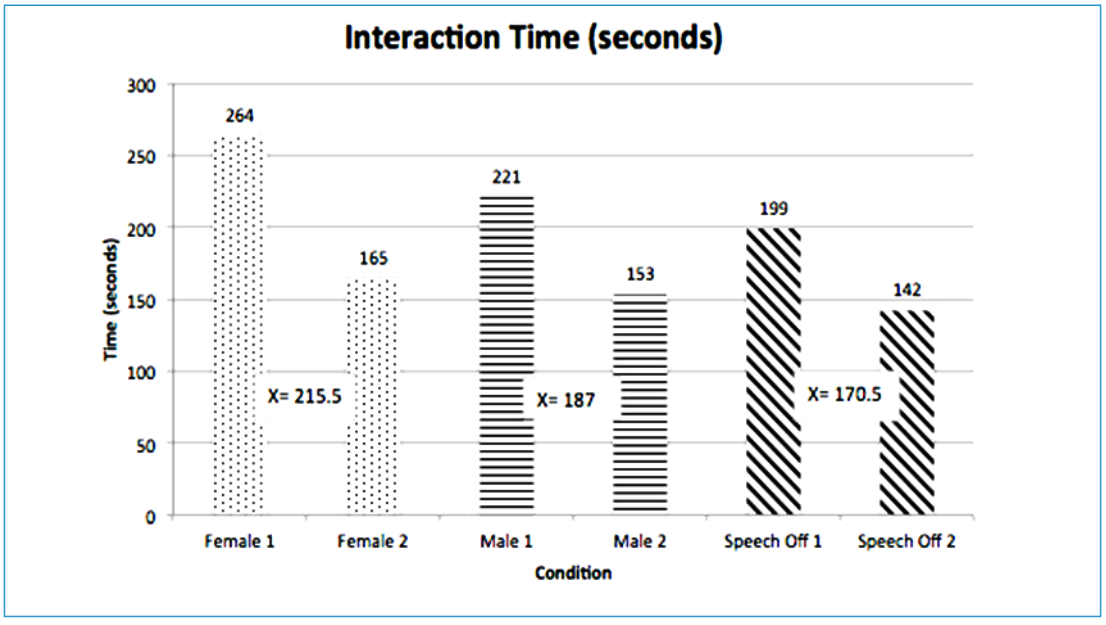

Figure 1: Percentage of Independent Responses across Baseline and Intervention for Henry

Abandoned utterances occurred just 3 times across all experimental sessions. This primarily took place when the communication partner changed the subject, answered the partially typed question or the communication partner walked away, unaware that there was an impending message. Two abandoned utterances occurred in the male speech output condition, and the only other abandoned utterance occurred in the speech off condition. Interestingly, the female conditions did not have any abandoned utterances.

Condition	Total contributions	Augmented Speaker Generative Contributions
Female 1	5	3
Female 1	6	4
Male 1	6	4
Male 2	6	4
Speech Off 1	5	3
Speech Off 2	5	3

Table 2: The frequency of contributions, including the novel messages produced by the augmented speaker across conditions.

While just six interactions were officially recorded for interaction analysis, survey data included eight total respondents. The additional surveys resulted from multiple desk clerks participating in one structured interaction. For example, during one interaction two desk clerks participated in the interaction and both filled out the Likert scale survey. In a different exchange, technological issues led to a survey being collected without the accompanying video. This data collection session had to be repeated at a later date in order to collect quantitative data for the specific condition.

	Strongly Disagree	Disagree	Slightly Disagree	Neither Agree nor Disagree	Slightly Agree	Agree	Strongly Agree
Katrina expressed herself clearly						2	6
Katrina was easy to understand						2	6
The speed of communication was just right(Neither too fast nor too slow)					1	4	3
Katrina's computer voice was easy to hear						2	7
Katrina's text/font size was easy to read						3	7
Katrina was succesful in getting her point across							7
The way katrina communicated resulted in some misunderstandings; I needed her to clarify her message	4	1		1			7
Katrina was very easy to talk to					1	1	6

Table 3: Survey response data

Qualitative information was retained from all interactions in an effort to collect data that was representative of partner's perceptions of the primary investigator as an augmented speaker.

The results of the survey were favorable across conditions. Partner ratings for each of the questions ranged from slightly agree to strongly agree (Table 3). Participants indicated minimal misunderstanding as a result of AAC use, and 100% "strongly agreed" that the augmented speaker was a successful communicator. In addition, participants indicated that the speed of communication was neither too fast nor too slow, that the voice was easy to hear, and that the text/font size was easy to read (Table 3).

Summary of Results

The speech off condition resulted in the least amount of interaction time and included the fewest augmented speaker contributions. The male and female conditions involved the most augmented speaker contributions and longest interactions. The female voice interaction took 45 seconds longer than the speech-off condition, and nearly 30 seconds longer than the male condition. Minimal differences were observed in the interaction times and augmented speaker contributions. No repetitions or repairs occurred in any of the interactions. Communication partners appeared to read off the iPad screen regardless of speech conditions. All participants indicated they had positive experiences with and perceptions of the primary participant as an augmented speaker.

DISCUSSION

Augmentative and alternative communication (AAC) is designed and implemented with the goal of supporting individuals with communication impairments to communicate effectively and efficiently. The relatively consistent interaction times and a number of augmented speaker contributions indicates an effective communicative exchange between the primary participant and communication partners across all conditions. The absence of repetitions and repairs further strengthens that AAC was a successful method of communication for the study's interaction setting. In addition to the objective results, favorable survey results confirm that the AAC methods used in the structured interaction context of asking for library assistance were successful.

The speech-off function in the current study was arguably the most efficient because of its short interaction duration and low contribution count. This may have been because background noise is not a factor when the communication partner is reading the text rather than listening to the synthesized voice.Perhaps processing demands for synthesized speech are greater in comparison to reading the screen. Regardless, findings may suggest partner is reading the screen rather than listening to the synthesized voice. . This may be especially true during information seeking interactions where the communication partner can read the sought after material from the AAC device screen. Other examples of informational exchanges may include restaurant settings, business transactions or medical related discussions, where the focus is on the efficient exchange of information rather than the personality of the AAC user. Additional study is warranted to determine if voice customizability may be less important or even exchanged for a text-only communication method in these types of information based interactions.

Communication rate differences or intelligibility issues were not identified by the communication partner, as indicated by the survey results. The lack of variation in augmented speaker contributions across conditions further suggests that rate/intelligibility differences were not noteworthy. The strategy of beginning the interaction using two pre-stored messages may have contributed to this rate finding. In addition, information-seeking interactions have more structure than interactions for sociability purposes because the quest for information makes it easier to determine the end of the conversation [1,8,9]. Because there was an end goal to the interaction, the communication partner knew to expect a message until they answered the requests of the AAC user. The narrow context of the current study may also explain the consistent survey results describing the intelligibility of the synthesized voice, along with the lack of requests for repetitions. As the context of the interaction increased, the communication partner was prepared for later contributions from the augmented speaker. These results replicate previous findings that context enhances intelligibility and comprehension.

There were no results that directly suggested different intelligibility levels between gendered voices, despite previous research that suggested female speech might be slightly less intelligible than male speech [5,24]. Slightly longer interaction times and an increase in augmented speaker contributions observed in the female voice condition may have indicated decreased intelligibility, but are not significant enough to definitively attribute these differences to intelligibility problems. In addition to adequate participant hearing abilities and highly contextualized information, the fact that communication partners read off the iPad screen contributed to their understanding of the message.

Finally, the current study also involved a high-quality voice that enhanced intelligibility. If the structured interactions were completed with a lower quality voice there may have been more difficulties with intelligibility. More recent synthesized voices have increased intelligibility and sound less robotic than older models [4]. Although intelligibility has increased, continued efforts to improve vocal quality to portray emotional content and personal identity are needed.

Identity with the synthesized voice did not appear to be an issue during this study. Interestingly, the communication partners did not indicate problems when the female primary participant communicated using a male synthesized voice. The shortage of response to this mismatch during the current study suggests that concerns about the synthesized voice matching the user's identity may be restricted to friends, family and the AAC user themselves [4,6,7]. This may be because the communication partner in this study was primarily concerned with responding to a request for information, rather than trying to connect with the augmented speaker as an individual. Concerns about the individuality of the synthesized voice may have been more prevalent in exchanges other than information seeking interactions. Additional research, in which partners experience both voice output conditions and are asked directly about preferences, is warranted.

Limitations and Future directions

Findings from this study cannot be generalized to a larger population due to a small sample size. In addition, these observations were based on visual inspection of the data. More data is necessary to generalize these results.

A longer interaction would allow for a more thorough investigation of the components of augmented speaker interactions. Future studies should address augmented interaction in a variety of contexts; some of which may be designed to last for more communicative exchanges, be implemented in different environments, and/or use actual augmented speakers to build a complete picture of the different effects between each voice. In addition, future studies could build a complete picture of the interaction by collecting data from both the augmented speaker and the communication partner.

Unfortunately, each environment was not represented equally. A tradeoff in testing in several different locations is that each location adheres to its own practices of searching for information and answering questions. This may affect the interaction time of each condition. For example, the longer interaction time for female voice may be because one female condition was tested in the Orono Public Library, and the desk clerk left the interaction to physically look for the book, spending more time than if they had used a computerized system.

High competence ratings in this study may be influenced by the primary investigator "breaking character" at the end of the interaction to debrief the desk clerk. By using mouth speech rather than continuing the interaction using augmentative communication, the primary investigator may have influenced perceptions of her that may have been different if she continued using AAC. Future investigations should consider recruiting a third-party ally who can provide the debriefing and distribute the survey. Having a third party ally disperse and analyze the participant survey would also eliminate any elements of bias caused by having the primary participant soliciting comments on her performance and also interpreting the results.

Additionally, the fact that the primary participant was not an authentic augmented speaker may have affected from the communication partner perceptions. There were dramatic differences in regards to attitudes about the augmented speaker when contrasted with Bedrosian's [8] study. Participants in Bedrosian's [9] study commented that they were impressed that the AAC user was able to communicate at all, given their physical limitations. Perhaps the participant's impressions during the current study would have been different if the primary participant appeared "disabled" or if the AAC device were attached to a wheelchair or an object that holds a stereotype of disability. Although this study suggested that identity with the synthesized voice was not a priority in this particular setting, it doesn't mean that representative voices are not important. The current study did not reveal any stark differences between male and female synthesized voice. Future research is warranted to determine if these findings would apply to other brands of synthesized voices and to repair differences if they were to arise.

CONCLUSION

In this study, interaction time and augmented speaker contributions were the only variations between conditions. The secondary participants rated all interactions favorably. No participants expressed concern when the primary participant used a mismatched voice gender. Future research should explore if different interaction settings warrant different levels of identity with the synthesized voice. For example, an interaction more focused on personal characteristics of the individual, such as conversations with friends.

Short interaction times and reduced augmented speaker contributions observed in the speech-off condition suggest text-based interaction may be the most efficient for information seeking tasks. More research regarding the

differences between gendered voices, in addition to possible benefits of communicating with a speech-off function is warranted. Augmented speakers have expressed that they feel a lack of identity with their synthesized voice, especially when several people in the same classroom use the same voice [5,20,21]. The inability to have unique vocal qualities to represent an individual's personality limits the adoption of the AAC device as an extension of the individual and creates a divide between AAC users and mouth speakers. More research on gendered speech and qualities of synthesized speech in general could provide augmented speakers with a personalized way to express themselves.

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