"The World is Designed for Fluent People": Benefits and Challenges of Videoconferencing Technologies for People Who Stutter

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ABSTRACT

This work studies the experiences of people who stutter (PWS) with videoconferencing (VC) and VC technologies. Our interview study with 13 adults who stutter uncovers extra challenges introduced by current VC platforms to people who stutter. While some of the challenges are a direct result of the characteristics of stuttering (e.g. people/systems mistaking pauses as end of turn), a bigger yet less visible challenge comes with the significant amount of emotional and cognitive effort required to manage one's speech and identity over VC, in which people's existing communication strategies - such as body language and eye contact - are under-supported and their biggest discomfort - such as seeing oneself stutter - are exacerbated by preset features like self view. Overall, our work sheds light on the structural barriers and the opportunities for PWS to engage and enjoy virtual communications via VC technologies.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in accessibility**; **Computer supported cooperative work**.

KEYWORDS

videoconferencing, computer-mediated communication, stuttering, speech diversity, accessibility

1 INTRODUCTION

Stuttering is a complex neurodevelopmental condition that is estimated to affect between 1% to 4% of the population [58, 73]. Traditionally considered as a speech *disorder* characterized by atypical speech behaviors such as sound repetitions, prolongations, and speech blocks [58], recent research on stuttering has underscored its emotional and cognitive impact on people who stutter [7, 77]. Stuttering comes with substantial social penalties, including negative listener reactions, bullying and teasing, social harm and rejection, and stereotypes of being less intelligent, less capable, less attractive, less socially competent, and more anxious than fluent speakers [8, 15, 20, 23, 25, 28, 77, 85]. As a result, people who stutter (PWS) often develop strong emotional and cognitive reactions towards stuttering, including feelings of fear, guilt, shame, helplessness, social anxiety, self-stigma, as well as avoidance of certain sounds, words, situations, people, and relationships. Despite the success of a few notable people who stutter - such as President Biden, research shows that people who stutter are structurally disadvantaged and have an overall reduced quality of life: stuttering is associated with less satisfying personal relationships, higher risk of mental health problems, lower educational attainment, underemployment, and 20% - 35% reduced earnings compared to people who do not stutter [20, 34, 77].

Rooted in ableism and stigmatization, the marginalization of people who stutter is often exacerbated by and materialized through communication technology. For example, as many people who stutter find phone calls more difficult than in-person conversations, phone interviews and phone conversations at work create barriers to employment for people who stutter [34, 42]. As we enter a new era in which videoconferencing becomes the dominant and normalized mode for interpersonal and professional communications, it is crucial to understand its impact on people who stutter. Despite its widespread adoption, videoconferencing comes with unique challenges, such as the reduction of non-verbal cues [5, 57], turn-taking confusion, connectivity/technical difficulties [51], and generally "Zoom Fatigue" [5]. While most of these challenges are also experienced by the general population, a recent study showed an amplified effect on people with aphasia that made it even more challenging for them to stay connected during the pandemic [57]. We thus hypothesize that people who stutter also face greater challenges with videoconferencing, and such challenges impact not only communication productivity but also the social-emotional wellbeing of people who stutter. In this work, we explore the experience with videoconferencing technologies of people who stutter through interviews with 13 adults who stutter. The interviews and data analysis were conducted to understand the benefits, challenges, and coping strategies for people who stutter during video conferences, in comparison to in-person meetings.

This paper provides a unique contribution to HCI and accessibility research by presenting, to our knowledge, the first formal study of the lived experiences of people who stutter with video conferences and videoconferencing technologies. Informed by previous work on videoconferencing challenges for the general population [5, 30, 51, 53] and people with disabilities [49, 57, 66, 75, 79, 87], our study emphasizes the emotional and cognitive impact of such challenges beyond observable outcomes such as communication

accuracy and efficiency. By examining how videoconferencing technology interacts with core elements of the stuttering experience such as stigma, avoidance, and acceptance, our study uncovers challenges that are unique to PWS - such as keeping their speaking turn through stuttering blocks, as well as known videoconferencing challenges that have an amplified effect on PWS - such as the lack of emotional connection with the audience and the mental stress of seeing oneself on camera. While most of our interviewees reported spending extra effort to participate in video conferences due to such challenges, they also identified various benefits of videoconferencing for PWS, including the increased connectivity within the stuttering community, and general public empathy towards communication disruptions. Taken together, our work sheds light on the structural barriers and the opportunities for PWS to effectively communicate and emotionally connect with others via videoconferencing.

2 BACKGROUND

2.1 Stuttering

Stuttering is a genetic, neurodevelopmental condition that impacts people who stutter in behavioral, emotional, and cognitive aspects [7]. Illustrated by the "stuttering iceberg" analogy, the observable behaviors associated with stuttering, such as speech disruptions and facial tension, are only the "tip of the iceberg", and most of the affective reactions to disfluencies - including fear, guilt, shame, and helplessness - lie below the surface [69]. These negative affective reactions often lead to an increased level of social anxiety and self-stigma, and over time develop into cognitive reactions such as "avoidance strategies" to cope with the fear with stuttering and pass as fluent [7].

The hidden nature of these emotional and cognitive challenges also leads to limited visibility and public awareness of struggles and needs of the stuttering community. Despite clearly documented social and occupational disadvantages associated with stuttering, people who stutter are rarely offered or ask for reasonable accommodations, such as extra speaking time to account for unpredictable blocks [20]. As a result, people who stutter often need to go through interview processes with disabling barriers or get passed over on career opportunities that involve verbal communications [14]. This work aims to contribute to the public knowledge on the experience of people who stutter - and the barriers they face - in professional and social communications mediated by videoconferencing technologies.

Our research is also inspired by the recent breakthrough in stuttering research and therapy that emphasizes the subjective experience of stuttering rather than the perspectives and observations of the listeners [21, 77]. This epistemic shift led the field to understand that the biggest struggle with stuttering moments is not the disfluencies but the feeling of "being stuck" and "losing control" [59, 77], and people who stutter find it most satisfying when their speech is spontaneous, regardless of how fluent it is [21]. Combined with the theoretic framework from the social model of disability, these insights empowered the stuttering community to push back on the listener-oriented, fluency-focused notion of stuttering as an impaired, undesirable form of speech, and advocate for the right to stutter in public life [20]. Following a similar approach, we collect

and study first-person accounts and reflections from people who stutter, of their experience with video conferences and videoconferencing technologies, to unpack the *emotional* and *cognitive* impact imposed by these technologies on people who stutter, beyond what is typically observed by third-parties, such as other meeting interviewees, employers, and communication researchers. Our findings highlight the significant *hidden costs* people who stutter have to pay in order to effectively participate in video conferences, calling for structural changes in videoconferencing technologies as well as the meeting culture to create a more inclusive and empowering digital communication environment for all.

2.2 Assistive Technologies for People Who Stutter

Despite the prevalence of stuttering [58, 73], little research efforts have been devoted by HCI and Accessibility researchers to understanding and improving the experiences of PWS with technologies. A search of the keywords "stutter" or "stammer" over the proceedings of CHI, CSCW, and ASSETS conferences in the past 20 years ('02 - '22) only returned 3 research articles [6, 32, 55] and one poster paper [26].

Although underrepresented in the HCI literature, the experience of stuttering is nevertheless shaped by technology. For example, many people who stutter find it more challenging to speak over telephone, and as a result tend to avoid phone calls and even job opportunities that involve phone calls [42]. Speech operated technologies, such as smart speakers and automated phone menus, can also introduce new accessibility challenges for people with speech disfluencies [6, 56], creating degraded user experience and additional barriers for the stuttering community [64, 81].

2.2.1 Technology-mediated Interpersonal Communication. Existing technical efforts that support PWS through interpersonal verbal communication challenges follow roughly two approaches depending on the subject they operate on. The first approach aims to **manipulate the speaker** and make PWS speak more fluently. For example, delayed auditory feedback (DAF) devices [74] and their smartphone equivalent (e.g. DAP Pro[1]) enable their users to hear themselves speaking with a slight time delay, creating the "choral effect" that is known to induce temporarily fluent speech [45]. Similarly, leveraging the fact that PWS often stutter less when whispering [60], Whispp digitally transforms the input whispering speech by PWS into a "clearer and more pleasant" voice through its AI-powered microphone App [82]. A recent work by Ghai and Mueller introduced a speech writing tool that provides AI suggested substitutions for words that are more challenging to speakers who stutter [32]. On the other hand, the second approach by assistive technology for PWS in telecommunications seeks to **manipulate the speech** without necessarily changing the behavior of the speaker. For example, Google recently launched Project Relate, an app targeted at people with non-standard speech, with a *Repeat* feature that repeats what the user said into a "clear, synthesized voice" [17]. Although there has been no formal research on the effectiveness of the second approach to the best of our knowledge, technologies following the first approach are known to have clear

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[1]https://speechtools.co/daf-pro

drawbacks: DAF devices are reported to have their effect worn out over time, lead to louder and higher pitched (shouted) speech, and prevent the speaker from hearing outside sounds [36]; whispering can strain vocal chord and cause supraglottic hyperfunction [65]; and word substitution - as a form of concealing stuttering - can lead to reduced self esteem and quality of life for PWS [11]. Moreover, all of these technologies focus on "fixing" or "masking" stuttering speech rather than embracing it, reinforcing the ableist assumption that stuttering is inferior and unacceptable [31] - an idea that the stuttering community has been actively pushing against [16, 20].

2.2.2 Speech Operated Technologies for People Who Stutter. There has been a small but emerging body of research investigating the experience of PWS with speech interfaces. For example, a recent work by Bleakley *et al.* [6] conducted diary studies and semi-structured interviews with 11 individuals who stuttered to understand their experience with smart speakers. Their study showed existing challenges (e.g. saying certain device woke words) as well as opportunities (e.g. access to speech and language therapy) for this user population, highlighting the need to include PWS in the design process of smart speakers. Similarly, Clark *et al.* called out the importance of considering diverse speech patterns in developing speech technologies and identified the key challenges for inclusive speech interfaces [19].

On the technical side, current work on improving speech interfaces for PWS has primarily focused on: 1) collecting and curating datasets with stuttering speech; 2) tuning automatic speech recognition (ASR) models to better detect and recognize stuttering speech. Started as resources for speech therapy, several datasets with speech samples from stuttering individuals have been developed, including the FluencyBank [63], University College London's Archive of Stuttered Speech (UCLASS) [37], the SEP-28K dataset from public podcasts [50], and the LibriStutter dataset with synthesized stutters [48]. Although these datasets have enabled progress in ASR for stuttering speech, they are limited by the amount of data and the lack of consistent annotations for ASR tasks [50]. Nevertheless, leveraging these datasets, researchers have explored different techniques to better detect stuttering events [1, 47, 48, 50, 70] and auto transcribe disfluent speech [2, 35, 54, 56, 72]. While these works reported various success in improving the detection accuracy and reducing the word error rate (WER) in machine transcriptions over existing stuttering datasets, little is known about stuttering users' experience of these ASR systems in real world scenarios [6], highlighting the epistemic disconnection between the subjective experience of stuttering and the scientific research on stuttering [19, 31, 55, 77].

2.2.3 Technology for Stuttering Therapy. Lastly, there have been some efforts on digitizing self-therapy for people who stutter. Some programs guide people through fluency shaping techniques with instruction videos and virtual coaches (e.g. Stamurai[2], BeneTalk[3]), and others offer mindfulness exercises and self-reflection prompts specific to mental health challenges with stuttering (e.g. Buddo, StammerApp [55]). However, no formal evaluation of these systems by PWS has been published so far, except for the StammerApp [55], which is not commercially available today.

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[2]https://stamurai.com/
[3]https://www.benetalk.com

Overall, we see the gap in the research and development of technologies regarding stuttering, and intend to contribute to the literature of HCI and accessibility by uncovering the needs and opportunities for technologies that empower PWS in the increasingly technology-mediated verbal communication environment of today. Moreover, with the lack of perspectives and involvement of PWS in current design and research of speech and communication technologies [6, 19, 55], this work makes epistemic contribution by directly engaging with PWS and foregrounding their voices and agency regarding videoconferencing.

2.3 Videoconferencing Experience by People with Disabilities

Since its conceptualization [3], videoconferencing and videoconferencing technologies have gained market popularity by enabling real-time conversation across distance with increased modalities and affordance over traditional communication technologies such as the telephone [29, 39]. Despite several well-known issues with videoconferencing - such as the challenge with maintaining eye contact [68, 80] and surveillance effect of the camera feed [12] - videoconferencing was widely adopted during the Covid-19 pandemic, and has since become a prominent channel for professional and personal communications [38]. Following this shift, recent research has discussed the challenges arising from excessive videoconferencing in professional settings, such as "Zoom Fatigue" [5, 53] and constant distractions [51], and attributed the causes of such challenges to social and technical factors such as nonverbal overload, close-up gaze, extended screen time, reduced mobility, heighten self-awareness from self-view, and technical/connection difficulties.

Researchers have studied the use of videoconferencing technologies by people with disabilities, identifying both benefits and accessibility challenges with videoconferencing. Tang *et al.* conducted an interview study with 25 individuals with different types of disabilities about their telework experience [75], finding that, while videoconferencing significantly reduced mobility barriers and offered some flexibility and control over one's meeting experiences, it also brought additional challenges to people with disabilities. For example, people with visual impairments needed to simultaneously manage two independent audio streams (one by screen reader, one by other people talking) from the computer, d/Deaf and hard of hearing (DHH) individuals had trouble being "seen" in the voice activated speaker view when participating using sign language, and people who are neurodiverse reported increased cognitive efforts to maintain eye contact and manage the video presentation of themselves during video calls. The additional emotional and cognitive burden for autistic users of videoconferencing technologies was also reported by Zolyomi *et al.* in their 2019 interview study with 22 autistic adults [87]. In particular, their interviewees reported feeling self-conscious and uncomfortable with close-up camera view by oneself and others, and often turned off their own camera and the video feed of other meeting participants as a result. The interviewees also adopted strategies to "masking" their neurodiversity through neurotypical behaviors such as engaging in small talks and making eye contacts. [49, 66] examined the accessibility of videoconferencing for d/Deaf and hard of hearing (DHH) community, calling out unique challenges such as getting

attention of others, turn-taking with captioning and interpreting delays, and managing visual attention over the current speaker, ASL interpreters, other meeting participants, and live captions. Different from [75], in which DHH users reported finding it easier to read the lips and facial expression of the speaker over VC, [49, 66] discussed the challenge with lower visual clarity due to cluttered background and poor lighting of the speaker/signer. Recently, Neate *et al.* studied the experience of videoconferencing for people with aphasia through naturalistic observations, interviews of people with aphasia, as well as interviews with speech and language therapists and support volunteers who worked with people with aphasia via VC during the pandemic [57]. In addition to observing commonly shared challenges such as turn-taking confusion caused by network delays [46] and 3rd-party distractions [51], their work highlighted the importance of "total communication" strategies (e.g. props, gestures, body language) for people with language impairments in contrast with the lack of support for non-verbal communication channels by current VC technologies.

Our work contributes to this area of research by presenting the experiences of videoconferencing by people who stutter - a population that have traditionally faced systematic challenges in in-person communications but have not been included in the HCI/CSCW research of video-mediated communications. While we see parallels with other communities - such as the anxiety with seeing oneself on video [75, 87], the cognitive efforts to "pass" as typical [75, 87], and the need for broader non-verbal communication channels [57, 66, 71], our study also uncovers unique and amplified challenges for PWS to participate in video calls. We hope our work will deepen current understanding on accessibility challenges for videoconferencing and inspire the design and development of a more inclusive videoconferencing experience for all.

3 METHOD

We conducted semi-structured interviews with adults who stutter from the US and UK to learn about their experience of videoconferencing.

3.1 Recruitment

The interviewees were recruited directly by the author, through online speech therapy groups, virtual and in-person stuttering community events, and social contacts. To qualify for this study, the interviewees were required to: 1) self-identify as a person who stutters; 2) use VC technologies at least once in the past 3 months. These criteria were put in place to ensure the interviewees were from the targeted community with meaningful insights about VC and VC technologies. We did not screen people based on stuttering severity since most of the emotional and cognitive struggles with stuttering are shared by PWS with little or none observable disfluencies [18, 23]. We also did not require the interviewees to be geographically co-located with the research team to expand the pool of the potential interviewees. Understanding the multiple forms of suppression at play during professional and public communications, we prioritized the inclusion of interviewees with multiply marginalized identities besides stuttering, such as women, ethnic and racial minorities, immigrants, and English as a Second

Language (ESL) speakers. To do so, we deliberately started the interviewee recruitment process from sub-communities such as women only speech therapy groups, bilingual stuttering support groups, and BIPOC stuttering events, rather than higher-visibility places such as the mailing list of the National Stuttering Association (NSA). We also started conducting interviews as soon as people signed up for the study, and continued the recruitment process in parallel until consistent high-level themes emerged from the interviews.

As a result, we were able to report the results from 13 interviewees, with a significant percentage of them self-identified as women (7 out of 13), people of color (7 out of 13), ESL speakers living and working in an English environment (5 out of 13), and first-generation immigrants (5 out of 13). Table 1 provides an overview of the demographics of the interviewees.

3.2 Interviews

The interviews took place between February 2022 and August 2022 over Zoom videoconferencing system, and were recorded with explicit consent from the interviewees for later transcription. Using VC as a medium for interview not only helped us better contextualize the discussion and reproduce certain situations, but also was necessary as the researchers and the interviewees were all geographically distributed. We chose Zoom over other VC platforms because all interviewees had experience with Zoom and it did not require extra technical setup. However, we did ask the interviewees about their experiences with other VC technologies to gather insights beyond the specifics of Zoom. Cognizant of the potential challenges and discomfort for people who stutter to speak over Zoom, we made conscious efforts to create an accommodating environment for interviewees to speak freely and comfortably. For example, for multilingual interviewees, we conducted the interview in their preferred language (e.g. P4 in Mandarin Chinese) rather than in English. The transcription was later translated by the author for analysis and reporting purposes. While respecting the interviewee's time, we always left ample time after the scheduled interview slot and let the interviewees know that there was no time pressure for them to speak fast or concisely. Additionally, all but two (P1, P10) interviews were conducted by a research team member who identified themselves as a person who stutters to the interviewees and showed stuttering behaviors during the interviews. As a result, the length of the interviews varies, lasting between 45 mins to 1.5 hours. None of the interviewees displayed severe stuttering during the interview or used an augmentative and alternative communication (ACC) device. The interviewees were not compensated.

The interviews were structured with the following four components.

(1) *Personal background and characteristics of one's stuttering.* Stuttering is not monolithic, and our interviewees described their stuttering in terms of the speech and non-speech challenges with stuttering, impact of stuttering, coping behaviors, and current attitude towards stuttering. This helped us assess the representativeness of our interviewees to the stuttering community, and understand the challenges with videoconferencing in relation to the speech/behavior, affective, and cognitive aspects of stuttering. When asking about

Table 1: Background Information of Interview interviewees

ID	Gender	Country	Occupation	Self-identified Stuttering Characteristics
P1	F	US	Software engineer	Covert, filler words, blocks, word substitution, loss of eye contact
P2	M	UK	Professional athlete	Covert, blocks, word substitute, raising heart rate, sweat
P3	F	UK	Ophthalmologist resident	Covert & mild, avoid sounds, reorder words
P4	M	US	Postdoc researcher	Blocks, word substitute, struggle more with starting vowels
P5	F	US	SLP grad student	Blocks, some repetition
P6	M	US	Product designer	Mild to moderate, blocks, backtracking, word substitution
P7	F	UK	SLP	Stutter openly with little struggle
P8	M	US	Medical student	Filler words, pauses, tongue clicks
P9	F	UK	University staff	Covert, blocks, some repetition, word substitution
P10	F	US	PhD student	Blocks, repetition, some prolongation, facial tension
P11	M	US	UX researcher	Covert, speak slowly, word substitution
P12	F	US	Geospatial analyst	Covert, mild, blocks on names
P13	M	US	Program manager	Blocks, word substitution, look away when stuttering

Table 2: VC Context and Technology Use

ID	VC Frequency	Platforms (most to least used)
P1	Several times a day for work; weekly with family & friends	Zoom, Google Meet, MS Teams, WeChat
P2	4-5 times a week for work; daily with family & friends	Zoom, Microsoft Teams, Facetime
P3	Several times a week for work & school	Zoom, MS Teams, Google Hangout
P4	Several times a week for work; weekly with other PWS	Zoom
P5	All classes for master program; weekly with other PWS	Zoom, Google Hangout
P6	Several times a day for work	Zoom, Slack calls, MS Teams
P7	Several times a week for work	Zoom
P8	1-3 times a day for work, several times weekly with other PWS	Zoom, Google Meet, MS Teams
P9	Several times a day for work, weekly for therapy	Zoom, WebEx
P10	Several times a day for work & school, weekly for church	Zoom, FaceTime, WebEx
P11	Several times a day for work	Zoom
P12	Daily for work	MS Teams, WebEx, Zoom
P13	Several times a day for work	Zoom

the characteristics of one's stuttering, we asked the interviewees to describe their stutter/stammer in their own words, with prompts such as "how does it sound like", "what do you feel like when you stutter" to help the interviewee to elaborate. We also asked about the situations when they have the most or least struggle with their stutter, as stuttering often varies with speaking situations [22, 78]. To understand the interviewee's attitude towards stuttering, we drew on the literature of self-stigma and openness towards stuttering [10] and asked about when and with whom they have disclosed their stutter to, if any.

(2) *Use of videoconferencing technologies*. We asked about the frequency of videoconferencing, top use cases for videoconferencing (e.g. school, work, community, friends & family), as well as the types of videoconferencing technologies used (e.g. Zoom, Google Meet, Microsoft Teams, Skype, Facetime, etc) in the past 6 months.

(3) *Experience of videoconferencing*. We asked about interviewees' general experience of videoconferencing in comparison to in-person meetings: whether they find one more challenging than the other, and in what situations. We also asked the interviewees to reflect on the top challenges and benefits they experienced with videoconferencing, as well as the role of stuttering in those experiences. We also inquired about the strategies interviewees have developed to manage their videoconferencing experiences.

(4) *Future of videoconferencing*. We brainstormed with the interviewees for technical or non-technical ways to make videoconferencing easier and more pleasant for them and/or for the stuttering community in general.

The interviews were transcribed and analyzed using inductive qualitative methods drawn from grounded theory [13]. The research team first reviewed the transcripts of two interviews to identify key ideas. Two researchers then coded all transcripts, and reconvened to review and discuss the coded material. We used affinity diagrams

to organize these ideas into the themes and sub-themes presented below.

4 FINDINGS

Here we present the themes that emerged from our interviews. All interviewees had used videoconferencing in both professional and personal settings, and identified various challenges and benefits with videoconferencing compared to in-person meetings. While the top challenges - such as limited non-verbal channels, seeing oneself in the video, and more difficulties with turn taking - overlap with VC challenges identified by the general public and other disability populations [33, 46, 57, 75, 87], their impact is exacerbated by the behavioral, affective, and cognitive characteristics of stuttering [7], making videoconferencing an emotionally charged and cognitively exhausting experience for PWS.

4.1 Context for Videoconferencing

Similar to the general population [38], our interviewees underwent a sharp uptake in videoconferencing due to the COVID-19 pandemic, and expected an increased amount of videoconferencing for work and community involvement to persist post pandemic. However, the learning curve for videoconferencing could be significantly steeper for PWS, as they adopt a whole set of speech behaviors and communication strategies for videoconferences. As a result, PWS could pay a higher cost when switching to videoconferencing, experiencing substantial speech blocks and disengagement from the conversation. Besides the professional setting, PWS also used videoconferencing to participate in speech therapy and connect with other people who stutter, building channels where they could seek guidance and support for videoconferencing related communication challenges. Our interviewees also juggled with the choice of embracing or concealing their stuttering identity during work videoconferences, selectively disclosing their stutter depending on the situation and the social relationships with other VC participants.

4.1.1 Use Cases and Frequency. We summarize the context and frequency of videoconferencing for our interviewees in Table 2. All interviewees have used videoconferencing predominantly for professional purposes such as **work and school**, especially since the outbreak of COVID-19 pandemic. Besides regular work meetings, several interviewees (P1, P3, P4, P11) have also gone through job interviews via videoconferencing in the past year. Another common use case for videoconferencing by our interviewees is to participate in **community events**, such as virtual events and support groups for people who stutter (P4, P5, P8), and online bible study for P10. Videoconferencing for **speech therapy** was also popular among our interviewees: several interviewees (P1, P2, P3, P9) have received speech therapy through videoconferencing, and two interviewees (P5, P7) have provided speech therapy over video calls since the pandemic. Some interviewees (e.g. P1, P2) also mentioned using video calls to keep connected with **friends and family**, especially during the COVID lockdown. Note that the use cases for stuttering community events and speech therapy are likely over represented in our sample since we seeded our recruitment process from virtual speech therapy groups and online stuttering support groups.

All interviewees have been participating videoconferences at least several times a week for the past 6 months, although some people (P2, P3, P4, P5, P7, P9) only started this level of frequency since the pandemic. Although most COVID restrictions had been lifted in countries where our interviewees resided, many interviewees anticipated some professional meetings remained on videoconferencing channels. Some interviewees' work had become permanently remote (P1, P6, P112) or hybrid (P7, P11, P13), making videoconferencing an essential part of their work routine. As P13 recognized, "*Zoom, and virtual, and hybrid working, is never going away. There is still collaboration across coasts, across countries, that is not gonna go away.*" Our interviewees also enjoyed videoconferencing with other people who stutter and expected the virtual community events to continue going forward. For example, both P5 and P8 started hosting regular stuttering community events over Zoom since the pandemic, and were committed to keep these virtual gatherings post pandemic. As for speech therapy, most of the interviewees who received video-mediated speech therapy experience had positive opinions about their experience and some (P1, P9) indicated the interest in receiving speech therapy via videoconferencing in the future. However, P9 found video-mediated speech therapy less effective for her son, who also received stuttering speech therapy over Zoom during the pandemic, and had switched to in-person speech therapy for him when in-person sessions were resumed. While P5 and P7 were transitioning back to providing speech therapy in person, they also anticipated offering video-mediated speech therapy as an option for some clients.

4.1.2 Self Disclosure in Videoconferences. The rightmost column of Table 1 summarizes the speech and behavioral characteristics of their stuttering with the keywords used by the interviewees when describing their stutter. The dominant terms, such as "blocks", "word substitution", "repetition", are common speech therapy terminologies that most of our interviewees were familiar with. None of the interviewees identified as having a severe stutter. In fact, several interviewees identified their stuttering as "covert", a type of stuttering with little or no disfluencies that can be effectively passed as fluent speech to the listener [23]. It is equivalent to "interiorized stammering" in the United Kingdom [18], and we use these two terms interchangeably.

For people with mild or covert stutter, masking their stuttering to "pass" as fluent could be a preferable option that protects them from discriminations against stuttering [23]. Indeed, most of our interviewees did not proactively disclose their stutter in professional settings unless the circumstances required so. While most interviewees disclosed in high-stake situations such as job interviews (P1, P2, P11), important presentations (P1, P4, P10), and oral exams (P8). However, P4 chose to conceal his stutter during his most recent job interview on VC, as he worried that showing his stutter would make him a less desirable job candidate - a concrete threat documented by numerous studies [34, 67]. The decision to disclose is also situational and relationship dependent. For example, some interviewees (P6, P11, P13) mentioned that they would acknowledge and disclose their stutter after having a major stuttering moment in a meeting, and some interviewees (P1, P9) only disclosed to people at work who they trusted or considered "need-to-know" (e.g. close teammates, direct manager). To summarize,

our interviewees disclosed their stutter rather selectively at professional settings (except for P5 and P7 who worked as SLPs), as a result, other participants of the VC meetings most often did not know about our interviewees' stutter or associate their speech and secondary behavior with stuttering.

On the other hand, our interviewees readily disclosed their stutter in virtual stuttering community events and reported feeling more at ease when speaking with other PWS over VC. While some interviewees (e.g. P3, P4) found themselves speaking more fluently in stuttering support groups and community meet-ups than in other context, others (e.g. P1) reported having similar level of speech fluency but more mentally relaxed. Similar findings were shown with people with neurodiversity [75], highlighting the significant mental efforts required to selectively embrace or hide one's identity by people with invisible disabilities.

4.1.3 General Sentiment towards Videoconferencing. Our interviewees reported various degrees of satisfaction with their video conferencing experiences. While most of the interviewees agreed that video calls are easier than phone calls with no video, the preference for video conferencing versus in-person meetings varied, depending on the meeting context as well as the amount of experience interviewees had with video conferencing and the video conference platforms. For some (P3, P4, P9), video conferencing is more suitable for small groups or 1-on-1 conversations since it is most similar to the in-person experience; and for others (P2, P6, P11, P13), it is easier to have larger meetings or public presentations over video conferencing platforms than in-person since "*you can change how many people you view on the screen* (P6)". While several interviewees (P3, P4, P10, P12) cited the lower expectation for active participation made it easier for them to attend videoconferences, some (P1, P13) felt more comfortable when they served an active role with control over a meeting's structure and norms.

Our interviewees' sentiments towards videoconferencing also evolved over time, especially after spending more time videoconferencing since the pandemic. For example, P4 found "*video calls were a nightmare for me, at least at the beginning*", as he would have extended speech blocks only over VC. However, after videoconferencing for work for over two years, he felt "*now I am getting used to this nightmare.*". Similarly, P9 went through an adjusting period with VC since the pandemic, and found her comfort level with VC versus in-person is "*50:50*" at this point, because of "*the amount of time we used it, just the practice we have had*".

Some interviewees found themselves so accustomed to speaking in video calls that they actually preferred videoconferencing over in-person interactions for certain situations:

> *With work, on VC, I stutter much less because I got used to. Because I work on software, I have been working remotely for the past few years, I lost some muscle memory of that kind of (in-person) interactions. Having small talks with people in person, as an introvert, that was difficult.* (P6)

> *In terms of me leading a meeting, or facilitating something, events like if I'm in the hot seat, at this point - that I never would have said this before the pandemic - I would actually rather do it virtual. I actually don't have a lot of experience facilitating, or panel, in person,*

> *because a lot of those opportunities came to me during the pandemic. The idea of doing a live TED Talk freaks me out, but I've just done a half hour presentation over the computer, and I loved it!* (P13)

4.2 Videoconferencing Benefits for PWS

Although the usage and context for videoconferencing varies, all of our interviewees saw some benefits of videoconferencing, throughout the Covid pandemic and extending into the future. While these benefits can also be appreciated by other populations, they meet specific behavioral, emotional, and cognitive needs of people who stutter, and were thus highlighted by our interviewees.

4.2.1 Reducing Mental Barriers to "Show Up". Research has shown that adults who stutter suffer from heightened social anxiety and are more likely to avoid social situations as a result [40]. The avoidance behaviors (e.g. not showing up, avoiding speaking, avoiding eye contact) would then elicit negative responses from others and reinforce existing social anxiety [61]. Modern speech therapy research and practice has accumulated evidence that by reducing avoidance behaviors, people who stutter can break from this vicious cycle to live and speak much more comfortably [18, 40].

Similar to how videoconferencing reduced the physical barriers for people with mobility challenges to participate in meetings [75], it also reduced the mental barriers for our interviewees to "show up" to meetings and social events, through multiple mechanisms.

First, compared to in-person meetings, the process to schedule and join a meeting is easier via videoconferencing technologies. P8 noted "*the ease of joining meetings*" as one of the biggest advantages of Zoom and commended Zoom for "*making it easiest possible for people to find and join meetings*".

Second, videoconferencing affords more control over one's visual presentation. Being observed during a stuttering moment is a major source of anxiety for people who stutter [40], similar to the insights from research with neurodiverse individuals [75, 87], our interviewees (eg. P3, P4) reported finding a sense of psychological safety in larger meetings with the ability of mute themselves and turn off the camera. When they had to turn on the video, our interviewees carefully curated their video presence to fit in with the majority and mitigate the potential biases and discrimination against their stuttering, especially when they possessed other marginalized identities besides stuttering:

> *It's easier to control how I am being perceived when all you can see is a square. I'm 5'3, I am a small Caucasian woman. I'm not tall, and I'm not a man. A lot of my colleagues are men, my clients are men, the leadership are typically male, so I want to look tall when I try to introduce myself. That - in my mind - creates a little bit more of an even playing field. I think that kind of makes me feel more comfortable. It's a very controlled setting.* (P12)

Third, videoconferencing offers PWS more flexibility and control over their meeting environment. People who stutter often have more speech difficulties in new and unfamiliar environments [27]. Consistent with the findings with other disability populations [75], videoconferencing makes it possible for people who stutter to participate in a wide range of speaking situations while staying in a

familiar and accessible environment that is customized to their preferences and needs. Many of our interviewees took advantage of this aspect of videoconferencing to curate their physical environment and noted its positive mental effect:

> *I feel comfortable, I'm in my house, I'm in my chair, I'm very comfortable with my setup here. I have two screens.* (P13)

> *I certainly try to create a working environment that feels very positive to me. It's a way I can shape my environment to make me feel more comfortable, and also feel like I have a personality that I am presenting. So that you are not focusing on my stutter.* (P12)

> *I can manage my energy a little bit better on VC, because you are in your own environment. For people who stutter, going to a bar is very challenging, the office can have a similar effect.[...] you just have more control on VC than in-person environment.* (P6)

Besides the control over their physical environment, videoconferencing technology also allowed our interviewees to customize the virtual environment. By adjusting the position, layout, and size of the display of their audience and conversation partners, several of our participated indicated gaining the sense of "in control", especially when speaking to authority figures and in bigger groups - settings that are generally more challenging for people who stutter [27]. As P6 explained: "*the other thing with VC is that it can be one or with a thousand people, you can change how many people you view on the screen. VC makes it easy for you to speak to a larger group. [...] I will be more anxious in person for larger group meetings, maybe even holding the mic is a different dynamic, versus on Zoom, it doesn't feel too much different to me, one person or a thousand people*". While the need and desire to customize one's virtual meeting view have been reported by research with the autistic and DHH communities, its effect on PWS is more to reduce social anxiety, same as for people with neurodiversity [75, 87], and less for better management of visual attention for DHH individuals [49, 66, 75].

4.2.2 Masking Stutter. As most of our interviewees only selectively disclosed their stutter in professional settings, they appreciated the nature of videoconferencing and the design of VC technologies that enabled them to better manage impressions and mask their stutter in meetings.

Videoconferencing also allows our interviewees to utilize existing or new strategies to manage their speech, without drawing unnecessary attention to their struggle. For example, both P1 and P12 mentioned the strategy of rehearsing what they wanted to say beforehand with both microphone and video turned off. P12 gave the example of rehearsing her self-introduction in a video call:

> *When I know I have to introduce myself, but I am a little nervous because it's a new group, or in front of leadership, and so I want to impress them. So I won't have my audio on, I won't have my video on, I will just quietly say to myself and I'll practice my breath work with it, so that I can add the skillset I have to try to mitigate any disfluencies, [...] just to make myself more confident. I will probably do that, like, 30 seconds before, or even before the meeting starts.* (P12)

Other speech and identity management strategies that worked particularly well for our interviewees over videoconferencing include squeezing a stress ball (P1), tapping the feet (P1, P6), turning off the camera when struggling with facial tension (P6, P12), blaming the Internet connection for speech blocks and long pauses (P2, P3, P11), and using fluency-inducing technologies discreetly (P4).

After having a terrible experience with a job interview over the phone, P4 used DAF Pro, an smartphone app that let its user hear themselves speaking with a 60 ms delay, for a job interview via videoconferencing. While P4 managed to have "*perfect fluency*" during the interview process and passed the interview, his speech challenges reoccurred shortly after starting on the job, as the effect of delayed auditory feedback (DAF) worn out - a common phenomenon for DAF users [36]. As a result, P4 now struggled with not only speech difficulties, but also the feeling of embarrassment and guilt at the workplace:

> *I felt a little bit guilty that I spoke very fluently during the interviews by using the DAF app, but showing stutter afterwards. I don't want my supervisor to think that I cheated. I wanted to be an honest person, but during the interview I did want to cover up the fact that I stutter, so I didn't disclose during the interview, and I was also a bit worried that my stuttering would impact whether they give me the offer. I am a bit embarrassed now.* (P4)

In addition to speech disfluencies, people who stutter often struggle with secondary stuttering behaviors, such as facial tension, flushing, sweating, and sudden head and body movements [7]. While most of these behaviors are involuntary, they can trigger negative social reactions due to the stigma towards stuttering [7]. Several of our interviewees called out the benefit of videoconferencing as to hide their secondary behaviors more easily when they stuttered. For example, P1 perspires more when she stutters, and often worries that others would see or smell her sweat at in-person meetings. Videoconferencing largely eliminated this worry for her, reducing her stuttering related anxiety during meetings. Similarly, P10 noticed, "*I sometimes get really shaky if I'm presenting in person. But if I'm presenting on Zoom, I am already sitting down so it's okay. And nobody can see me even if I'm shaking*".

Distinct from "masking" strategies (e.g. making eye contact, engaging in small talks) reported in research of videoconferencing experiences with neurodiverse individuals [75], the strategies shared by our interviewees are facilitated or made possible by videoconferencing. On the other hand, similar to masking autism [75], masking stutter also requires significant cognitive efforts and could lead PWS to feel more stressed and less capable of engaging in the conversation [10]. However, most of our interviewees still appreciated the flexibility and control offered by videoconferencing over their stutter and stuttering identity, and cited the ability to mask stutter as a benefit of videoconferencing.

4.2.3 Connecting with the Stuttering Community. With stuttering being marginalized socially and the stuttering community scattered geographically, stuttering is often a very isolating and isolated experience. While research has found the effect of stuttering support groups at boosting self-esteem and self-efficacy for PWS [9], the self-stigma towards stuttering could prevent people from meeting and connecting with other people who stutter [11].

The ease of finding and joining meetings and the option to participate anonymously make videoconferencing an effective tool for our interviewees to reach out to the stuttering community, even when they were not yet in acceptance of their stuttering identity. For example, P5's journey of self-acceptance began with a weekly global support group meeting over Google Hangout that she participated passively and anonymously without turning on her camera or microphone. With the support of the group, she gradually became comfortable "coming out" as a person who stutters and eventually started a Chinese-English bilingual stuttering support group over Zoom, with people joining from China, US, and Europe. Similar to P5, almost all the attendants from China first joined the meeting with a pseudonym and camera off; over time, people started showing their faces and introducing themselves. Through this experience, P5 believed that "*Zoom played an important part in my education and in my healing journey*" - a sentiment shared by many other interviewees of our interview study. P1, P2, P3, and P9 started acceptance-based speech therapy and meeting other people who stutter since the pandemic, only through videoconferencing. P8 remarked on the community connections that were made possible through videoconferencing: "*the world has become more and more connected. Now, on a regular basis, I talk to people across the world, because people are used to Zoom. I know people across the world who stutter, that is a blessing.*"

4.2.4   Increased Public Empathy for Communication Challenges. As COVID-19 disrupted lives and blurred work-life boundaries, research also showed that people have developed increased empathy towards others since the outbreak of the pandemic [4]. In the context of video conferencing, our interviewees noticed that people have become more patient and more understanding with communication challenges, which alleviated some pressure for them to speak fluently. As P3 noticed, "*even fluent speakers have difficulties on Zoom, having challenge of being heard is more understood now*".

As disruptions to videoconferencing became more salient [51], meeting participants, as well as videoconferencing technologies, have developed more ways to anticipate and accommodate different ways to participate in meetings. All but two interviewees mentioned the "hand raising" function in Zoom, and found it effective at getting people's attention when it was understood and enforced as the norm. Chat is another feature that some interviewees appreciated, especially when it was monitored and used by other meeting participants. Compared to in-person conversations, P2 felt typing in the chat is more socially appropriate over VC meetings, as "*in some way you can avoid having to speak, it does give you that option; whereas when you are face to face, it's be a bit strange to text them, or email the message.*". However, several interviewees also found the chat "ancillary"(P11), "unnoticeable"(P3), and "distracting"(P4), and would not participate through chat unless someone was actively monitoring and addressing it (P1, P3, P10, P11). The reaction feature in Zoom was not as popular, although a few interviewees (P8, P10, P13) did use it as a way to actively participate in virtual meetings. Besides the functionality of videoconferencing platforms, interviewees also made use of the asynchronous communication channels:

> *In distributed work, there are other ways for you to speak up. You can "speak up" in documents, you can*

> *"speak up" in posts. I think that's extremely valuable. I think it is definitely something I have leaned on more. [...] There are just more options to speak up in different ways.* (P6)

Overall, our interviewees saw a cultural shift towards more inclusive meeting expectations and behaviors that empowered everyone to speak up. As P6 noted, "*10 years ago, it was perfectly acceptable to just have one person speak in the entire meeting; but now, if there is only one person speaking, I will definitely call it out*".

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Our interviewees were excited to embrace the more empathetic meeting culture and leveraged videoconferencing to redefine meeting dynamics and norms. For example, P13 has been hosting training on virtual meeting best practices at his workplace, promoting for a more inclusive, accommodating communication environment for all:

> *I want everyone to use the same, or similar practices, when it comes to communicating through the computer. Because if we all use the same, best practices, everyone is better off, not only the people you presenting to. If I model behavior, that might trickle to the next meeting.* (P13)

4.3   Videoconferencing Challenges for PWS

Despite benefits, videoconferencing and videoconferencing technologies also introduced additional challenges for people who stutter to engage and participate in meetings and conversations. While some of the challenges are a direct result of speech related communication difficulties (e.g. people/systems mistaking a pause as the end of speech), the bigger part of the challenge comes from the significant amount of emotional and cognitive effort required to manage one's speech and identity over a communication environment where our interviewees's existing "total communication" strategies - such as body language and emotional connections with the audience - are under supported, whereas their struggle with stuttering were directly exposed and exacerbated by the close-up view of one's facial features and the preset feature of self-view. As P5 pointed out:

> *On Zoom, your voice is so much important for you to communicate than before. They can not see your body, your gestures, your words carry more meaning, you have to impress people with your words, for someone who stutters, that's a disadvantage.* (P5)

P2 also noted, "*I have to focus so much on trying to say the right thing at the right time and then also alongside managing the stammer*", and as a result the top emotional reactions he had with video conferences were "*exhausting*" and "*not rewarding*". While the exhaustion and dissatisfaction from VC meetings was shared among many people who do not stutter [5, 66, 75, 87], they could create emotional and cognitive burdens that reinforce some of the most negative impact of stuttering, preventing PWS from engaging and enjoying communications via videoconferencing technologies.

In the rest of this section, we report three major challenges with videoconferencing identified by our interviewees, together with the corresponding coping strategies they developed.

4.3.1 Stress and Distractions with Self-view. Numerous studies have shown seeing oneself in a mirror can induce self-evaluation and distress [5, 30, 83], and the effect is stronger for certain social groups such as women and Asian, as compared to men and White, respectively [62]. Not surprisingly, the "self view" function - a default design in commercial video conferencing systems that can not be turned off in Apple Facetime and Meta Messenger Room - stands out as one of the top challenges with videoconferencing in our data. Almost all of our interviewees indicated some discomfort with the self-view, finding it stressful and "distracting" (P1, P7, P9, P19). P5 considered self-view as a "*curse*" in which "*you have to face your worst fear as a person who stutters*", highlighting the additional stress it brought to PWS over in-person meeting: "*before, when you talk to a person, you don't necessarily see your own face; seeing your own face puts the person who stutter in a direct confrontation with your stuttering*".

Although the mental stress with self view is not unique to people who stutter [5, 75, 87], our interviewees found the impact amplified by existing anxiety and self-stigma around stuttering. As P11 explained,

> *During COVID, people would share that, for the first time, they were very self-conscious in meetings, because they see themselves, and hear themselves, and I was like, 'oh my god, this is the first time that you have been that conscious about how you talk?' Because that's how I am all the time. But now I am like 2x, because I am concerned about how I am coming off but then I am also seeing how I coming off. And it was just like that much mental energy.* (P11)

Similar to people with neurodiversity [75], our interviewees also found the self-view distracting as it directed their attention away from the content and their conversation partners. However, such distractions were also particularly hard for our interviewees to resist, as it highlighted the speech and secondary stuttering behaviors (e.g. facial tension) that PWS are often hypersensitive about.

To mitigate these challenge with the self-view, majority of the interviewees had turned it off, at least for some meetings (P1, P4, P7, P8, P9, P10, P12, P13), or tried to avoid looking at it when it is on (P4, P12). P13 explained his rationale behind turning off self view: "*I turn off my self-view, every meeting of it, so I don't see myself. Cuz I hate to see myself, I hate to see myself talk, I don't need to see. It makes me more self-conscious, it makes me look at myself more. Then, generously speaking, when you turn off your self view, it's more like mimic a real life conversation, because in real life conversations, you are not looking at yourself all the time, unless you are talking to a mirror! You can actually be more engaged with the person you are talking to, if you hide yourself, or no longer caring about yourself, only caring about the person you are with.*" In fact, the impact of the self-view was so detrimental, that P13 deliberately avoided videoconferencing platforms that do not let people hide their self views, and questioned the very idea of self-view in videoconferencing:

> *There are still some platforms, including Room, which is a product from Meta, where you can't turn off your self-view, so you have to watch yourself. So, any meeting I setup, I do Zoom, because, I can do that (turning off self-view). I'd be curious to hear what the rationale is for that as a preset feature, cuz it doesn't make sense to me.* (P13)

4.3.2 Difficulty Getting and Holding One's Turn Using Voice. While the connectivity issue and the lack of non-verbal cues over video-conferencing have created difficulties for taking turns and jumping into a conversation for everyone [5], these difficulties are multiplied for people with longer communication latency, such as people with aphasia [57], DHH individuals [49, 66], and our interviewees.

Many videoconferencing platforms have a speaker focused mode where the video of the current speaker is highlighted. This design makes the first utterance crucial to signal one's intention to speak. However, several of our interviewees found themselves struggling the most when initializing a sentence. With a limited channel for non-verbal communication strategies such as body language over videoconferencing, they would often be held back from cutting into the conversation by that very first word:

> *I find things just like saying "hello", that's probably the hardest bit. The hardest thing for me is starting the sentence of a conversation.* (P2)

> *As a stutterer, it is harder to get your first sound out. Body language is more visible in person. That's particularly challenging. I am trying to say something but before I can say something, somebody also already got the word out.* (P6)

On the other hand, the limited view of all participants in the VC meeting also made it harder for other participants to notice and give people who stutter the space to speak. P7, a SLP who had facilitated group therapy sessions with PWS via Zoom, noted that:

> *In a group situation, and you're stammering, maybe it is hard to indicate that you want to speak. When you are in the same room, you can see more of the body language that you want to speak, versus when we are just in the screen, it's harder to read the room, read the group in the same way. I think we are more focused on just looking at the one person who is talking, and not having the peripheral vision of the whole group.... that's true for everyone, not just for people who stammer, but I wonder whether your stammer adds an extra layer of difficulty that you can't get in.* (P7)

Even after PWS successfully cut into the conversation, they could face higher risk of losing their turn involuntarily due to their stutter. When dealing with an extended stuttering block, P10 also worried that people would assume she's finished and switch the topic. Some interviewees found it hard to differentiate a stuttering block with the loss of Internet connectivity, especially when the block is long and silent: "*if the person is not able to get any sound out, they can't say to people, 'I am not finished yet'; that's the loss of body (language) on Zoom, because often you can tell somebody is still trying to speak based on what they are doing with their body.*" (P7)

To make it easier for them to cut into conversations over VC, our interviewees leveraged videoconferencing features such as "hand raising" and "chat" extensively, and found the hand-raising function relatively effective at signaling their desire to have a turn. However, the interviewees also reported that the "hand raising" was sometimes ignored/unseen - especially when the speaker was in presentation mode. P1 also found the hand raising function stressful, as her speaking anxiety would often build up after clicking the button while anticipating her turn. P10 sometimes raised her physical hand in front of the camera at the same time as she pressed the hand-raising button, in the hopes for signaling her desire to participate more saliently. Some interviewees (P1, P10) also shared that they would not feel comfortable to be the first/only one to use the hand-raising function, if others in the meeting were getting their turns simply by speaking. Our interviewees found the "unmute" function effective at signaling their turn only when such a norm has already been established (i.e. everyone is muted except for the active speaker and the next speaker). However, P6 felt the need to click one additional button ("unmute") also raised the mental barrier to participate.

Another strategy our interviewees adopted for easier turn taking is to proactively set up the structure and norms of participation beforehand. For example, P1 tried always preparing an agenda for the larger meetings she hosted, with speaker name and timing assigned for each agenda item to ensure people on the agenda (including herself) would have their turns. P7 would ask people who did not speak to type out their ideas in the chat, and reserved time to read and respond to all chat messages. P13 would give people a heads-up on who would go next during round-the-room introductions or updates. And P9 would proactively check in with people who did not get a turn or people who had expertise on the topic for things to add.

Our interviewees also developed various strategies to protect one's turn during stuttering moments. For instance, using, and getting everyone else to use, the hand-raising button was found helpful by a few interviewees, as it not only indicated the turn order, but also created a break between speakers, giving PWS more time to unblock themselves before the next speaker cutting in. P7 would double check with people when in doubt, asking whether they were finished, and prevent other people from interrupting before getting an affirmative answer. P10 leaned on the non-verbal signals available on Zoom, keeping her camera on and making her facial expression more pronounced during her speaking turn, even though it felt "tiring" to have her face spotlighted for a prolonged period of time.

4.3.3 Limited Non-verbal Channels to Solicit Emotional Support from Others.
With a strong association between stuttering and social anxiety, people who stutter are more sensitive to negative evaluations from others, and more likely to engage with safety behaviors such as loss of eye contact [40]. While the reduction of social cues during video calls has made everyone feel less connected to their conversation partners [5], the lack of emotional support from others could exacerbate the social anxiety experienced by PWS, causing further behavioral and emotional struggles.

Preconditioned by their previous negative social experiences with speaking, our interviewees were more likely to associate the lack of responses from the audience with the loss of interest or patience with their speech:

> I think when you have a stammer, people can be at times, not intentionally, but unintentionally a bit more impatient with me. [...] In the context of a zoom call, they have the same impatience stance toward you when you are talking, and then they clock off straight away. That you start stammering on the first word and then they go "here we go". I definitely think it is heightened for stammers. [...] Whereas in a face-to-face interaction, [..] people can't clock off as easily without being rude. Whereas in a zoom meeting you can kind of clock out and it's not necessarily, obviously rude.   (P2)

Even when the audience gave responses, they could be interpreted more negatively, especially when non-verbal cues such as facial expression and eye contact were inaccessible. P11 shared the experience of giving a Zoom presentation to his CEO, who used phrases like "alright, let's move on" to communicate that he had comprehended the content of the presentation:

> I think that's a unique challenge for people who stutter, because anytime we are talking, and someone indicates "let's move on", we will always interpret it as "oh they are commenting on my speech, rather than my content". I would say that I am self conscious about it, I spend a lot more time worrying about it. I stayed up last night writing out my slides, because I wanted to be super crisp, even though I don't do that for any other meetings, because I actually find my stutter is worse when I am reading off something, so there is added burden.   (P11)

When asked about most satisfying meeting experiences in the past, several of the interviewees recalled group meetings or conversations where they clearly perceived the appreciation and attention by the listeners. For example, P4 called out one presentation he gave: "one girl in the project was listening very carefully, and I could tell from her eye contact the warmth, acknowledgement, and appreciation. I felt so much better immediately. I was basically fluent throughout the talk."

Our interviewees recognized eye contact as an important channel to build human connections and seek emotional support: "Eye contact is everything. Good eye contact means much more than what you say. Eye contact is indicative of the enthusiasm of your conversation" (P8). Even though many of the interviewees have a tendency to look away when they stutter, they appreciated being seen by their conversation partners and worked on improving eye contact with others in in-person conversations. They had success leveraging eye contact in major blocking moments to "hold the floor" and indicate to others that they are not finished, and getting the emotional support they needed from maintaining eye contact with one particularly friendly audience member. However, the design of most modern videoconferencing platforms has made effective eye contact almost impossible, especially in a group setting:

> It's hard for people to know who to look at on Zoom. In terms of eye contact, who do we keep eye contact with. Even if we all know whom we want to keep eye contact with, do they know that? How can they tell, they probably can't.   (P7)

Videoconferencing also disabled some other strategies our interviewees relied on for social and emotional support in in-person meetings. For example, when attending in-person group meetings, P3 and P10 would choose to sit next to friendly, familiar people to feel more relaxed. Small talks and chitchats before a meeting is another strategy that P10 and P7 deployed to feel more comfortable with a group. P11 have developed a personal "charisma" to compensate for his stutter, and found himself "*less effective on VC*" due to the limits videoconferencing put on communicating "*body language, energy, and interpersonal chemistry*":

> *I like to shake hands, I will give people a hug if I know them. If I am comfortable, I will talk with my hands, I will also be open, I will lean back on my chair, I will think out loud, try to model that this is a space where I hope you can be yourself. I can do that via VC, too, but I think it's much more noticeable when I am in person.* (P11)

To compensate for the lost connections with others, our interviewees strived for extended emotional communications within the boundary of existing videoconferencing design. For example, several interviewees (P1, P8) deliberately lifted the position of their camera to the eye level so that they could mimic the in-person eye contact. Almost all of our interviewees indicated that they were making an effort for maintaining eye contact over video conferences, and some even turned off the self view to better direct their gaze to the conversation partners. Some interviewees tried to make their facial expression more salient by lightening up their faces (P1, P8), putting on make-up (P3), and positioning the camera for a close-up view (P8, P10). And some interviewees (P1, P8, P10, P13) leveraged the reaction feature on Zoom to both give and gather direct, positive emotional feedback. Despite potential speech challenges, some interviewees actively describe their body language and the intention behind it to avoid misinterpretations. For example, P13 would explicitly tell the speaker that he was looking away only to open up the document the speaker just mentioned.

Our interviewees also sometimes leveraged their identity as PWS to better connect with others in virtual meetings. Most of the interviewees had proactively disclosed their stutter in high-stake situations such as job interviews, presentations, and oral exams, and found that effective at reducing mental stress and bringing in audience's emotional support. P13 purposefully embraced the vulnerability that came with the identity as a person who stutters, as a way to invite others to become more open and collaborative in virtual meetings:

> *As soon as I say something deeply personal about my stutter, they go, 'this guy is being open, okay, maybe I will be open, too!' I think the whole modeling behavior is huge over Zoom, and over virtual communications. I always want to model the behavior of being open and collaborative.* (P13)

4.4 Future of Videoconferencing

Although it was not the emphasis of our interviews, we brainstormed and discussed with our interviewee over a wide range of ideas to make the videoconferencing experience more positive and empowering for them and for the stuttering community in general.

We categorize these ideas into some major categories and present them below.

4.4.1 Option to Mask Stutter. Many interviewees found it desirable to have more control over their speech and secondary stuttering behavior, envisioning technologies with the capacity to better "mask" stutter over VC meetings.

The idea of a "voice mask" that auto-filters disfluencies from stuttering speech was discussed heavily by our interviewees. While most interviewees saw the benefit of having the option to sound more fluent in certain situations or for people with a severe stutter, none but two interviewees expressed the interest to use it themselves. The majority of our interviewees believed that technologies like this could potentially undermine their self-acceptance and the space for disfluent speech in our society. On the video channel, P1 also proposed the use of virtual cartoon masks or digital avatars to soften the appearance of facial tension and make eye contact more easily for PWS. However, as pointed out by P7, when it comes to masking stuttering speech or behaviors over videoconferencing, PWS need to consider the trade-off between short-term comfort and long-term empowerment, and set their own boundary between "*reasonable adjustment*" and "*unhelpful avoidance*".

4.4.2 Support Self-disclosure. Inspired by the increasingly common practice of appending pronouns after the participant's name displayed during VC meetings, P11 proposed to also have one's PWS status displayed manually or automatically based on speech recognition. P7 suggested adding a button "I'm not finished" into Zoom, to allow PWS to keep their speaking turn through stuttering blocks. P8 had the idea of having the videoconferencing system detect and show that "X is stuttering" to generate greater awareness for stuttering. As a cultural practice, P11 advocated for broader acceptance and norm around self-disclosing, even beyond stuttering, as he believed that when everyone starts to disclose their vulnerable identities, PWS would experience less stigma and marginalization in VC meetings.

4.4.3 Provide Real-time Therapeutic and Emotional Support. Our interviewees wanted VC technologies to relay the emotional support from the audience without interrupting their speaking flow. While emojis such as "clapping" and "heart" seemed to be designed to serve this purpose, our interviewees found the emojis underused by VC meeting participants and not salient enough for the speaker to notice or experience the emotional connection.

Our interviewees were also excited to have videoconferencing platforms serve as a therapeutic tool for people who stutter, offering them insights and support during stuttering moments and reinforcing positive mental images. For example, the platform could remind PWS to maintain eye contact during stuttering a moment if that is something they are working on, or display personalized tips like "keep moving forward" when a severe speech block is detected.

4.4.4 Adopt Videoconferencing Best Practices. Besides technological improvements, our interviewees also identified and advocated for more inclusive behaviors and a cultural change that could make videoconferencing easier for them.

For VC meeting organizers and facilitators, it is important to plan a meeting with sufficient flexibility in communication methods and timing. P1 recalled that one of her worst VC experiences

was to present her work in a "lighting talk" style with a 90-second time limit. And this sentiment against short and strict time limits for speaking was shared by many of our interviewees. To better accommodate speech and communication diversity in VC meetings, our interviewees recommended the meeting organizer to stay away from short and strictly timed live speaking activities and proactively encourage meeting participants to share ideas and interact in different formats, such as video/audio recordings, messages, virtual whiteboards, and shared documents. Some of those asynchronous communication channels - such as messages and documents - can also be kept open even after the meeting, allowing the participants to continue the conversation without the time pressure. When planning for a meeting, the organizer should also reserve ample time for questions, discussions and transitions between topics, so that the participants are not rushed to get their turn or to speak quickly.

For participants of VC meetings, our interviewees also identified ways to be more supportive and accommodating despite technological constraints. For example, while body languages and non-verbal communications are generally deprived over VC, meeting participants can be more intentional with their facial expressions and video feed: positioning their camera to show a front view of their face, making an effort to keep eye contact with the camera, and communicating their intention when they have to look away (e.g. "I am taking some notes"). P13 also recommended everyone - including non-stuttering participants - to turn off their self-view to pay more attention to other participants without the distraction. It is also desirable for meeting participants to be more conscious about communication challenges and build the habit of proactive "check-ins", e.g., checking in with the current speaker before taking one's turn, checking in with everyone in the meeting before changing the topic or concluding the meeting.

Many of our interviewees have adopted these behaviors in VC meetings and found them helpful for everyone. Our interviewees recognized the significance of social norms and expectations in shaping the experience of videoconferencing and hoped to see a healthy trend towards more inclusive meeting culture in general.

5   DISCUSSION

5.1   The Hidden Cost of Videoconferencing for People Who Stutter

Despite the benefits identified by our interviewees, videoconferencing has introduced significant emotional and cognitive costs to people who stutter.

The constant close-up view of their facial features and speaking behaviors by self and others could contribute to heightened self-consciousness and more negative thoughts. Although the challenge with "Zoom gaze" is shared by people with [75, 87] or without disabilities [5, 30], people who stutter are more likely to pay disproportionate attention to "negative" behaviors (e.g. stuttered words, facial tension) that reinforce existing self stigma and social anxiety [40]. The increased difficulty with cutting into conversations using one's voice over videoconferencing platforms posed structural barriers for people who stutter to have their voices heard and points across, deepening people's existing feeling of social isolation and reject, and preventing interviewees such as P6 and P12 from

seeing themselves as leaders. The uncertainty with turn taking and audience reactions further contributes to the sense of loss of control, one of the defining characteristics of stuttering and a direct cause of many negative emotional and cognitive reactions when people stutter [77]. While the emotional connection with their conversation partners was highlighted by several of our interviewees as the hallmark of their most rewarding communication experience, our interviewees are systematically disadvantaged in seeking and sharing emotional support now, as their previous strategies - such as physical proximity, hugs, and good eye contact - were largely unsupported by today's videoconferencing technology.

To overcome these VC challenges, people who stutter had to adopt strategies that often require extra time, labor, and mental efforts, on top of the existing cognitive and emotional loads associated with stuttering. For example, our interviewees made an effort to put on make-up, well-position themselves in front of the camera, give others more verbal and non-verbal feedback, and over-prepare themselves with the content and agenda of meetings. As P11 put it, "*it is an extraordinary mental effort, my brain is always in the 5th gear, like 150mph, I can't get it to stop.*" Even the use of the hand-raising feature and a predetermined speaking order worked at the expense of *spontaneity*, one of the top predictors for how satisfying a speaking experience is to people who stutter [21]. It is perhaps not surprising that our interviewees reported feeling videoconferencing particularly "*exhausting*", "*draining*", and "*unrewarding*", something that they - while still participating in - did "*not look forward to*".

Even the named benefits of videoconferencing could lead to questionable long-term outcomes for the stuttering community. For example, the convenience and comfort of a familiar, controlled videoconferencing environment could potentially disincentivize PWS from engaging in in-person meetings and social interactions. The ability to hide one's stuttering behaviors and identity via video-conferencing is also a double-edged sword: although it does serve PWS with better impression and identity management at the moment, it could also hold people back from accepting their stutter and stuttering identity, reinforcing negative emotions associated with stuttering [18]. Collectively, if people who stutter all manage to pass as "fluent" during video calls, speech-related challenges would be even less understood and further marginalized by mainstream society. While VC reduced the barriers for PWS to find and join the stuttering community, the bonding and commitment within the community might be weakened due to the difficulty in forming emotional connections via video conferences, making the community more fragmented and superficial.

To summarize, videoconferencing and videoconferencing technologies have substantially changed the dynamics and the structure of interpersonal communications, charging potentially profound emotional, cognitive, and social costs to people who stutter. The very design of the videoconferencing technologies that induced such costs (e.g. lack of non-verbal communication support), has also helped render these costs **invisible**, preventing public awareness on the structural barriers for PWS to participate and engage in the age of videoconferencing.

While the research on technology-mediated communications tend to evaluate the effectiveness of communication from the perspective of a 3rd party observer, the importance of communication

interviewees' subjective experience is often overlooked. Similarly, mainstream assistive technologies were typically designed to enhance "productivity, efficiency, normalcy, and speed" [44], without sufficiently attending to the user's emotional needs [52]. We argue that the subjective experiences of marginalized users - such as people who stutter - should be respected and prioritized over external observations in the research and design of videoconferencing technologies, in order to create an inclusive and equitable communication environment for all. Foregrounding the lived experiences of people who stutter not only offers us insights of communication technologies that were inaccessible from an observer perspective, but also serves epistemic justice to the stuttering community which - similar to many other historically marginalized groups - had long been treated as epistemic subjects rather than the knowers [77].

5.2 Design Implications

Our research reveals the needs of PWS in VC meetings that are not fully aligned with other user populations and under supported by existing videoconferencing technologies. It points us to a few areas where the design of videoconferencing can be further improved or customized to be more inclusive for all.

5.2.1 Self View. Self-view is a major struggle for our interviewees, bringing them significant amounts of mental stress and distractions. With similar phenomena identified in populations with or without disabilities [5, 30, 75, 87], it is important to question and evaluate the very existence of self-view in videoconferencing technologies. While a recent work by Miller *et al.* [43] examined the effect of self-view on social anxiety through a series of controlled experiments, reporting no evidence for increased social anxiety level with self-view in video calls, their experiments were time-boxed and with specific context (ice-breaking conversation), which might not reflect the real impact during more stressful/formal situations (e.g. work) over a long period of time.

While most commercial videoconferencing technologies today have the self-view always on (e.g. Facetime, Messenger Room) or as a preset feature that could be turned off through multiple steps, we recommend videoconferencing technologies to only offer a quick view of one's video stream for quality assurance purpose before joining the meeting, and hide self-view by default during the meetings. Leveraging current face detection technology, videoconferencing platforms can easily give the user some feedback when they are out of the frame or focus.

5.2.2 Enhance Non-verbal Communications. Our findings highlight the importance of non-verbal communications for people who stutter in offline and online settings. While the current design of videoconferencing technologies tend to over-index on verbal channels, non-verbal cues should be better incorporated into videoconferencing platforms. For example, the camera can detect and communicate meaningful body movements and facial expressions, such as leaning forward, clapping, and smiling. A recent work has explored detecting and conveying the emotional state of conversation partners to blind and low-vision users in video calls through audio channels, but found it challenging to differentiate most of the emotional states without overwhelming the audio channel [71]. Future work is needed to further explore this direction.

To reduce the mental stress from "Zoom gaze" while maintaining communicative facial expression and eye contact, VC systems could deploy filters/avatars that capture and exaggerate these features in a context appropriate way. Such design can also benefit other populations such as people with neurodiversity, empowering them through mental stress from close-up camara view and better interpret the emotional state of others [75, 87].

5.2.3 Support For Atypical Speech. Consistent with previous research, our work highlights some problematic assumptions embedded within existing videoconferencing systems. For example, the assumption about the synchronicity of video and audio streams makes it difficult for populations such as DHH [66] and people who stutter to cut into conversations and have a turn. With the same assumption, the speech-activated speaker view would thus structurally marginalize people with no or reduced speech, such as DHH [49, 66], people with aphasia [57], and in our case, people who stutter. Future design could consider supporting ways for VC participants to attract the spotlight by naturalistic gestures and body language.

Videoconferencing platforms also need to accommodate and empower diverse verbal inputs. While DHH users reportedly struggle with auto-generated captions when the audio quality is poor [49, 66], several of our interviewees also noted that Zoom's auto-captioning and translation function worked poorly for people who stutter. Although there have been some recent efforts in improving the performance of speech recognition models for stuttering speech (e.g. [54, 56, 72]), more investment is required in this domain to close the performance gap between stuttering and fluent speeches, especially in a more dynamic setting like video conferences.

Similarly to how the hand-raising button signals one's intention to speak, videoconferencing platforms could also design a non-intrusive way for the user to express their intention to pause and take a break. The message could potentially be customized to provide more context about the needs of people with verbal diversity and educate others on respectful ways to support someone during the struggling moments (e.g. stop repeatedly asking "*are you still there*?").

5.3 Intersectionality

Our research also highlights the need for intersectionality [24] in understanding and designing technological experiences with marginalized communities. For instance, over half of our interviewees were women, and reported experiencing the tension between "taking up space" with their speech disfluencies and the socialized "supportive" role in conversations for women [86]. A third of our interview interviewees were first-generation immigrants and non-native English speakers working in English environments. They have experiences that others attributed their speech disfluencies to the lack of English proficiency. They also reported higher levels of pressure to perform and establish themselves in the workplace, which could cause additional stress in both virtual and in-person meetings on top of the challenges brought by stuttering and language barriers. Many of our female interviewees and interviewees with ethnic and racial minorities also recalled being talked over at video conferences or being labeled as "quiet" by their colleagues - an experience well-documented for minority groups at work [41, 84]

but extra difficult for our interviewees to push against when they were already burdened with existing speech and emotional challenges from stuttering.

Although the intersectionality theory was originally framed around race and its intersection with other marginalized identities, none of our interviewees brought up race in their reflection and discussion of videoconferencing experiences, thus we chose not to share the race information about interviewees in Table 1.

6 LIMITATIONS AND FUTURE WORK

This work has a few limitations. First, the fact that our interviewees were recruited from stuttering community events and group therapy program determined that all the interviewees had at least partially accepted their identity as people who stutter, and were comfortable enough to talk about their experience and vulnerability with stuttering. As a highly stigmatized identity, many adults who stutter do not self identify as a person who stutters or speak openly about their stuttering experiences [10], and their perspectives and needs with videoconferencing technologies might be different from the interviewees in our study. Second, although we did not set recruitment criteria on stuttering severity, all interviewees had relatively mild speech disfluencies, with a large percentage of the interviewees stuttering covertly. For future work, more efforts are needed to reach out to the PWS population with more speech challenges, as they might have different types of communication challenges within the videoconferencing context. Third, while our recruitment was targeted at adults with videoconferencing experiences, all our interviewees were relatively young (the oldest interviewee is in their 40s). The intersectional experiences with older adults who stutter would be an interesting topic for future research. Finally, although we tried to cover diverse demographics in our study, all interviewees were recruited from and resided in the US and UK, a geographical region with a relatively greater awareness and acceptance of stuttering [76]. Future work should explore and compare the videoconferencing experiences for PWS across a wider range of countries and cultures.

7 CONCLUSION

Although typically considered a speech disorder, stuttering comes with strong emotional and cognitive reactions, and can have a profound effect on how people engage and experience conversations in-person and virtually. In this paper, we present one of the first studies that examines the experience of PWS with videoconferencing and videoconferencing technologies, based on interviews of 13 adults who stutter.

Our findings reveal that, despite benefits, videoconferencing presents extra challenges for people who stutter due to: the constant surveillance by oneself and others in the call; the default reliance on voice to structure turn-taking; and the reduction of non-verbal communication channels. Although these issues also exist for fluent people, they are greatly exacerbated by the characteristics and nature of stuttering. Confronted with the social stigma and negative assumptions associated with stuttering, people who stutter spend more time and effort curating their physical environment and virtual presence for video conferences, and have adopted different strategies to compensate for the lost non-verbal cues and

build emotional connections with others in video calls. Besides being technically challenging, videoconferencing is also a mentally draining experience, creating significant - yet invisible - emotional, cognitive, and social barriers for people who stutter to engage and enjoy. Even though most of our interviewees have generally accepted their speech and their identity as PWS, videoconferencing brings new struggles when their speech behavior violates the hard-coded assumptions made by current technologies about human speech and communication patterns (e.g. the length of a pause, the use of utterances to initiate speech). They are also more likely to be emotionally impacted by seeing themselves speak on camera, as well as the lack of attention and feedback from the audience, and further develop social anxiety and negative self-image as a result.

We hope our findings shed light on the gap between current videoconferencing technologies and the needs of people who stutter, and inform future research and development of a more inclusive communication environment for all.

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