Rochester Institute of Technology

B. Thomas Golisano College
of
Computing and Information Sciences

Master of Science in Human Computer Interaction

Project Approval Form

Student Name: Liya Thomas

Intersectionality of Disability and Race in Automatic Speech Recognition for Black Older Adults with Hearing Loss

Project Committee

Name	Signature	Date
Chair: Kristen Shinohara		12/18/2024
Committee Member: Garreth Tigwell		12/18/2024

Intersectionality of Disability and Race in Automatic Speech Recognition for Black Older Adults with Hearing Loss

by

Liya Thomas

Project submitted in partial fulfillment of the requirements for the degree of Master of Science in Human Computer Interaction

Rochester Institute of Technology

B. Thomas Golisano College
of
Computing and Information Sciences

Department of Information Sciences and Technologies

11/07/2024

Copyright Page

Abstract

Traditionally, assistive technology research has focused on specific disabilities, often overlooking the intersection of race and age. This capstone addressed racial disparities in assistive technology design by exploring how Black American older adults with hearing loss interact with automatic speech recognition (ASR) transcription apps and investigating their preferences for ASR designs. This project employed a contextual inquiry with interviews and observations, followed by co-design workshops to elicit user issues for this group. This study's findings highlight stigmas within the Black community regarding hearing loss and design preferences in ASR technology for Black American older adults, such as respectful design and misconceptions of AI. This capstone project offers insights to enhance the design and usability of ASR technology for Black American older adults with hearing loss, highlighting the importance of intersectionality in HCI and providing design guidelines to promote inclusivity and reduce biases.

Table of Contents

List of Tables, Charts, Illustrations, etc.

1 Introduction and Background

Research on assistive technologies often focuses solely on disability (e.g., [1, 3, 15]), overlooking identities such as sexuality, gender, age, and race [25]. Ignoring these factors limits the understanding of people with disabilities' daily experiences and introduces unintended biases that make assistive technologies less effective and less likely to be adopted. Automatic speech recognition (ASR) is one such technology. ASR uses AI to generate automatic captions, helping hearing and Deaf or Hard of Hearing (DHH) individuals better understand videos and conversations, particularly when sign language or interpreters are unavailable [4]. However, prior research has demonstrated that ASR systems struggle to accurately interpret Black voices, accents, and dialects [9, 23, 28].

Past research within the AWARE-AI NRT program at the Rochester Institute of Technology investigated the intersection of age and disability. Researchers determined how DHH older adults utilized ASR mobile applications and their design preferences for such apps. Building on the AWARE-AI program's findings and addressing racial disparities in ASR technology, this paper focuses on the intersecting identities of race and age. Specifically, the capstone investigates how racial identity influences the use and design of ASR transcription apps for Black American older adults with hearing loss.

ASR systems are commonly used today in closed captioning and virtual assistants [28]. They are also utilized in transcription apps to assist DHH individuals with live conversations. Apps like Live Transcribe and Live Transcribe+ enable users to speak into a phone and see instant transcripts, facilitating communication between DHH and hearing individuals in settings like doctor's appointments and group hangouts. All ASR systems face challenges, such as producing inaccurate transcripts [4, 5], struggling with accents and dialects [27, 36, 39], and failing to convey emotions [24, 29, 30]. For the Black community, these issues, particularly ASR's difficulty in understanding accents and dialects, stem from the exclusion of race as a consideration in technology design, leading to racial biases [9, 23, 28]. Although often unintentional, these biases can harm people of color, affecting their mental health and self-confidence [11, 12, 16].

This study aims to combat racial bias by including Black American older adults in the design process of ASR transcription apps. Building on prior research, we developed several designs to address ASR shortcomings and conducted co-design workshops where participants shared their opinions and created their own designs. This approach aligns with Harrington et al.'s, 2019, [19] recommendations for co-design with marginalized groups.

To address racial bias in ASR technology we must first understand how people of color use ASR and identify race-related challenges. Thus, I ask the following questions:

- Can racial identities, specifically Black American older adults with hearing loss, influence interactions with ASR transcription apps?
- What impact, if any, is there on the contexts in which they are used?
- And, are there any stigmas with using ASR within the Black community?

Understanding the complications people of color face with assistive technology can guide improvements through collaborative design, leading to my third question:

- How do participants, specifically Black American older adults with hearing loss, draw on their racial identities during a co-design workshop to inform design decisions for ASR transcription apps?

To answer my research questions, I recruited seven Black American older adults with hearing loss and conducted individual contextual inquiries and group co-design workshops. The results highlight stigmas associated with hearing loss within the Black community, current and future use of ASR technologies, and design suggestions for ASR transcription apps. This capstone emphasizes the importance of race in assistive technology design, addressing gaps in research on ASR design preferences among Black American older adults with hearing loss. It also contributes design guidelines for creating ASR transcription apps tailored to this group, based on the data from this study.

It is important to note the work being done within this capstone is not the first to explore the intersectionality of race and disability. Instead, it is a response to a call of action from prominent researchers within the field such as Dr. Schalk who explores Black disability politics [40], Dr. Williams whose work focuses on race within HCI specifically amplifying Black voices and including Black participants [33], and Dr. Harrington whose work revolves around including Black older adults in conversations about emerging technology [22]. They ask researchers to consider race and background, personal preferences, lifestyle, and culture in design decisions. Thus, this work contributes to this movement by including Black American participants with hearing loss in design investigations and foregrounding their experiences and preferences.

2 Related Work

An awareness of intersectional identities in HCI ensures that marginalized groups are not overlooked. As Rankin et al., 2020, [37] highlight, intersectionality is both a tool to combat social injustices and a means to promote inclusion. The intersection of race and disability elevates race and ethnicity as essential aspects of identity that significantly shape how individuals navigate their disability and interact with assistive technologies [21, 31]. Failing to include race as a framework in technology design overlooks these intersections and contributes to the development of racially biased technologies [16, 33].

2.1 Race and ASR

ASR technology is used for various speech-to-text applications, such as closed captioning and voice assistants like Alexa and Google Home [28]. Racial inequalities in ASR are evident, with studies showing higher word error rates for Black voices compared to White voices [28]. Brewer et al., 2023, [9] and Harrington et al., 2022, [23] revealed similar frustrations among Black older adults, who resorted to code-switching or using a ‘White voice’ to be understood by voice assistants. Although the misunderstanding by

ASR systems is unintentional, this racial bias can negatively impact Black users [11, 12, 16]. In a Wizard of Oz experiment, Wenzel et al., 2023, [45] found that Black participants experienced decreased self-esteem and confidence when voice assistants misunderstood them, whereas White participants blamed the technology. These findings highlight how racially biased technology weakens user trust, emphasizing the need to consider race in ASR design. While past research focuses on transcription errors, gaps remain in understanding Black users' design preferences for ASR apps.

2.2 Co-design with Black Older Adults

Co-design and participatory design workshops in HCI engage end-users in the design process, resulting in more inclusive, user-driven solutions compared to traditional methods where users are consulted after prototypes are built [2, 41]. While co-design workshops specifically involving Black older adults with hearing loss are limited, previous research has engaged Black older adults in co-design workshops centered on voice assistants [9, 20]. These studies aim to address racial disparities in voice technologies, particularly for Black older adults who are often excluded from technology discussions. Both Harrington et al.'s, 2019, [20] and Brewer et al.'s, 2023, [9] studies began with initial sessions or interviews that explored participants' everyday experiences and opinions about voice technologies before transitioning to co-design activities. This approach aligns with guidelines for conducting co-design workshops with marginalized groups, which emphasize building trust by meeting with participants multiple times, understanding historical contexts, and following through on commitments [19].

In addition to co-design structures, guidelines exist for materials and expected behaviors based on participant groups. While there are no specific guidelines for Black older adults with hearing loss, insights can be drawn from co-design workshops involving Black older adults, Deaf or Hard of Hearing (DHH) older adults, and older adults more broadly.

For Black older adults, Harrington et al., 2019, [19, 20] recommend tailoring materials and addressing sociocultural factors, such as perspectives on education. They note that some participants may take on leadership roles, while others may feel inadequate. For DHH older adults, Sakaguchi-Tang et al., 2021, [38] emphasize encouraging equal participation. Regarding older adults in general, Pradhan, (2021), [34] observes that their design suggestions may not always reflect personal preferences, as participants sometimes stereotype the older population rather than designing for their own needs [35]. Lazar et al., 2021, [32] suggest informing participants about planned activities in advance to avoid minimal engagement or participation motivated solely by a desire to please researchers. Although these guidelines are not specific to the participant group in this study, they offer valuable insights toward fostering active and meaningful participation in co-design.

2.4 Challenges within ASR and Captioning

Aside from difficulties understanding accents, ASR systems also struggle to accurately transcribe phonetically similar words, understand voices in noisy environments or small group settings, and convey emotions [13, 14]. Previous research has explored visual design strategies to address some of these challenges. For example, Berke et al., 2017, [5] investigated methods like red text and underlining to highlight low-confidence captions, indicating uncertainty in transcription accuracy. De Lacerda Pataca et al., 2024 and Hassan et al., 2023, [24, 29] explored using color and opacity to convey emotions in video captions. While these studies received positive feedback from DHH individuals, they did not include Black older adults with hearing loss. To address these gaps, I developed sample designs focusing on four key categories: handling transcription errors, managing multiple speakers, notifying users when their speech is not properly heard, and conveying emotions through text. These designs build upon insights from previous studies to assess preferences within this specific demographic. Designing for Social Accessibility (DSA) Method Cards address social issues in assistive technology, such as awkward moments [42–44]. To encourage discussions on how race influences social issues related to ASR, I use these cards in my co-design workshops to evaluate ASR designs with Black older adults who have hearing loss.

3 Method

Modeled after the mixed-method approach in Harrington et al.'s, 2020, [23] study, this project consists of two parts: a contextual inquiry and a co-design workshop. Part 1: Contextual Inquiry, involves a semi-structured interview and observation to understand how Black American older adults with hearing loss use ASR or other assistive technologies in daily life. Part 2: Co-Design Workshop, explores participants' design preferences for an ASR app.

3.1 Participants

Seven Black American participants, aged 65 to 78, participated in the study: five female and two male. Participants were from Rochester, New York, a city with strong historical ties to civil rights and social justice and a population that is 37.9% Black or African American [46]. All participants had hearing loss but did not identify as being part of the Deaf Community. The severity and onset of their hearing loss varied, as did their education levels and occupations. Recruitment flyers asked for Black people aged 65 and above with hearing loss. Flyers were posted at the NTID building on campus, placed in hearing loss clinics, emailed to various nursing homes and senior living communities, and distributed at local organizations for older adults in the Greater Rochester area. P1 was recruited at a hearing loss association meeting, and the rest through snowball sampling, resulting in participants being relatives or acquaintances. All participants confirmed having hearing loss, though some noted they did not personally feel it but acknowledged

it based on hearing test results, family comments about their poor hearing, or noticing changes over time. All participated in both parts of the study: Part 1 was individual, while Part 2 had two groups—P1, P2, P3, and P4 in one, and P5, P6, and P7 in the other. Participant details are in Table 1. Compensation was $30 for Part 1 and $90 for Part 2.

P#	Gender	Age	Years of Hearing Loss	Level of Education
P1	M	77	1	Some College
P2	F	76	3	Few Years in College
P3	F	78	10	A few Higher Education Courses
P4	F	83	10	2 Years of Higher Education
P5	M	77	12	Undergraduate Degree
P6	F	75	2	Graduate Degree
P7	F	81	4	Graduate Degree

Table 1: Participant Demographics

3.2 Part 1: The Contextual Inquiry

Drawing from Harrington et al.'s, 2019, [19] recommendations for building trust with participants, the contextual inquiry was conducted before the co-design workshops, from April 5 to 17, 2024, to get to know the participants. Communication with participants had been ongoing for about a month before the contextual inquiries. This process included a 20-minute conversation with the first participant at a hearing loss association meeting and multiple phone calls with other participants to discuss the study, its objectives, and an introduction from the interviewer, ensuring participants felt comfortable enough to invite interviewers into their homes. Five inquiries took place in participants' homes, one at a participant's sister's home, and one at the university. Figure 1 shows three of these locations. Participants chose suitable interview spots, such as the living room, kitchen, or dining table, and minimized background noise by turning off the TV. Some asked about the journey and offered drinks or snacks, expressing concern for the researcher's safety when visiting unfamiliar homes.

Interviews started with an engaging question, followed by research and demographic questions on hearing loss, assistive technology use, and ASR opinions. Participants demonstrated any assistive technology and highlighted hearing challenges, such as P1's difficulty hearing the TV from the back of the living room (Figure 1 (A)). They shared personal experiences with hearing loss in the Black community, ranging from positive to discriminatory. Participants were introduced to and tested the Live Transcribe+ ASR app on an iPhone made for real-time communication. This app was chosen because it offered a free trial and served as a high-level concept to help older adults understand how ASR transcription apps function in real time. The sessions lasted 15 to 35 minutes, ending with

small talk and planning for Part 2. All questions asked during the Contextual Inquiry can be found in Appendix 1.

A B C

Figure 1: (A) Location for P1, P2 and P3 Interviews. (B) Location for P5 and P6 Interviews. (C) Location for P7 Interview

3.3 Part 2: The Co-Design Workshop

The Co-Design Workshop took place in a private meeting room at the RIT campus in two sessions: Group 1 on April 10th with four participants, and Group 2 on April 29th with three participants. Workshops were designed for small groups with at least two participants to allow for collaboration. Groups were formed based on convenience, scheduling, and participant relationships. The workshop began with an introduction and explanation of Designing for Social Accessibility (DSA) Method cards, which prompted discussions on social issues in assistive technology. Participants used the DSA Method cards to evaluate sample designs based on four prompts: Error Correction, Speaker Identification, Notifications for Influencing Speaker Behavior, and Text Appearance and Emotions. Error Correction showed how to correct incorrect words in transcripts; Speaker Identification showed how various speakers can be recognized. Notifications for Influencing Speaker Behavior showed notification styles for when the speaker is speaking too fast. Text Appearance showed colorful text and font variations to convey emotions. Figure 2 shows one sample design from each prompt. The entire Co-Design Workshop procedure can be found in Appendix 2 and all sample designs are provided in Appendix 3.

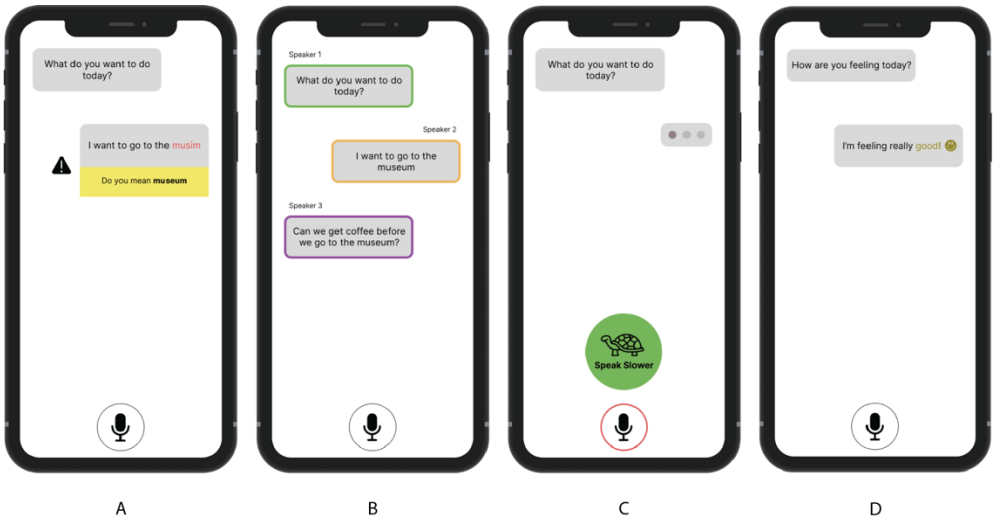


Figure 2: (A) Error Correction design with a single word replacement option. (B) Speaker Identification with different color borders to each speaker's speech bubbles. (C) Notifications for Influencing Speaker Behaviors design with a green circle above the mic icon with a turtle, that reads "speak slower." (D) Text Appearance and Emotions design that shows the word "good" in yellow with an emoji to convey happiness

All groups were meant to receive printed versions of the sample designs for easy sharing and comparison. Due to printing issues, Group 1 viewed the designs on an iPad, making it difficult to compare designs and pass them around. Group 2 received printed designs, which were easier to pass around and make notes on. After introducing each design prompt, participants viewed the designs, asked questions, and made comments on design elements they liked or disliked. They were asked to explain their opinions and suggest changes or original ideas. A sample drawing showed the low-fidelity level expected from participants. Group 1 only drew after the first prompt, with later suggestions discussed verbally or drawn by the researcher for clarity. To encourage more drawing in Group 2, printed iPhone templates and sample designs were provided, but participants drew only when verbal suggestions were not understood. Figure 3 shows Group 1 participants drawing and Figure 4 shows Group 2 participants discussing. The workshops ended with an exit interview on personal sentiments, communication, and workshop effectiveness. The workshops lasted 45 minutes to an hour and five minutes.

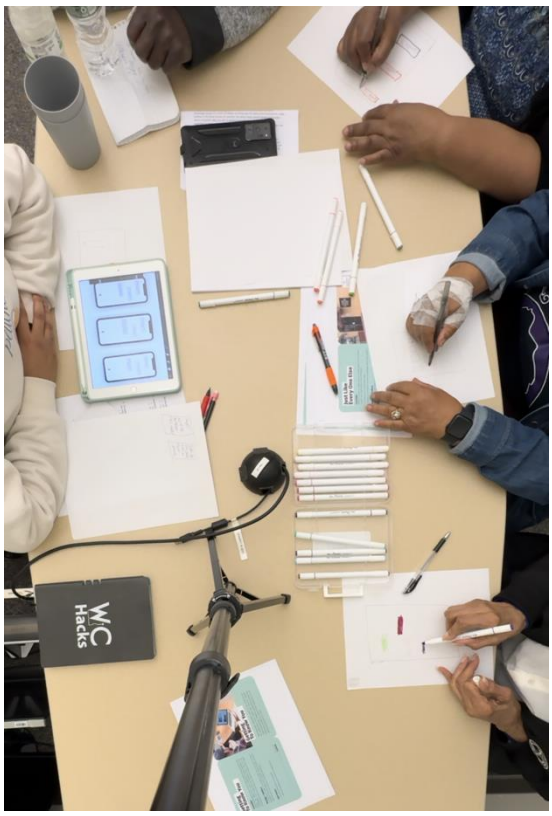


Figure 3: Participants Drawing in Group 1

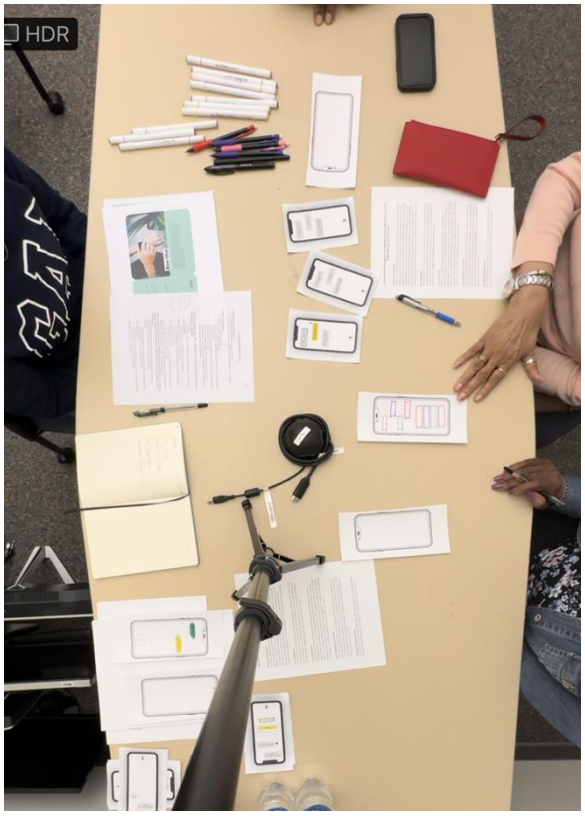


Figure 4: Participants Discussing in Group 2

3.4 Data Analysis

All contextual inquiries were voice recorded and transcribed within one week. Due to technical issues, P4's interview was not recorded; notes taken during the interview were later transcribed. The co-design workshops were video recorded and transcribed over two weeks. I followed Braun and Clarke's, 2006, [7] inductive thematic analysis method to analyze the transcripts, creating codes from the data and organizing them into themes and key concepts using Miro.

4 Results and Deliverables

The contextual inquiry and co-design workshops reveal participants' views and practices related to hearing loss, shaped by their experiences within the Black community and as Black Americans. The findings are organized into three main areas: Hearing Loss and ASR in the Black Community, which explores the stigma surrounding hearing loss and the use of assistive hearing technology in the Black community and among older adults; ASR Design Preferences, which details participants' opinions and suggestions for designing ASR systems and Misconceptions of AI, which highlights participants' reactions to AI features within the ASR transcription app.

4.1 Hearing Loss and ASR in the Black Community

4.1.1 Stigmas and Social Issues

When asked about stigmas in the Black community regarding hearing loss, five of seven participants believed such stigmas exist. Some shared personal stories, while others spoke generally. P6 stated that hearing loss in the Black community is often viewed negatively and can lead to cruel treatment.

> *"I think there is [a stigma]. So the thing is, there's always a problem in terms of whatever Black folks have, unfortunately, they want to go and say you're special, you're [r------d] [1] ... just being cruel.'" -- P6*

Aligned with the findings of Harrington and Edge's, 2023, [22] study, participants discussed systemic racism's impact on Black communities, contributing to inadequate healthcare and a reluctance to seek medical help. P5 mentioned that hearing loss stigmas exist among children in the Black community, not just older adults, noting, *"I'm gonna turn that around and say more so children. They're not being properly tested [for hearing loss] and so therefore there are stigmas put on them."* He claimed hearing issues in children often go undetected, leading to learning challenges and stereotyping. P1, P2, P4, and P5 believe the negative stigmas regarding hearing loss in the Black community prevent individuals from discussing, seeking help for, or admitting their hearing loss. P1 shared that a Black girl in his high school could not hear out of one ear, but no one knew until years after graduation. P2 mentioned she discovered many family members were wearing hearing aids recently when she contacted them about our project.

> *"A lot [of people] don't want to admit that they can't hear. Don't want to go to the doctors, you know. In fact, we just finding out when we heard about you, and we're calling [people] and they say 'Oh, I wear, I've got a hearing aid.' We don't even know family members that have [hearing aids] I mean, they've never said anything." -- P2*

P3 stated that stigmas exist in all communities, regardless of race. Despite being asked about stigmas, P7 was the only participant who did not mention any. Instead, she spoke about a positive interaction between a deaf boy and the Black community she was part of as a child.

> *"In my community we only have one deaf person, it was a man, a boy rather. And everybody had to really, you know, help him. Because - he tried to teach us sign language, but a lot of us kind of understood what he was saying….They loved him." -- P7*

Participants' experiences of hearing loss within the Black community varied, with some positive and some negative. The impacts of these experiences are reflected in the way participants currently use and discuss the future use of assistive technologies.

---

[1] Censored a word considered offensive by the disability community [17]

4.1.2 ASR Technology Use

Discussions with participants about hearing aids and ASR technology revealed findings consistent with prior research on the socio-emotional and psychological reactions of older adults and Black older adults who resist or are skeptical of assistive technology [9, 10, 22, 23].

Although all participants had hearing loss and were advised to use hearing aids, they denied the need for such technologies, reflecting varying levels of pride and self-awareness. Two participants outright refused ASR and hearing aids. P1 said he wouldn't wear a hearing aid because it would confirm his hearing loss and affect his mental health, while P5 saw ASR as useful for others, not himself.

> *"I'd never want to use it [hearing aids]. Because it's like, making myself... think I'm deaf. It would affect me mentally " – P1*

The other five participants expressed openness to using ASR in the future if needed. Some were reluctant and concerned about others' perceptions, such as P6, who found it awkward to ask people to speak into a phone for the ASR app. As P6 noted, *"But how do you approach people about speaking into the phone? They might be a little hesitant to do that."* However, some participants were fully on board with ASR, like P3, who embraced aging and was comfortable using the technology.

> *"I always say it's a blessing. I'm comfortable with my age. I'm comfortable with the fact that I'm still here. So you know, I don't feel like I will ever be ashamed… definitely would do this one [ASR app]" - - P3*

Similar to prior research with Black older adults and voice assistants [9, 22, 23], participants raised concerns about ASR's ability to accurately translate various accents commonly heard among Black relatives and friends. P1, P2, and P3 mentioned that understanding their grandchildren, who speak with Southern U.S. accents, was sometimes difficult. They believed ASR would encounter similar challenges.

Overall, participants noted that ASR could help in communication with fast talkers, soft speakers, or in group settings. They mentioned potential use cases like buses, casinos, churches, nursing homes, family gatherings, and prayer circle Zoom calls, covering both intimate and public settings.

4.2 ASR Design Preferences

During the co-design workshops, most of the results pertained to the design preferences of Black American older adults with hearing loss.

4.2.1 Spelling Concerns

One concern raised by participants related to common issues older adults face. The first issue mentioned by both groups was the potential lack of spelling knowledge among users. The Error Correction design options required users to select a suggested word or

type in their own to replace an incorrect word, which could be challenging if the user does not know how to spell the correct word. To address this, P5 and P6 suggested replacing the 'Type your word' button, shown in Figure 5 (A), with the 'Record Again' button, shown in Figure 5 (B), both circled in blue. Figure 5 (C) shows the new design.

Figure 5: (A) Error Correction sample design 2. (B) Error Correction sample design 3. (C) A drawing showing the combination of Error Correction sample design 2 and design 3.

Some participants felt Figure 5 (A) was too busy with three options and preferred Figure 6 (A) with one option. P7 wanted further instruction in Figure 6 (A) if the suggested word was incorrect, she suggested adding a yes or no button below. The new design is shown in Figure 6 (B).

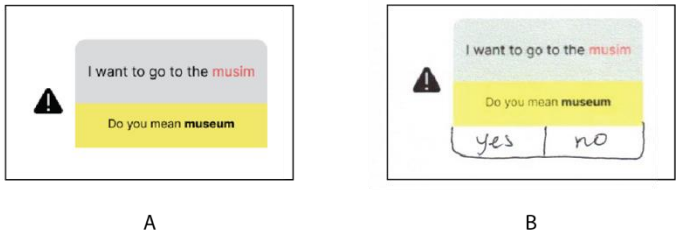


Figure 6: (A) Error Correction sample design 1. (B) Addition of 'yes' and 'no' buttons to Error Correction sample design 1.

4.2.2 Respectful Design

Although age-related factors such as font size are important, participants noted that designs for older adults should not be condescending. While larger font sizes are appreciated, they should be appropriately sized; excessively large text can be perceived as disrespectful. As P5 explained, *"You don't want it real big because it just throws the whole thing off… they'll feel like they're being criticized."*

Older adults found some design samples rude or disruptive to conversation flow. Participants disliked large red pop-up designs (Figure 7 (A) and (B)) and viewed them as intrusive due to their screen-blocking and conversation-interrupting nature. Participants preferred designs with subtle colors that still grabbed attention to notify speakers without

interrupting them. Including the word “please” in notifications was also favored and considered polite. Both groups suggested notification styles that could alert a single speaker to speak slower without disrupting the entire conversation. In Group 1, P3 proposed changing the single speaker's words to a different color to indicate they should speak faster. This suggestion is shown in Figure 7 (C), illustrated by the researcher during the co-design workshop.

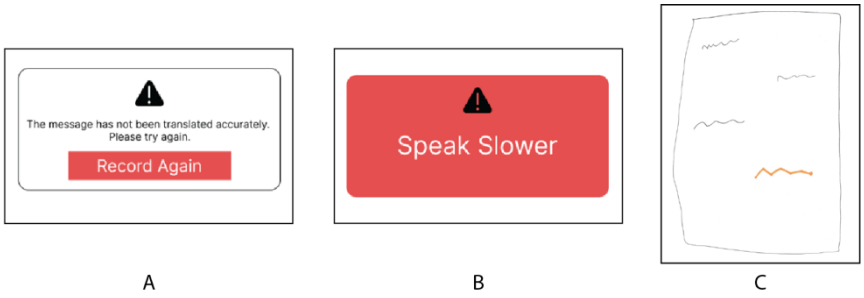


Figure 7: (A) Error Correction sample design. (B) Notifications for Influencing Speaker Behavior sample design. (C) Notification Style suggested by P3.

In Group 2, P5 suggested to keep the elements—the turtle, green color, and “please speak slower” wording—from Figure 8 (A) and Figure 8 (B) (both circled in blue), but place them on the mic icon and add grow and shrink animations to capture the speaker’s attention. As P5 mentioned, *“I like this, it says the word please. It's not offensive, this is more appealing.”* The new design is shown in Figure 8 (C).

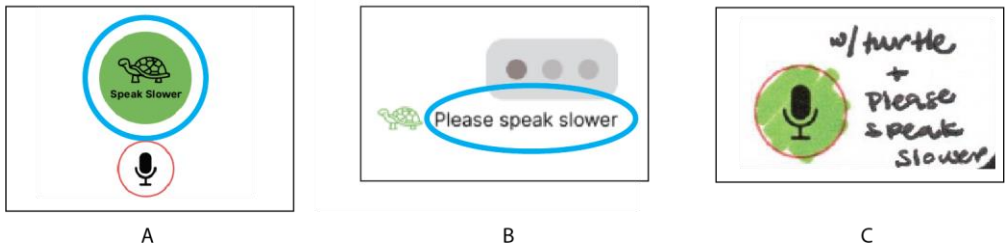


Figure 8: (A) Notifications for Influencing Speaker Behavior sample design 1. (B) Notification Style sample design 2. (C) Drawing that combines Notifications for Influencing Speaker Behavior sample designs 1 and 2

4.2 Misconceptions of AI

Participants in the workshop demonstrated they are not fully up to date with current technology and may not understand commonly used features. Both co-design workshop groups raised concerns about spelling when evaluating the Error Correction sample designs and noted that auto-correct is not a suitable solution. Many found auto-correct confusing and inconvenient due to its tendency to suggest wrong words or automatically change correct words. As P3 stated, *“In case it [autocorrect] didn't really understand me I wanna choose my own.”*

Throughout the co-design workshops and contextual inquiry sessions, participants voiced numerous cautionary comments about AI. For instance, P5 whispered 'AI' in an

ominous tone whenever it was mentioned, indicating wariness about AI's capabilities. P1 expressed concern about AI storing his conversations, fearing privacy invasion. A major misconception occurred with a feature that automatically added emojis to transcriptions based on spoken words, shown in Figure 8.

Figure 9: Text Appearance and Emotion design that shows the word "good" appears in yellow, accompanied by an automatically added emoji to convey happiness.

Participants assumed the AI was detecting the speaker's emotions and selecting emojis accordingly, rather than choosing emojis based solely on the transcribed words. They expected the AI to display emojis reflecting the speaker's true feelings. As P7 noted, *"You tell me one thing and the emoji will tell me something different."* Most participants disliked this feature and felt it was an invasion of their thoughts. They did not want their emotions displayed at all times. One participant even asked if he could turn off the feature for himself but keep it on for others, believing the emojis could help him determine if someone was lying. This misconception initially led to a negative reaction to the emoji feature. However, after clarifying that the emojis were based on transcribed words and not intended to reflect emotions, participants became more accepting of the design. Despite this, they still had concerns about unfamiliarity with current technology and understanding each emoji's meaning. As P3 stated, *"Because I be trying to figure out what people say these days there will be a moon with a face and the hearts around it."* To avoid misunderstandings, P3 suggested including a list of emojis and their meanings in the app for users to reference.

5 Discussion

This project provides information on the influence of personal experiences with aging, hearing loss, and assistive technologies, and implications for preferences for ASR design among Black older adults with hearing loss.

5.1 Stereotypes, ASR Interactions, and Behaviors of Black Older Adults

Stereotypes and stigmas surrounding hearing loss, hearing aids, ASR, and health are common among Black older adults with hearing loss. As shown in prior work with Black older adults [22], these stigmas often stem from mistrust in healthcare due to systematic racism and racial disparities and lead many to keep health issues private. Despite acknowledging these stigmas, participants struggled to accept their hearing loss and expressed reservations about hearing assistive technologies. For example, participants who initially claimed indifference to others' opinions later preferred a discreet ASR app in public. The limited use of ASR among Black older adults with hearing loss prevents us from drawing clear conclusions regarding my first two research questions about the interactions and contexts in which ASR is used. However, due to the stigmas surrounding hearing loss within the Black community, public use of ASR technology may not be widely accepted. Additionally, in Harrington et al.'s, 2019, [20] study, Black American older adults expressed a desire to keep their health issues private, even from people they see regularly, such as family, friends, and neighbors. This caution stems from concerns about information spreading, which further reinforces existing stigmas within the community.

5.2 ASR Preferences and Negative Perceptions of AI

Aside from stigmas and reluctance to use ASR, Black older adults with hearing loss also expressed negative perceptions and skepticism toward certain features and design aspects of ASR transcription apps. Similar to findings in prior work with Black older adults and voice assistants [9, 23], participants were concerned about the app's ability to accurately understand and transcribe various accents and dialects commonly used among Black people. Some preferences and misconceptions were not explicitly tied to race but aligned with sentiments expressed by Black older adults in previous research. For instance, as in Brewer et al.'s, 2023, [9] study, our participants also wanted ASR designs to provide clear error messages and direct solutions to address issues.

When participants learned that ASR uses AI, it initially triggered fears of privacy invasion and data misuse. Although privacy concerns are not uncommon among Black older adults' using voice assistants and chat bots [9, 22], our findings brought out a notable misconception involving the emoji feature. Participants expected AI to detect and display their emotions as emojis automatically. Research shows that Black older adults often misunderstand AI's capabilities or accuracy, leading to mistrust of its outputs and origins [8, 22]. In this case, participants overestimated AI's abilities and perceived the feature as intrusive, leading to initial rejection of the emoji feature. However, once the misconception was addressed, participants appreciated the feature, demonstrating that clearly explaining the extent of AI's capabilities in a system can enhance Black American older adults' willingness to use it.

5.3 Diversity and Inclusion in Emerging Technology Design

As seen in prior research on racial preferences in technology (e.g., [18–20]), I designed the methodology with race in mind, creating a space where participants felt comfortable discussing racial themes. Participants shared personal experiences about the Black community, historical events like the Tuskegee Experiment, and systemic issues such as funding disparities in predominantly Black schools, which influenced their technology use. This capstone's findings revealed that in both workshop groups, a participant naturally took on a leadership role, actively encouraging others to share opinions and ensuring everyone understood the sample designs. This contrasts with past work, such as Harrington et al., 2019, [20], where differences in education led some participants to feel less knowledgeable than self-appointed leaders. I identified similar patterns of self-appointed leaders as seen in past work, but our participants differed in that they knew each other and were related, which promoted mutual respect.

Previous work emphasizes including diverse racial and marginalized groups in technology design. While studies have examined Black older adults, older adults, DHH people, or DHH older adults (e.g., [6, 9, 20, 26]), few have explored preferences at the intersection of these groups. Although I cannot claim that preferences are directly related to race, my paper's findings reveal preferences of Black American older adults with hearing loss regarding ASR mobile applications, an area not previously explored.

5.4 ASR app Design Guidelines for DHH Black American older adults

The following guidelines, in Table 2, are created from the stigmas and preferences voiced by Black American older adults with hearing loss during our co-design workshops.

1. **Common technology knowledge may not be common knowledge for older adults:** When designing for older adults, it is important not to rely solely on modern features like autocorrect. Do not assume new icons such as emojis and emoticons are straightforward. Digital literacy among older adults varies, so designs should provide clear instructions or information to ensure accessibility and ease of use for all users.
2. **AI components should be explained clearly:** Older adults can carry negative connotations about AI and therefore AI should be explained within applications to avoid misunderstandings.
3. **Conversation etiquette should be upheld within design:** Older adults consider etiquette and politeness when selecting notification styles and the overall visual interface of an app. Designs for notifications should prioritize a visually cordial and respectful appearance.
4. **Design around Stigmas and Stereotypes:** ASR designs should not try to destigmatize, but they should have subtle notifications and appearance to reduce embarrassment and increase confidence for older adults using mobile

applications. Designs should not be flashy or draw too much attention with features like flashing lights, haptic vibrations, or notification sounds.

5.4 Limitation and Future Work

The behaviors exhibited by participants in the co-design workshops, along with the study's limitations, highlight opportunities for future research. The study had a small sample size of just seven participants, and ideally, a study emphasizing the inclusion of the Black community should involve a much larger number of participants. Future work should aim to recruit a larger sample.

The participants were either related or knew each other as friends. This familiarity may have introduced bias in how the participants interacted during the co-design sessions. Although they interacted positively and encouraged each other to speak, future research should explore co-design workshops with participants who do not know each other to better understand the preferences of a more diverse group.

The printing error that occurred for Group 1 during the co-design sessions could have impacted the participants' understanding of the designs and, ultimately, their design preferences for ASR transcription apps. Future research should ensure that the same medium is used for all co-design groups when presenting sample designs, ideally a medium that can be passed around or a set of samples for each participant.

Lastly, since some participants were hesitant to draw designs, future research should explore alternative, more engaging activities that encourage participation without relying on sketching. For example, a mix-and-match paper prototype approach, where various icons, speech bubbles, and other symbols relevant to ASR transcription apps are prepared beforehand. Participants can place these icons on an iPhone template or draw their own icons. This would allow participants to provide design suggestions without the emphasis on drawing.

6. Conclusion

This study explored the intersection of race and disability to understand ASR design preferences among Black American older adults with hearing loss. Seven participants engaged in contextual inquiries and co-design workshops, providing insights into their use of assistive technologies and preferences for ASR app design. While the initial goal was to determine if race influenced design decisions, it became clear that attributing preferences to a single factor like race is complex. Design preferences likely result from a mix of upbringing, background, and life experiences rather than one isolated characteristic. Nevertheless, this work enhances understanding of marginalized groups—specifically Black, hard of hearing, and older adults—who are often overlooked. The findings offer a unique perspective and have led to the development of design guidelines for ASR mobile applications, emphasizing the importance of inclusivity and intersectionality in technology design.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Award No. DGE-2125362. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Bibliography

[1] Jamey Albert, Daniel Koronthály, Samantha Jane Dobesh, Zafir Nasim, Ilaana Khan, Shameem Ahmed, and Moushumi Sharmin. 2022. To Aid Emotion Expression for Non-Verbal Autistic Individuals, In an App, Less (Features) is More (Better). In *Proceedings of the 2022 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, September 11, 2022. ACM, Cambridge United Kingdom, 4–6. https://doi.org/10.1145/3544793.3560338

[2] Sadiq Aliyu, Sushmita Khan, Aminata N. Mbodj, Oluwafemi Osho, Lingyuan Li, Bart Knijnenburg, and Mauro Cherubini. 2024. Participatory Design to Address Disclosure-Based Cyberbullying. In *Proceedings of the 2024 ACM Designing Interactive Systems Conference* (*DIS '24*), July 01, 2024. Association for Computing Machinery, New York, NY, USA, 1547–1565. https://doi.org/10.1145/3643834.3660716

[3] Ali Selman Aydin, Shirin Feiz, Vikas Ashok, and IV Ramakrishnan. 2020. Towards making videos accessible for low vision screen magnifier users. In *Proceedings of the 25th International Conference on Intelligent User Interfaces* (*IUI '20*), March 17, 2020. Association for Computing Machinery, New York, NY, USA, 10–21. https://doi.org/10.1145/3377325.3377494

[4] Larwan Berke, Khaled Albusays, Matthew Seita, and Matt Huenerfauth. 2019. Preferred Appearance of Captions Generated by Automatic Speech Recognition for Deaf and Hard-of-Hearing Viewers. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*, May 02, 2019. ACM, Glasgow Scotland Uk, 1–6. https://doi.org/10.1145/3290607.3312921

[5] Larwan Berke, Christopher Caulfield, and Matt Huenerfauth. 2017. Deaf and Hard-of-Hearing Perspectives on Imperfect Automatic Speech Recognition for Captioning One-on-One Meetings. In *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility*, October 19, 2017. ACM, Baltimore Maryland USA, 155–164. https://doi.org/10.1145/3132525.3132541

[6] Johnna Blair and Saeed Abdullah. 2019. Understanding the Needs and Challenges of Using Conversational Agents for Deaf Older Adults. In *Companion Publication of the 2019 Conference on Computer Supported Cooperative Work and Social Computing* (*CSCW '19 Companion*), November 09, 2019. Association for Computing Machinery, New York, NY, USA, 161–165. https://doi.org/10.1145/3311957.3359487

[7] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 2 (January 2006), 77–101. https://doi.org/10.1191/1478088706qp063oa

[8] Robin N. Brewer. 2022. “If Alexa knew the state I was in, it would cry”: Older Adults’ Perspectives of Voice Assistants for Health. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*, April 27, 2022. ACM, New Orleans LA USA, 1–8. https://doi.org/10.1145/3491101.3519642

[9] Robin N. Brewer, Christina Harrington, and Courtney Heldreth. 2023. Envisioning Equitable Speech Technologies for Black Older Adults. In *2023 ACM Conference on Fairness, Accountability, and Transparency*, June 12, 2023. ACM, Chicago IL USA, 379–388. https://doi.org/10.1145/3593013.3594005

[10] Aimée K. Bright and Lynne Coventry. 2013. Assistive technology for older adults: psychological and socio-emotional design requirements. In *Proceedings of the 6th International Conference on PErvasive Technologies Related to Assistive Environments* (*PETRA ’13*), May 29, 2013. Association for Computing Machinery, New York, NY, USA, 1–4. https://doi.org/10.1145/2504335.2504344

[11] Joy Buolamwini. 2023. *Unmasking AI : my mission to protect what is human in a world of machines*. Random House, New York.

[12] Joy Buolamwini and Timnit Gebru. 2018. Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification. In *Proceedings of the 1st Conference on Fairness, Accountability and Transparency*, January 21, 2018. PMLR, 77–91. Retrieved November 3, 2024 from https://proceedings.mlr.press/v81/buolamwini18a.html

[13] Jie Cao, Ananya Ganesh, Jon Cai, Rosy Southwell, E. Margaret Perkoff, Michael Regan, Katharina Kann, James H. Martin, Martha Palmer, and Sidney D’Mello. 2023. A Comparative Analysis of Automatic Speech Recognition Errors in Small Group Classroom Discourse. In *Proceedings of the 31st ACM Conference on User Modeling, Adaptation and Personalization* (*UMAP ’23*), June 19, 2023. Association for Computing Machinery, New York, NY, USA, 250–262. https://doi.org/10.1145/3565472.3595606

[14] Anjie Fang, Simone Filice, Nut Limsopatham, and Oleg Rokhlenko. 2020. Using Phoneme Representations to Build Predictive Models Robust to ASR Errors. In *Proceedings of the 43rd International ACM SIGIR Conference on Research and Development in Information Retrieval* (*SIGIR ’20*), July 25, 2020. Association for Computing Machinery, New York, NY, USA, 699–708. https://doi.org/10.1145/3397271.3401050

[15] Dylan Gaines, Mackenzie M Baker, and Keith Vertanen. 2023. FlexType: Flexible Text Input with a Small Set of Input Gestures. In *Proceedings of the 28th International Conference on Intelligent User Interfaces* (*IUI ’23*), March 27, 2023. Association for Computing Machinery, New York, NY, USA, 584–594. https://doi.org/10.1145/3581641.3584077

[16] David Hankerson, Andrea R. Marshall, Jennifer Booker, Houda Elmimouni, Imani Walker, and Jennifer A. Rode. 2016. Does Technology Have Race? In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, May 07, 2016. ACM, San Jose California USA, 473–486. https://doi.org/10.1145/2851581.2892578

[17] Vicki L. Hanson, Anna Cavender, and Shari Trewin. 2015. Writing about accessibility. *interactions* 22, 6 (October 2015), 62–65. https://doi.org/10.1145/2828432

[18] Christina Harrington and Tawanna R Dillahunt. 2021. Eliciting Tech Futures Among Black Young Adults: A Case Study of Remote Speculative Co-Design. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, May 06, 2021. ACM, Yokohama Japan, 1–15. https://doi.org/10.1145/3411764.3445723

[19] Christina Harrington, Sheena Erete, and Anne Marie Piper. 2019. Deconstructing Community-Based Collaborative Design: Towards More Equitable Participatory Design Engagements. *Proc. ACM Hum.-Comput. Interact.* 3, CSCW (November 2019), 1–25. https://doi.org/10.1145/3359318

[20] Christina N. Harrington, Katya Borgos-Rodriguez, and Anne Marie Piper. 2019. Engaging Low-Income African American Older Adults in Health Discussions through Community-based Design Workshops. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, May 02, 2019. ACM, Glasgow Scotland Uk, 1–15. https://doi.org/10.1145/3290605.3300823

[21] Christina N. Harrington, Aashaka Desai, Aaleyah Lewis, Sanika Moharana, Anne Spencer Ross, and Jennifer Mankoff. 2023. Working at the Intersection of Race, Disability and Accessibility. In *The 25th International ACM SIGACCESS Conference on Computers and Accessibility*, October 22, 2023. ACM, New York NY USA, 1–18. https://doi.org/10.1145/3597638.3608389

[22] Christina N. Harrington and Lisa Egede. 2023. Trust, Comfort and Relatability: Understanding Black Older Adults' Perceptions of Chatbot Design for Health Information Seeking. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, April 19, 2023. ACM, Hamburg Germany, 1–18. https://doi.org/10.1145/3544548.3580719

[23] Christina N. Harrington, Radhika Garg, Amanda Woodward, and Dimitri Williams. 2022. "It's Kind of Like Code-Switching": Black Older Adults' Experiences with a Voice Assistant for Health Information Seeking. In *CHI Conference on Human Factors in Computing Systems*, April 29, 2022. ACM, New Orleans LA USA, 1–15. https://doi.org/10.1145/3491102.3501995

[24] Saad Hassan, Yao Ding, Agneya Abhimanyu Kerure, Christi Miller, John Burnett, Emily Biondo, and Brenden Gilbert. 2023. Exploring the Design Space of Automatically Generated Emotive Captions for Deaf or Hard of Hearing Users. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems* (*CHI EA '23*), April 19, 2023. Association for Computing Machinery, New York, NY, USA, 1–10. https://doi.org/10.1145/3544549.3585880

[25] Megan Hofmann, Devva Kasnitz, Jennifer Mankoff, and Cynthia L Bennett. 2020. Living Disability Theory: Reflections on Access, Research, and Design. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility* (*ASSETS '20*), October 29, 2020. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3373625.3416996

[26] Yucheng Jin, Wanling Cai, Li Chen, Yizhe Zhang, Gavin Doherty, and Tonglin Jiang. 2024. Exploring the Design of Generative AI in Supporting Music-based

Reminiscence for Older Adults. In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (*CHI '24*), May 11, 2024. Association for Computing Machinery, New York, NY, USA, 1–17. https://doi.org/10.1145/3613904.3642800

[27] Seoyoung Kim, Yeon Su Park, Dakyeom Ahn, Jin Myung Kwak, and Juho Kim. 2024. Is the Same Performance Really the Same?: Understanding How Listeners Perceive ASR Results Differently According to the Speaker's Accent. *Proc ACM Hum-Comput Interact* 8, CSCW1 (April 2024), 169:1-169:22. https://doi.org/10.1145/3641008

[28] Allison Koenecke, Andrew Nam, Emily Lake, Joe Nudell, Minnie Quartey, Zion Mengesha, Connor Toups, John R. Rickford, Dan Jurafsky, and Sharad Goel. 2020. Racial disparities in automated speech recognition. *Proc. Natl. Acad. Sci. U. S. A.* 117, 14 (April 2020), 7684–7689. https://doi.org/10.1073/pnas.1915768117

[29] Caluã de Lacerda Pataca, Saad Hassan, Nathan Tinker, Roshan Lalintha Peiris, and Matt Huenerfauth. 2024. Caption Royale: Exploring the Design Space of Affective Captions from the Perspective of Deaf and Hard-of-Hearing Individuals. In *Proceedings of the CHI Conference on Human Factors in Computing Systems* (*CHI '24*), May 11, 2024. Association for Computing Machinery, New York, NY, USA, 1–17. https://doi.org/10.1145/3613904.3642258

[30] Caluã de Lacerda Pataca, Matthew Watkins, Roshan Peiris, Sooyeon Lee, and Matt Huenerfauth. 2023. Visualization of Speech Prosody and Emotion in Captions: Accessibility for Deaf and Hard-of-Hearing Users. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (*CHI '23*), April 19, 2023. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3544548.3581511

[31] Emily Ladau. 2021. *Demystifying disability: what to know, what to say, and how to be an ally / Emily Ladau.* Ten Speed Press, Emeryville.

[32] Amanda Lazar, Ben Jelen, Alisha Pradhan, and Katie A. Siek. 2021. Adopting Diffractive Reading to Advance HCI Research: A Case Study on Technology for Aging. *ACM Trans Comput-Hum Interact* 28, 5 (August 2021), 32:1-32:29. https://doi.org/10.1145/3462326

[33] Ihudiya Finda Ogbonnaya-Ogburu, Angela D.R. Smith, Alexandra To, and Kentaro Toyama. 2020. Critical Race Theory for HCI. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, April 21, 2020. ACM, Honolulu HI USA, 1–16. https://doi.org/10.1145/3313831.3376392

[34] Alisha Pradhan. 2021. An Entanglement Perspective on How Older Adults Use and Design Emerging Ubiquitous Technologies. In *Companion Publication of the 2021 Conference on Computer Supported Cooperative Work and Social Computing*, October 23, 2021. ACM, Virtual Event USA, 287–290. https://doi.org/10.1145/3462204.3481796

[35] Alisha Pradhan, Ben Jelen, Katie A. Siek, Joel Chan, and Amanda Lazar. 2020. Understanding Older Adults' Participation in Design Workshops. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (*CHI '20*), April 23, 2020. Association for Computing Machinery, New York, NY, USA, 1–15. https://doi.org/10.1145/3313831.3376299

[36] Kerri Prinos, Neal Patwari, and Cathleen A. Power. 2024. Speaking of accent: A content analysis of accent misconceptions in ASR research. In *Proceedings of the 2024 ACM Conference on Fairness, Accountability, and Transparency* (*FAccT '24*), June 05, 2024. Association for Computing Machinery, New York, NY, USA, 1245–1254. https://doi.org/10.1145/3630106.3658969

[37] Yolanda A. Rankin, Jakita O. Thomas, and Nicole M. Joseph. 2020. Intersectionality in HCI: lost in translation. *Interactions* 27, 5 (September 2020), 68–71. https://doi.org/10.1145/3416498

[38] Dawn K. Sakaguchi-Tang, Jay L. Cunningham, Wendy Roldan, Jason Yip, and Julie A. Kientz. 2021. Co-Design with Older Adults: Examining and Reflecting on Collaboration with Aging Communities. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW2 (October 2021), 1–28. https://doi.org/10.1145/3479506

[39] Leda Sarı, Mark Hasegawa-Johnson, and Chang D. Yoo. 2021. Counterfactually Fair Automatic Speech Recognition. *IEEEACM Trans Audio Speech Lang Proc* 29, (November 2021), 3515–3525. https://doi.org/10.1109/TASLP.2021.3126949

[40] Sami Schalk. 2022. *Black Disability Politics*. Duke University Press. https://doi.org/10.1215/9781478027003

[41] Douglas Schuler and Aki Namioka. 1993. *Participatory Design: Principles and Practices*. CRC Press.

[42] Kristen Shinohara, Cynthia L. Bennett, Wanda Pratt, and Jacob O. Wobbrock. 2018. Tenets for Social Accessibility: Towards Humanizing Disabled People in Design. *ACM Trans Access Comput* 11, 1 (March 2018), 6:1-6:31. https://doi.org/10.1145/3178855

[43] Kristen Shinohara, Nayeri Jacobo, Wanda Pratt, and Jacob O. Wobbrock. 2020. Design for Social Accessibility Method Cards: Engaging Users and Reflecting on Social Scenarios for Accessible Design. *ACM Trans Access Comput* 12, 4 (January 2020), 17:1-17:33. https://doi.org/10.1145/3369903

[44] Kristen Shinohara, Jacob O. Wobbrock, and Wanda Pratt. 2018. Incorporating Social Factors in Accessible Design. In *Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility* (*ASSETS '18*), October 08, 2018. Association for Computing Machinery, New York, NY, USA, 149–160. https://doi.org/10.1145/3234695.3236346

[45] Kimi Wenzel, Nitya Devireddy, Cam Davison, and Geoff Kaufman. 2023. Can Voice Assistants Be Microaggressors? Cross-Race Psychological Responses to Failures of Automatic Speech Recognition. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, April 19, 2023. ACM, Hamburg Germany, 1–14. https://doi.org/10.1145/3544548.3581357

[46] U.S. Census Bureau QuickFacts: Rochester city, New York. Retrieved December 13, 2024 from https://www.census.gov/quickfacts/fact/table/rochestercitynewyork/PST045223

Appendices

Appendix 1: Contextual Inquiry and Script Questions

The contextual inquiry will take place in a location of the participants choosing and will include observation and a semi-structured interview. Consent forms will be given out if they are not signed prior to this meeting.

I am going to ask you a few questions regarding your hearing loss, any assistive technology you use for your hearing and automatic speech recognition. I will also ask you questions regarding race and the black community. The purpose of the project is to understand the influence of race on the use of assistive technology so any stories, memories, or experiences you think are relevant and are comfortable sharing I would really appreciate and encourage you to share.

I am going to start with a fun question just to get us going and comfortable:

Question Options:

1. Can you tell me the story of how you met your partner?
2. What is your favorite meal to prepare and why?
3. Can you tell me about one of your favorite childhood memories?

Part 1: Hearing Loss Background

1. Can you describe the extent of your hearing loss? For example, when did it start and how severe would you say it is?
2. What are some common daily activities that are affected by your hearing loss?
3. Are there any activities or places you now avoid due to your hearing loss?
4. Have you felt any negative feelings such as shame or discrimination because of your hearing loss? Maybe specifically with relatives, friends, or certain communities?
5. Do you ever feel that there are stigmas when it comes to being deaf or hard of hearing within the Black community?

Part 2: Assistive Technology

6. What technologies (if any) are you currently using to assist with hearing? These could include hearing aids or other technologies like laptops, smartphones, tablets and online chat apps.
7. If you are not using any technologies, why not?
8. Could you show me these technologies?
9. Can you take me through your daily activities in which you use these technologies? Either explain or show me.
10. Are there times when you have difficulties with these technologies?

11. Have these technologies aided or hindered any communication in daily life?
12. Do you ever feel ashamed or like you cannot use these technologies around certain people or communities?
13. Overall, how satisfied would you say you are with these technologies?

Part 3: Automatic Speech Recognition Discussion

14. Do you have any experience working with automatic speech recognition (ASR) tool? If necessary, explain what automatic speech recognition technology is or show an example of such existing technology.
15. If so, what are your experiences working with any ASR tools?
16. Why did you try it?
17. Are there specific times or situations when you would choose to use it?
18. If not, why not? Have you been given the opportunity to try out some of these technologies?
19. Would you be interested in using these kinds of technologies to aid communication in everyday life?
20. Do you think ASR could be helpful to your daily life?
21. If yes, can you think of situations when you would use it?

Appendix 2: Co-Design Workshop Procedure

1. Introductions and Icebreaker
    a. Introductions by researcher, and all participants.
    b. Consent forms will be given out if they are not signed prior to this meeting.

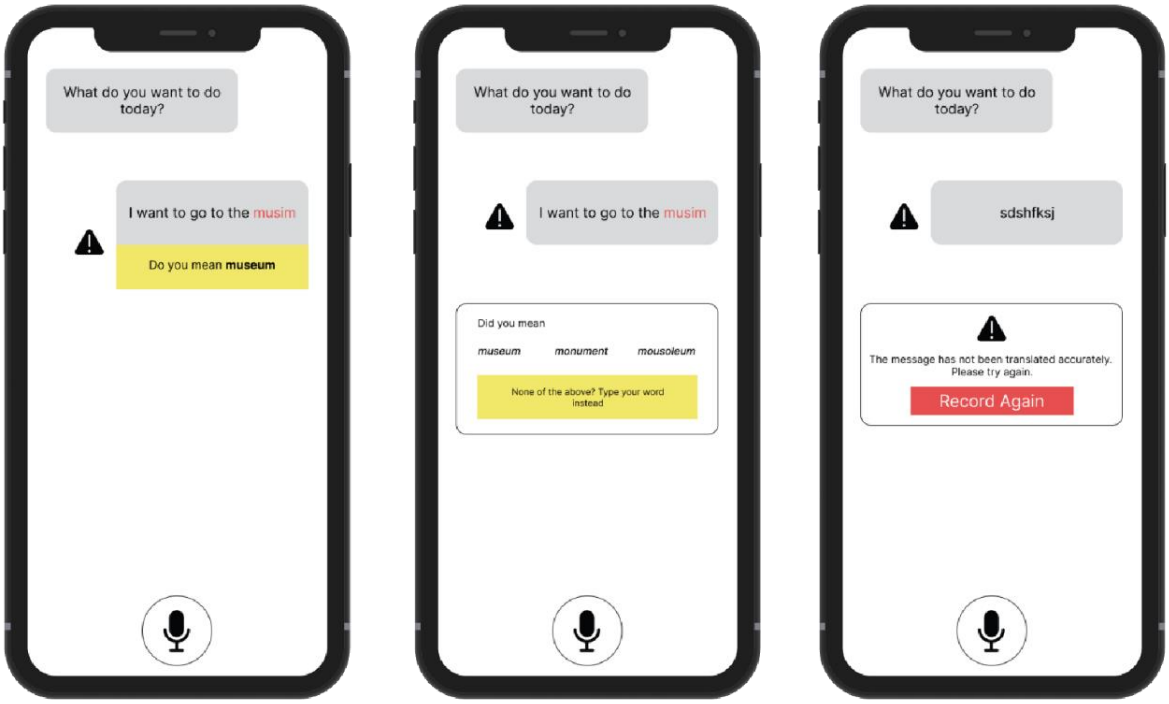
2. Explaining the Study
    a. Discuss the agenda for the day.
    b. Brief introduction of ASR and Design
        i. Show an ASR app on the phone so they have more of an idea what they are working with.
        ii. Show them how the app works and how we would like to make changes that will best suit their needs.
        iii. Discuss that example designs will be shown and describe their contribution will be through discussion of existing ideas, brainstorming, and sketching if they are comfortable.

3. Prompts for Design work: Show participants some pre-made printouts for each of the following 4 categories:
    a. Error correction

        i. How should errors in ASR output be corrected? Show a variety of ways.
    b. Speaker Identifier
        i. Show some ways in which speakers can be identified.
    c. Notifications for influencing speaking behaviors.
        i. How should speakers be notified that they are not speaking clearly? Show a variety of ways.
    d. Text appearance and emotions
        i. Show some ways in which the size, font style and emotional expression of text used in the app can be shown.
    e. Instruct participants to express their opinions by drawing on existing designs or creating new ones by drawing on paper or the templates given.
4. Using prompts from DSA Cards to evaluate designs that were shown and designs that were created by the participants. (Still offering a chance to change or make new designs)
    a. Talk through what DSA cards are and how they are used to encourage discussion and explore different use cases of ASR apps.
    b. Non-Use
        i. Discuss any situations where participants would be uncomfortable using ASR technology and why, and potential solutions.
    c. That Awkward Moment
        i. Can participants visualize any moments using this technology that would be uncomfortable or awkward in their daily life?
    d. Perceptions of “Special” Technology
        i. Would participants feel that other people judge them differently for using this technology? Would this change how they use ASR?
    e. My Professional Life
        i. If participants are still working, ask if they would incorporate ASR into their professional environment. Can skip if they are retired.
5. Exit Interview
    a. What worked well during this workshop session?
    b. What did not work well and could be improved?
    c. How effective was communication for everyone involved?
    d. What was your favorite part of this workshop?
    e. What was your least favorite part of this workshop?
    f. Have your thoughts about ASR changed after experiencing this workshop?
        i. Are you more excited or less excited about the potential of ASR for accessibility?
    g. Any other suggestions, feedback, concerns, or comments?

Appendix 3: Sample Designs Shown in Co-Design Workshops

1. Error Correction



A B C

(A) Interface Design that gives a singular word replacement.
(B) Interface Design that gives three options for word replacement.
(C) Interface Design that allows for the message to be rerecorded.

Description:
Image A: Interface Design with a yellow pop-up that corrects the incorrect word.
Image B: Interface Design with a yellow pop-up that gives three options to correct the incorrect word.
Image C: Interface design with a red pop-up that reads 'Record Again.'

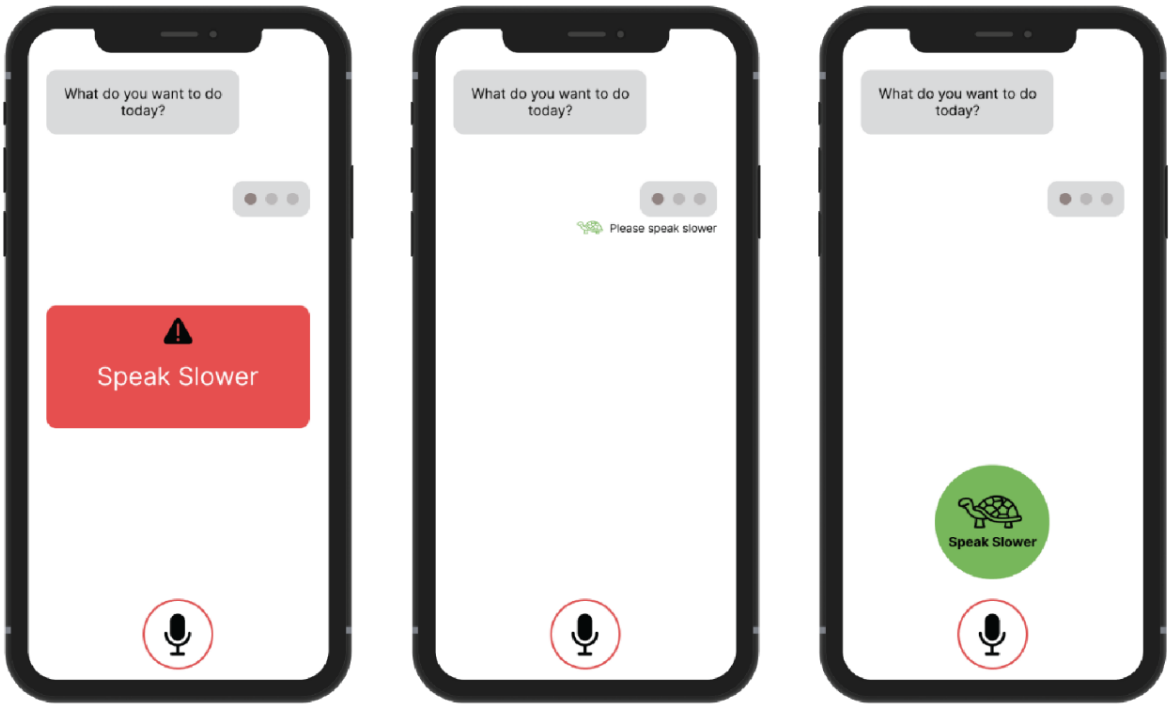
2. Speaker Identification

A B C

(A) Interface Design that puts the speaker number in the speech bubble.
(B) Interface Design that puts the speaker number outside the speech bubble.
(C) Interface Design with color borders around speech bubbles.

Description:
Image A: Interface Design with speech bubbles that place 'Speaker 1' and 'Speaker 2' in the text bubbles.
Image B: Interface Design with speech bubbles that place 'Speaker 1' and 'Speaker 2' on top of the text bubbles.
Image C: Interface Design with speech bubbles that places 'Speaker 1' and 'Speaker 2' in the text bubbles and adds different color borders around the speech bubbles.

3. Notifications for Influencing Speaker Behavior



(A) Interface Design with a red pop-up indicating the speaker to speak slower.
(B) Interface Design with a green turtle icon and text that reads 'Please speak slower.'
(C) Interface Design with a green circular pop-up that reads 'Speak Slower' and has a turtle icon.

Description:
Image A: Interface Design with a red pop-up that reads 'Speak Slower' and has a triangle caution icon.
Image B: Interface Design with a green turtle icon and text that reads 'Please speak slower.'
Image C: Interface Design with a green circular pop-up that reads 'Speak Slower' and has a turtle icon.

4. Text Appearance

(A) Interface Design that conveys emotion with red text that reads 'so annoying!'
(B) Interface Design that conveys emotions with yellow-colored text and an emoji.
(C) Interface Design with white text on a black background.

Description:
Image A: Interface Design with speech bubbles that places 'Speaker 1' and 'Speaker 2' in the text bubbles.
Image B: Interface Design with yellow text that reads 'I'm feeling really good,' followed by a yellow smiley face emoji.
Image C: Interface Design of a speech bubble with white text on a black background.