

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

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This work studies the experiences of people who stutter (PWS) with videoconferencing (VC) and VC technologies. Our interview study with 14 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 stutter (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 efforts 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**.

Additional Key Words and Phrases: videoconferencing, computer-mediated communication, stuttering, speech diversity, accessibility

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1 INTRODUCTION

Stuttering is a complex neurodevelopmental condition that is estimated to affect between 1% to 4% of the population [57, 72]. Traditionally considered as a speech *disorder* characterized by atypical speech behaviors such as sound repetitions, prolongations, and speech blocks [57], recent research on stuttering has underscored its emotional and cognitive impact to people who stutter [7, 76]. 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, 27, 76, 84]. 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, 33, 76].

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 [33, 41]. 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, 56], turn-taking confusion, connectivity/technical difficulties [50], and generally “Zoom Fatigue” [5]. While

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53 most of these challenges are also experienced by the general population, a recent study showed an amplified effect on
54 people with aphasia that made it even more challenging for them to stay connected during the pandemic [56]. We thus
55 hypothesize that people who stutter also face greater challenges with videoconferencing, and such challenges impact
56 not only communication productivity but also the social-emotional wellbeing of people who stutter. In this work, we
57 explore the experience of people who stutter with videoconferencing technologies through interviews with adults who
58 stutter. The interviews and data analysis were conducted to understand the benefits, challenges, and coping strategies
59 for people who stutter during video conferences, in comparison to in-person meetings.
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62 This paper provides a unique contribution to HCI and accessibility research by presenting to our knowledge the first
63 formal study of the lived experiences of people who stutter with video conferences and videoconferencing technologies.
64 Informed by previous work on videoconferencing challenges for the general population [5, 29, 50, 52] and people
65 with disabilities [48, 56, 65, 74, 78, 86], our study emphasizes the emotional and cognitive impact of such challenges
66 beyond observable outcomes such as communication accuracy and efficiency. By examining how videoconferencing
67 technology interacts with core elements of stuttering experiences such as stigma, avoidance, and acceptance, our
68 study uncovers challenges that are unique to PWS - such as keeping their speaking turn through stuttering blocks,
69 as well as known videoconferencing challenges that have an amplified effect on PWS - such as the lack of emotional
70 connection with audience and the mental stress with seeing self on camera. While most of our interviewees reported
71 spending extra effort to participate in video conferences due to such challenges, they also identified various benefits of
72 videoconferencing for PWS, including the increased connectivity within the stuttering community, and general public
73 empathy towards communication disruptions. Taken together, our work sheds light on the structural barriers and the
74 opportunities for PWS to effectively communicate and emotionally connect with others via videoconferencing.
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79 2 BACKGROUND

80 2.1 Stuttering

81 Stuttering is a genetic, neurodevelopmental condition that impacts people who stutter in behavioral, emotional, and
82 cognitive aspects [7]. Illustrated by the “stuttering iceberg” analogy, the observable behaviors associated with stuttering,
83 such as speech disruptions and facial tension, are only the “tip of the iceberg”, and most of the affective reactions
84 to dysfluencies - including fear, guilt, shame, and helplessness - lie below the surface [68]. These negative affective
85 reactions often lead to an increased level of social anxiety and self-stigma, and over time develop into cognitive reactions
86 such as “avoidance strategies” to cope with the fear with stuttering and pass as fluent [7].
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90 The hidden nature of these emotional and cognitive challenges also leads to limited visibility and public awareness
91 of struggles and needs of the stuttering community. Despite clearly documented social and occupational disadvantages
92 associated with stuttering, people who stutter are rarely offered or ask for reasonable accommodations, such as extra
93 speaking time to account for unpredictable blocks [20]. As a result, people who stutter often need to go through interview
94 processes with disabling barriers or get passed over on career opportunities that involve verbal communications [14].
95 This work aims to contribute to the public knowledge on the experience of people who stutter - and the barriers they
96 face - in professional and social communications mediated by videoconferencing technologies.
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99 Our research is also inspired by the recent breakthrough in stuttering research and therapy that emphasizes the
100 subjective experience of stuttering rather than the perspectives and observations of the listeners [21, 76]. This epistemic
101 shift led the field to understand that the biggest struggle with stuttering moments is not the dysfluencies but the feeling
102 of “being stuck” and “losing control” [58, 76], and people who stutter find it most satisfying when their speech is
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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 [57, 72], little research efforts haven been devoted to understanding and improving the experiences of PWS with technologies. A search of the keywords “stutter” or “stammer” over the proceedings of CHI conferences in the past 20 years (’02 - ’22) only returned 1 paper, which presents a standalone mobile app to support PWS to self-manage of stuttering in everyday interactions [54].

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 [41]. Speech operated technologies, such as smart speakers and automated phone menus, can also introduce new accessibility challenges for people with speech disfluencies [6, 55], creating degraded user experience and additional barriers for the stuttering community [63, 80].

2.2.1 Technology-mediated Interpersonal Communication. Existing technical efforts that supports 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 [73] and their smart phone equivalent (e.g. DAP Pro¹) enable their users to hear themselves speaking with a slight time delay, creating the “choral effect” that is known to induce temporarily fluent speech [44]. Similarly, leveraging the fact that PWS often stutter less when whispering [59], Whispp digitally transforms the input whispering speech by PWS into a “clearer and more pleasant” voice through its AI-powered microphone App [81]. 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 [31]. 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 who non-standard speech, with a *Repeat* feature that repeats what the user said into a “clear, synthesized voice” [17]. Although there has 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 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 [35]; whispering can strain vocal chord and cause supraglottic hyperfunction [64]; 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”

¹<https://speechtools.co/daf-pro>

157 or “masking” stuttering speech rather than embracing it, reinforcing the ableist assumption that stuttering is inferior
158 and unacceptable [30] - an idea that the stuttering community has been actively pushing against [16, 20].
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160 *2.2.2 Speech Operated Technologies for People Who Stutter.* There has been a small but emerging body of research
161 investigating the experience of PWS with speech interfaces. For example, a recent work by Bleakley *et al.* [6] conducted
162 diary studies and semi-structured interviews with 11 individuals who stutter to understand their experience with smart
163 speakers. Their study showed existing challenges (e.g. saying certain device woke words) as well as opportunities (e.g.
164 access to speech and language therapy) for this user population, highlighting the need to include PWS in the design
165 process of smart speakers. Similarly, Clark *et al.* called out the importance of considering diverse speech patterns in
166 developing speech technologies and identified the key challenges for inclusive speech interfaces [19].
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169 On the technical side, current work on improving speech interfaces for PWS has primarily focused on 1) collecting
170 and curating datasets with stuttering speech; 2) tuning automatic speech recognition (ASR) models to better detect
171 and recognize stuttering speech. Started as resources for speech therapy, several datasets with speech samples from
172 stuttering individuals have been developed, including the FluencyBank [62], University College London’s Archive
173 of Stuttered Speech (UCLASS) [36], the SEP-28K dataset from public podcasts [49], and the LibriStutter dataset with
174 synthesized stutters [47]. Although these datasets have enabled progress in ASR for stuttering speech, they are limited
175 by the amount of data and the lack of consistent annotations for ASR tasks [49]. Nevertheless, leveraging these datasets,
176 researchers have explored different techniques to better detect stuttering events [1, 46, 47, 49, 69] and auto transcribe
177 disfluent speech [2, 34, 53, 55, 71]. While these work reported various success in improving the detection accuracy and
178 reducing the word error rate (WER) in machine transcriptions over existing stuttering datasets, little is known about
179 stuttering users’ experience of these ASR systems in real world scenarios [6], highlighting the epistemic disconnection
180 between the subjective experience of stuttering and the scientific research on stuttering [19, 30, 54, 76].
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184 *2.2.3 Technology for Stuttering Therapy.* Lastly, there has been some efforts on digitalizing self-therapy for people
185 who stutter. Some guide people through fluency shaping techniques with instruction videos and virtual coaches (e.g.
186 Stamura², BeneTalk³), and others offer mindfulness exercises and self-reflections specific to mental health challenges
187 with stuttering (e.g. Buddo, StammerApp [54]). However, no formal evaluation of these systems by PWS has been
188 published so far, except for the StammerApp [54], which is not commercially available today.
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191 Overall, we see the gap in the research and development of technologies regarding stuttering, and intend to
192 contribute to the literature of HCI and accessibility by uncovering the needs and opportunities for technologies
193 that empower PWS in the increasingly technology-mediated verbal communication environment of today. Moreover,
194 with the lack of perspectives and involvement of PWS in current design and research of speech and communication
195 technologies [6, 19, 54], this work makes epidemic contribution by directly engaging with PWS and presenting their
196 voices and agency in videoconferences.
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200 **2.3 Videoconferencing Experience by People with Disabilities**

201 Since its conceptualization [3], videoconferencing and videoconferencing technologies have gained market popularity by
202 enabling real-time conversation across distance with increased modalities and affordance over traditional communication
203 technologies such as the telephone [28, 38]. Despite several well-known issues with videoconferencing - such as the
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206 ²<https://stamura.com/>

207 ³<https://www.benetalk.com>

209 challenge with maintaining eye contact [67, 79] and surveillance effect of the camera feed [12] - videoconferencing was
210 widely adopted during the Covid-19 pandemic, and has since become a prominent channel for professional and personal
211 communications [37]. Following this shift, recent research has discussed challenges with excessive videoconferencing
212 in professional settings, such as “Zoom Fatigue” [5, 52] and constant distractions [50], and attributed the causes of such
213 challenges to social and technical factors such as nonverbal overload, close-up gaze, extended screen time, reduced
214 mobility, heightened self-awareness from self-view, and technical/connection difficulties.

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217 Researchers have studied the use of videoconferencing technologies by people with disabilities, identifying both
218 benefits and accessibility challenges with videoconferencing. Tang *et al.* conducted a interview study with 25 individuals
219 with different types of disabilities about their telework experience [74], finding that, while videoconferencing signifi-
220 cantly reduced mobility barriers and offered some flexibility and control over one’s meeting experiences, it also brought
221 additional challenges to people with disabilities. For example, people with visual impairments needed to simultaneously
222 manage two independent audio streams (one by screen reader, one by other people talking) from the computer, d/Deaf
223 and hard of hearing (DHH) individuals had trouble being “seen” in the voice activated speaker view when participating
224 using sign language, and people who are neurodiverse reported increased cognitive efforts to maintain eye contact and
225 manage their video presentation of self during video calls. The additional emotional and cognitive burden for autistic
226 users of videoconferencing technologies was also reported by Zolyomi *et al.* in their 2019 interview study [86] with
227 22 autistic adults. In particular, their interviewees reported feeling self-conscious and uncomfortable with close-up
228 camera view by oneself and others, and often turned off their own camera and the video feed of other interviewees as
229 a result. The interviewees also adopted strategies to “masking” their neurodiversity through neurotypical behaviors
230 such as engaging in small talks and making eye contacts. [48, 65] examined the accessibility of videoconferencing
231 for d/Deaf and hard of hearing (DHH) community, calling out unique challenges such as getting attention of others,
232 turn-taking with captioning and interpreting delay, and managing visual attention over speaker, ASL interpreters,
233 other meeting interviewees, and live caption. Different from [74], in which DHH users reported finding it easier to
234 read the lips and facial expression of the speaker over VC, [48, 65] discussed the challenge with lower visual clarity
235 due to cluttered background and poor lighting of the speaker/signer. Recently, Neate *et al.* studied the experience of
236 videoconferencing for people with aphasia through naturalistic observations and interviews of people with aphasia
237 about VC sessions, as well as interviews with speech and language therapists and VC session support volunteers [56]. In
238 addition to uncovering commonly shared challenges such as turn-taking issues with Internet latency [45] and 3rd-party
239 distractions [50], their work highlighted the importance of “total communication” strategies (e.g. props, gestures, body
240 language) for people with language impairments and the lack of support for non-verbal communication channels by
241 current VC technologies.

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248 Our work contributes to this area of research by presenting the experiences of videoconferencing by people who
249 stutter - a population that have traditionally faced systematic challenges in in-person communications but have not been
250 included in the HCI/CSCW research of video-mediated communications. While we see parallels with other communities
251 - such as the anxiety with seeing oneself on video [74, 86], the cognitive efforts to “pass” as typical [74, 86], and the need
252 for broader non-verbal communication channels [56, 65, 70], our study also uncovers unique and amplified challenges
253 for PWS to participate in video calls. We hope our work will deepen current understanding on accessibility challenges
254 for videoconferencing and inspire the design and development of more inclusive videoconferencing experience for all.
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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(s), 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 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 continue the recruitment process on 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 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 one of the authors 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 stutters and had moments of stuttering 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.

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 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 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, 77]. 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 three 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 emerged from our interviews. All interviewees had used videoconferencing in both professional and personal settings, and identified various challenges and benefits with videoconferencing comparing 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 [32, 45, 56, 74, 86], 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 [37], 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 adopting 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 conversations. 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 purpose 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

417 for videoconferencing by our interviewees is to participate in **community events**, such as virtual events and support
418 groups for people who stutter (P4, P5, P8), and online bible study for P10. Videoconferencing for **speech therapy**
419 was also popular among our interviewees: several interviewees (P1, P2, P3, P9) have received speech therapy through
420 videoconferencing, and two interviewees (P5, P7) have provided speech therapy over video calls since the pandemic.
421 Some interviewees (e.g. R1, R2) also mentioned using video calls to keep connected with **friends and family**, especially
422 during the COVID lockdown. Note that the use cases for stuttering community events and speech therapy are likely
423 over represented in our sample since we seeded our recruitment process from virtual speech therapy groups and online
424 stuttering support groups.
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427 All interviewees have been participating videoconferences at least several times a week for the past 6 months,
428 although some people (P2, P3, P4, P5, P7, P9) only started this level of frequency since the pandemic. Although most
429 COVID restrictions had been lifted in countries where our interviewees resided, many interviewees anticipated some
430 professional meetings remained on videoconferencing channels. Some interviewees’ work had become permanently
431 remote (P1, P6, P112) or hybrid (P7, P11, P13), making videoconferencing an essential part of their work routine. As
432 P13 recognized, “Zoom, and virtual, and hybrid working, is never going away. There is still collaboration across coasts,
433 across countries, that is not gonna go away.” Our interviewees also enjoyed videoconferencing with other people who
434 stutter and expected the virtual community events to continue going forward. For example, both P5 and P8 started
435 hosting regular stuttering community events over Zoom since the pandemic, and were committed to keep these virtual
436 gatherings post pandemic. As for speech therapy, most of the interviewees who received video-mediated speech therapy
437 experience had positive opinions about their experience and some (P1, P9) indicated the interest in receiving speech
438 therapy via videoconferencing in the future. However, P9 found video-mediated speech therapy less effective for her
439 son, who also received stuttering speech therapy over Zoom during the pandemic, and had switched to in-person
440 speech therapy for him when in-person sessions were resumed. While P5 and P7 were transitioning back to providing
441 speech therapy in person, they also anticipated to offer video-mediated speech therapy as an option for some clients.
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447 *4.1.2 Self Disclosure in Videoconferences.* The right most column of Table 1 summarizes the speech and behavioral
448 characteristics of their stuttering with the keywords used by the interviewees when describing their stutter. The
449 dominant terms, such as “blocks”, “word substitution”, “repetition”, are common speech therapy terminologies that
450 most of our interviewees were familiar with. None of the interviewees identified as having a severe stutter. In fact,
451 several interviewees identified their stuttering as “covert”, a type of stuttering with little or no disfluencies that can
452 be effectively passed as fluent speech to the listener [23]. It is equivalent to “interiorized stammering” in the United
453 Kingdom [18], and we use these two terms interchangeably.
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456 For people with mild or covert stutter, masking their stuttering to “pass” as fluent could be an preferable option
457 that protects them from discriminations against stuttering [23]. Indeed, most of our interviewees did not proactively
458 disclose their stutter in professional settings unless the circumstances required so. While most interviewees disclosed
459 in high-stake situations such as job interviews (R1, R2, R11), important presentations (R1, R4, R10), and oral exams (R8).
460 However, R4 chose to conceal his stutter during his most recent job interview on VC, as he worried that showing his
461 stutter would make him a less desirable job candidate - a concrete threat documented by numerous studies [33, 66].
462 The decision to disclose is also situational and relationship dependent. For example, some interviewees (P6, P11, P13)
463 mentioned that they would acknowledge and disclose their stutter after having a major stuttering moment in a meeting,
464 and some interviewees (P1, P9) only disclosed to people at work who they trusted or considered “need-to-know”
465 (e.g. close teammates, direct manager). To summarize, our interviewees disclosed their stutter rather selectively at
466
467
468

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 speak 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 [74], 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 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.

521 4.2.1 *Reducing Mental Barriers to “Show Up”*. Research has shown that adults who stutter suffer from heightened
522 social anxiety and are more likely to avoid social situations as a result [39]. The avoidance behaviors (e.g. not showing
523 up, avoiding speaking, avoiding eye contact) would then elicit negative responses from others and reinforce existing
524 social anxiety [60]. Modern speech therapy research and practice has accumulated evidence that by reducing avoidance
525 behaviors, people who stutter can break from this vicious cycle to live and speak much more comfortably [18, 39].
526

527 Similar to how videoconferencing reduced the physical barriers for people with mobility challenges to participate
528 in meetings [74], it also reduced the mental barriers for our interviewees to “show up” to meetings and social events,
529 through multiple mechanisms.
530

531 First, comparing to in-person meetings, the process to schedule and join a meeting is easier via videoconferencing
532 technologies. P8 noted “*the ease of joining meetings*” as one of the biggest advantages of Zoom and commended Zoom
533 for “*make it easiest possible for people to find and join meetings*”.
534

535 Second, videoconferencing affords more control over one’s visual presentation. Being observed during a stuttering
536 moment is a major source of anxiety for people who stutter [39], similar to the insights from research with neurodiverse
537 individuals [74, 86], our interviewees (eg. P3, P4) reported finding a sense of psychological safety in larger meetings
538 with the ability of mute themselves and turn off the camera. When they had to turn on the video, our interviewees
539 carefully curated their video presence to fit in with the majority and mitigate the potential biases and discrimination
540 against their stuttering, especially when they possessed other marginalized identities besides stuttering:
541
542

543 *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*
544 *Caucasian woman. I’m not tall, and I’m not a man. A lot of my colleagues are men, my clients are men, the*
545 *leadership are typically male, so I want to look tall when I try to introduce myself. That - in my mind -*
546 *creates a little bit more of an even playing field. I think that kind of makes me feel more comfortable. It’s a*
547 *very controlled setting. (P12)*
548

549 Third, videoconferencing offers PWS more flexibility and control over their meeting environment. People who
550 stutter often have more speech difficulties in new and unfamiliar environments [26]. Consistent with the findings
551 with other disability populations [74], videoconferencing makes it possible for people who stutter to participate in a
552 wide range of speaking situations while staying in a familiar and accessible environment that is customized to their
553 preferences and needs. Many of our interviewees took advantage of this aspect of videoconferencing to curate their
554 physical environment and noted its positive mental effect:
555

556 *I feel comfortable, I’m in my house, I’m in my chair, I’m very comfortable with my setup here. I have two*
557 *screens. (P13)*
558

559 *I certainly try to create a working environment that feels very positive to me. It’s a way I can shape my*
560 *environment to make me feel more comfortable, and also feel like I have a personality that I am presenting.*
561 *So that you are not focusing on my stutter. (P12)*
562

563 *I can manage my energy a little bit better on VC, because you are in your own environment. For people*
564 *who stutter, going to a bar is very challenging, the office can have a similar effect.[...] you just have more*
565 *control on VC than in person environment. (P6)*
566

567 Besides the control over their physical environment, videoconferencing technology also allowed our interviewees
568 to customize the virtual environment. By adjusting the position, layout, and size of the display of their audience and
569 conversation partners, several of our participants indicated gaining the sense of “in control”, especially when speaking
570
571
572

573 to authority figures and in bigger groups - settings that are generally more challenging for people who stutter [26]. As
574 P6 explained: “*the other thing with VC is that it can be one or with a thousand people, you can change how many people*
575 *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*
576 *group meetings, maybe even holding the mic is a different dynamic, versus on Zoom, it doesn't feel too much different to me,*
577 *one person or a thousand people*”. While the need and desire to customize one’s virtual meeting view have been reported
578 by research with the autistic and DHH communities, its effect on PWS is more to reduce social anxiety, same as for
579 people with neurodiversity [74, 86], and less for better management of visual attention for DHH individuals [48, 65, 74].
580
581

582 4.2.2 *Masking Stutter*. As most of our interviewees only selectively disclosed their stutter in professional settings, they
583 appreciated the nature of videoconferencing and the design of VC technologies that enabled them to better manage
584 impression and mask their stutter in meetings.
585

586 Videoconferencing also allows our participants to utilize existing or new strategies to manage their speech, without
587 drawing unnecessary attention to their struggle. For example, both P1 and P12 mentioned the strategy of rehearsing
588 what they wanted to say beforehand with both microphone and video turned off. P12 gave the example of rehearsing
589 her self-introduction in a video call:
590

591 *When I know I have to introduce myself, but I am a little nervous because it's a new group, or in front of*
592 *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*
593 *just quietly say to myself and I'll practice my breath work with it, so that I can add the skillset I have to*
594 *try to mitigate any disfluencies, [...] just to make myself more confident. I will probably do that, like, 30*
595 *seconds before, or even before the meeting starts. (P12)*
596
597

598 Other speech and identity management strategies that worked particularly well for our interviewees over videoconferencing
599 include squeezing a stressball (P1), tapping the feet (P1, P6), turning off the camera when struggling with
600 facial tension (P6, P12), blaming the Internet connection for speech blocks and long pauses (P2, P3, P11), and using
601 fluency-inducing technologies discretely (P4).
602

603 After having a terrible experience with a job interview over the phone, P4 used DAF Pro, an smartphone app that let
604 its user hear themselves speaking with a 60ms delay, for a job interview via videoconferencing. While P4 managed to
605 have “*perfect fluency*” during the interview process and passed the interview, his speech challenges reoccurred shortly
606 after starting on the job, as the effect of delayed auditory feedback (DAF) worn out - a common phenomenon for DAF
607 users [35]. As a result, P4 now struggled with not only speech difficulties, but also the feeling of embarrassment and
608 guilt at the workplace:
609
610

611 *I felt a little bit guilty that I spoke very fluently during the interviews by using the DAF app, but showing*
612 *stutter afterwards. I don't want my supervisor to think that I cheated. I wanted to be an honest person, but*
613 *during the interview I did want to cover up the fact that I stutter, so I didn't disclose during the interview,*
614 *and I was also a bit worried that my stuttering would impact whether they give me the offer. I am a bit*
615 *embarrassed now. (P4)*
616
617

618 In addition to speech disfluencies, people who stutter often struggle with secondary stuttering behaviors, such
619 as facial tension, flushing, sweating, and sudden head and body movements [7]. While most of these behaviors
620 are involuntary, they can trigger negative social reactions due to the stigma towards stuttering [7]. Several of our
621 interviewees called out the benefit of videoconferencing as to hide their secondary behaviors more easily when they
622 stuttered. For example, P1 perspires more when she stutters, and often worries that others would see or smell her sweat
623
624

625 at in-person meetings. Videoconferencing largely eliminated this worry for her, reducing her stuttering related anxiety
626 during meetings. Similarly, P10 noticed, “*I sometimes get really shaky if I’m presenting in person. But if I’m presenting on*
627 *Zoom, I am already sitting down so it’s okay. And nobody can see me even if I’m shaking*”.

629 Distinct from “masking” strategies (e.g. making eye contact, engaging in small talks) reported in research of video-
630 conferencing experiences with neurodiverse individuals [74], the strategies shared by our interviewees are facilitated or
631 made possible by videoconferencing. On the other hand, similar to masking autism [74], masking stutter also requires
632 significant cognitive efforts and could lead PWS to feel more stressed and less capable to engaging in the conversa-
633 tion [10]. However, most of our interviewee still appreciated the flexibility and control offered by videoconferencing
634 over their stutter and stuttering identity, and cited the ability to mask stutter as a benefit of videoconferencing.
635
636

637 **4.2.3 Connecting with the Stuttering Community.** With stuttering being marginalized socially and the stuttering
638 community scattered geographically, stuttering is often a very isolating and isolated experience. While research has
639 found the effect of stuttering support group at boosting self-esteem and self-efficacy for PWS [9], the self-stigma
640 towards stuttering could prevent people from meeting and connecting with other people who stutter [11].
641

642 The ease of finding and joining meetings and the option to participate anonymously make videoconferencing an
643 effective tool for our interviewees to reach out to the stuttering community, even when they were not yet in acceptance
644 of their stuttering identity. For example, P5’s journey of self-acceptance began with a weekly global support group
645 meeting over Google Hangout that she participated passively and anonymously without turning on her camera or
646 microphone. With the support of the group, she gradually became comfortable “coming out” as a person who stutters
647 and eventually started a Chinese-English bilingual stuttering support group over Zoom, with people joining from China,
648 US, and the Europe. Similar to P5, almost all the attendants from China first joined the meeting with a pseudonym
649 and camera off; over time, people started showing their faces and introducing themselves. Through this experience,
650 P5 believed that “*Zoom play an important part in my education and in my healing journey*” - a sentiment is shared
651 by many other interviewees of our interview study. P1, P2, P3, and P9 started acceptance-based speech therapy and
652 meeting other people who stutter since the pandemic, only through videoconferencing. P8 remarked the community
653 connections that were made possible through videoconferencing: “*the world has become more and more connected. Now,*
654 *on a regular basis, I talk to people across the world, because people are used to Zoom. I know people across the world who*
655 *stutter, that is a blessing.*”
656
657
658
659

660 **4.2.4 Increased Public Empathy for Communication Challenges.** As COVID-19 disrupted lives and blurred work-life
661 boundaries, research also showed that people have developed increased empathy towards others since the outbreak of
662 the pandemic [4]. In the context of video conferencing, our interviewees noticed that people have become more patient
663 and more understanding with communication challenges, which alleviated some pressure for them to speak fluently. As
664 P3 noticed, “*even fluent speakers have difficulties on Zoom, having challenge of being heard is more understood now*”.

665 As disruptions to videoconferencing became more salient [50], meeting participants, as well as videoconferencing
666 technologies, have developed more ways to anticipate and accommodate different ways to participate in meetings. All
667 but two interviewees mentioned the “hand raising” function in Zoom, and found it effective at getting people’s attention
668 when it was understood and enforced as the norm. Chat is another feature that some interviewees appreciated, especially
669 when it was monitored and used by other meeting participants. Compared to in-person conversations, P2 felt typing in
670 the chat is more socially appropriate over VC meetings, as “*in some way you can avoid having to speak, it does give you*
671 *that option; whereas when you are face to face, it’s be a bit strange to text them, or email the message.*”. However, several
672 interviewees also found the chat “ancillary”(P11), “unnoticeable”(P3), and “distracting”(P4), and would not participate
673
674
675
676

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”.

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. (P6)

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, 65, 74, 86], 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.

729 4.3.1 *Stress and Distractions with Self-view.* Numerous studies have shown seeing oneself in a mirror can induce
730 self-evaluation and distress [5, 29, 82], and the effect is stronger for certain social groups such as women and Asian,
731 as comparing to men and White, respectively [61]. Not surprisingly, the “self view” function - a default design in
732 commercial video conferencing systems that can not be turned off in Apple Facetime and Meta Messenger Room -
733 stands out as one of the top challenges with videoconferencing in our data. Almost all of our interviewees indicated
734 some discomfort with the self-view, finding it stressful and “distracting” (P1, P7, P9, P19). P5 considered self-view as a
735 “curse” in which “*you have to face your worst fear as a person who stutters*”, highlighting the additional stress it brought
736 to PWS over in-person meeting: “*before, when you talk to a person, you don’t necessarily see your own face; seeing your*
737 *own face puts the person who stutter in a direct confrontation with your stuttering*”.

740 Although the mental stress with self view is not unique to people who stutter [5, 74, 86], our interviewees found the
741 impact amplified by existing anxiety and self-stigma around stuttering. As P11 explained,

742
743 *During COVID, people would share that, for the first time, they were very self-conscious in meetings,*
744 *because they see themselves, and hear themselves, and I was like, ‘oh my god, this is the first time that you*
745 *have been that conscious about how you talk?’ Because that’s how I am all the time. But now I am like 2x,*
746 *because I am concerned about how I am coming off but then I am also seeing how I coming off. And it was*
747 *just like that much mental energy. (P11)*

750 Similar to people with neurodiversity [74], our interviewees also found the self-view distracting as it directed their
751 attention away from the content and their conversation partners. However, such distraction were also particularly hard
752 for our interviewees to resist, as it highlighted the speech and secondary stuttering behaviors (e.g. facial tension) that
753 PWS are often hypersensitive about.

754 To mitigate these challenge with the self-view, majority of the interviewees had turned it off, at least for some
755 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
756 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*
757 *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.*
758 *Then, generously speaking, when you turn off your self view, it’s more like mimic a real life conversation, because in real*
759 *life conversations, you are not looking at yourself all the time, unless you are talking to a mirror! You can actually be*
760 *more engaged with the person you are talking to, if you hide yourself, or no longer caring about yourself, only caring*
761 *about the person you are with.*” In fact, the impact of the self-view was so detrimental, that P13 deliberately avoided
762 videoconferencing platforms that do not let people hide their self views, and questioned the very idea of self-view in
763 videoconferencing:

764
765 *There are still some platforms, including Room, which is a product from Meta, where you can’t turn off*
766 *your self-view, so you have to watch yourself. So, any meeting I setup, I do Zoom, because, I can do that*
767 *(turning off self-view). I’d be curious to hear what the rationale is for that as a preset feature, cuz it doesn’t*
768 *make sense to me. (P13)*

774
775 4.3.2 *Difficulty Getting and Holding One’s Turn Using Voice.* While the connectivity issue and the lack of non-verbal
776 cues over videoconferencing have created difficulties for taking turns and jumping into a conversation for everyone [5],
777 these difficulties are multiplied for people with longer communication latency, such as people with aphasia [56], DHH
778 individuals [48, 65], and our interviewees.

781 Many videoconferencing platforms have a speaker focused mode where the video of current speaker is highlighted.
 782 This design makes the first utterance crucial to signal one’s intention to speak. However, several of our interviewees
 783 found themselves struggle the most when initializing a sentence. With a limited channel for non-verbal communica-
 784 tion strategies such as body language over videoconferencing, they would often be held back from cutting into the
 785 conversation by that very first word:
 786

787 *I find things just like saying “hello”, that’s probably the hardest bit. The hardest things for me is starting*
 788 *the sentence of a conversation. (P2)*
 789

790 *As a stutterer, it is harder to get your first sound out. Body language is more visible in person. That’s*
 791 *particularly challenging. I am trying to say something but before I can say something, somebody also*
 792 *already got the word out. (P6)*
 793

794 On the other hand, the limited view of all participants on the VC meeting also made it harder for other participants
 795 to notice and give people who stutter the space to speak. P7, a SLP who had facilitated group therapy sessions with
 796 PWS via Zoom, noted that:
 797

798 *In a group situation, and you’re stammering, maybe it is hard to indicate that you want to speak. When*
 799 *you are in the same room, you can see more of the body language that you want to speak, versus when we*
 800 *are just in the screen, it’s harder to read the room, read the group in the same way. I think we are more*
 801 *focused on just looking at the one person who is talking, and not having the peripheral vision of the whole*
 802 *group.... that’s true for everyone, not just for people who stammer, but I wonder whether your stammer*
 803 *adds an extra layer of difficulty, that you can’t get in. (P7)*
 804
 805

806 Even after PWS successfully cut into the conversation, they could face higher risk of losing their turn involuntarily
 807 due to their stutter. When dealing with an extended stuttering block, P10 also worried that people would assume she’s
 808 finished and switch the topic. Some interviewees found it hard to differentiate a stuttering block with the loss of Internet
 809 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*
 810 *people, I am not finished yet. that’s the loss of body (language) on Zoom. because often you can tell somebody is still trying*
 811 *to speak based on what they are doing with their body.” (P7)*
 812

813 To make it easier for them to cut into conversations over VC, our interviewees leveraged videoconferencing features
 814 such as “hand raising” and “chat” extensively, and found the hand-raising function relatively effective at signaling their
 815 desire to have a turn. However, the interviewees also reported that the “hand raising” was sometimes ignored/unseen -
 816 especially when the speaker was in presentation mode. P1 also found the handraising function stressful, as her speaking
 817 anxiety would often build up after clicking the button while anticipating her turn. P10 sometimes raised her physical
 818 hand in front of the camera at the same time as she pressed the hand-raising button, in the hopes for signaling her
 819 desire to participate more saliently. Some interviewees (P1, P10) also shared that they would not feel comfortable to be
 820 the first/only one to use the hand-raising function, if others in the meeting were getting their turns simply by speaking.
 821 Our interviewees found the “unmute” function effective at signaling their turn only when such norm has already been
 822 established (i.e. everyone is muted except for the active speaker and the next speaker). However, P6 felt the need to
 823 clicking one additional button (“unmute”) also raised the mental barrier to participate.
 824
 825
 826

827 Another strategy our interviewees adopted for easier turn taking is to proactively setup the structure and norms of
 828 participation beforehand. For example, P1 tried always preparing an agenda for the larger meetings she hosted, with
 829 speaker name and timing assigned for each agenda item to ensure people on the agenda (including herself) have their
 830 turns. P7 would ask people who did not speak to type out their ideas in the chat, and reserved time to read and respond
 831
 832

833 to all chat messages. P13 would give people a heads-up on who would go next during round-the-room introductions or
834 updates. And P9 would proactively check in with people who did not get a turn or people who had expertise on the
835 topic for things to add.
836

837 Our interviewees also developed various strategies to protect one’s turn during stuttering moments. For instance,
838 using, and getting everyone else to use, the hand-raising button was found helpful by a few interviewees, as it not only
839 indicated the turn order, but also created a break between speakers, giving PWS more time to unblock themselves before
840 the next speaker cutting in. P7 would double check with people when in doubt, asking whether they were finished,
841 and prevent other people from interrupting before getting an affirmative answer. P10 leaned on the non-verbal signals
842 available on Zoom, keeping her camera on and making her facial expression more pronounced during her speaking
843 turn, even though it felt “tiring” to have her face spotlighted for a prolonged period of time.
844
845

846
847 *4.3.3 Limited Non-verbal Channels to Solicit Emotional Support from Others.* With a strong association between
848 stuttering and social anxiety, people who stutter are more sensitive to negative evaluations from others, and more likely
849 to engage with safety behaviors such as loss of eye contact [39]. While the reduction of social cues during video calls
850 has made everyone feel less connected to their conversation partners [5], the lack of emotional support from others
851 could exacerbate the social anxiety experienced by PWS, causing further behavioral and emotional struggles.
852

853 Preconditioned by their previous negative social experiences with speaking, our interviewees were more likely to
854 associate the lack of responses from the audience with the loss of interest or patience with their speech:
855

856 *I think when you have a stammer, people can be at times, not intentionally, but unintentionally a bit*
857 *more impatient with me. [...] In the context of a zoom call, they have the same impatience stance toward*
858 *you when you are talking, and then they clock off straight away. That you start stammering on the first*
859 *word and then they go “here we go”. I definitely think it is heightened for stammers. [...] Whereas in a*
860 *face-to-face interaction, [...] people can’t clock off as easily without being rude. Whereas in a zoom meeting*
861 *you can kind of clock out and it’s not necessarily, obviously rude. (P2)*
862
863

864 Even when the audience gave responses, they could be interpreted more negatively, especially when non-verbal cues
865 such as facial expression and eye contact were inaccessible. P11 shared the experience of giving a Zoom presentation to
866 his CEO, who used phrases like “*alright, let’s move on*” to communicate that he had comprehended the content of the
867 presentation:
868

869 *I think that’s a unique challenge for people who stutter, because anytime we are talking, and someone*
870 *indicates “let’s move on”, we will always interpret it as “oh they are commenting on my speech, rather than*
871 *my content”. I would say that I am self conscious about it, I spent a lot more time worrying about it. I stayed*
872 *up last night writing out my slide, because I want to be super crisp, even though I don’t do that for any*
873 *other meetings, because I actually find my stutter is worse when I am reading off something, so there is*
874 *added burden. (P11)*
875
876
877

878 When asked about most satisfying meeting experiences in the past, several of the interviewees recalled group
879 meetings or conversations where they clearly perceived the appreciation and attention by the listeners. For example,
880 R4 called out one presentation he gave: “*one girl in the project was listening very carefully, and I could tell from her*
881 *eye contact the warmth, acknowledgement, and appreciation. I felt so much better immediately. I was basically fluent*
882 *throughout the talk.*”
883
884

885 Our interviewees recognized eye contact as an important channel to build human connections and seek emotional
 886 support: “Eye contact is everything. Good eye contact means much more than what you say. Eye contact is indicative of the
 887 enthusiasm of your conversation” (P8). Even though many of the interviewees have a tendency to look away when they
 888 stutter, they appreciated being seen by their conversation partners and worked on improving eye contact with
 889 others in in-person conversations. They had success leveraging eye contact in major blocking moments to “hold the
 890 floor” and indicate to others that they are not finished, and getting the emotional support they needed from maintaining
 891 eye contact with one particularly friendly audience member. However, the design of most modern videoconferencing
 892 platforms has made effective eye contact almost impossible, especially in a group setting:
 893

895 *It’s hard for people to know who to look at on Zoom. In terms of eye contact, who do we keep eye contact*
 896 *with. Even if we all know whom we want to keep eye contact with, do they know that? How can they tell,*
 897 *they probably can’t. (P7)*
 898

899 Videoconferencing also disabled some other strategies our interviewees relied on for social and emotional support in
 900 in-person meetings. For example, when attending in-person group meetings, P3 and P10 would chose to sit next to
 901 friendly, familiar people to feel more relaxed. Small talks and chitchats before a meeting is another strategy that P10
 902 and P7 deployed to feel more comfortable with a group. P11 have developed a personal “charisma” to compensate for
 903 his stutter, and found himself “less effective on VC ” due to the limits videoconferencing put on communicating “body
 904 language, energy, and interpersonal chemistry”:
 905

907 *I like to shake hands, I will give people a hug if I know them. If I am comfortable, I will talk with my*
 908 *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*
 909 *space where I hope you can be yourself. I can do that via VC, too, but I think it’s much more noticeable*
 910 *when I am in person. (P11)*
 911

912 To compensate for the lost connections with others, our interviewees strives for extended emotional communications
 913 within the boundary of existing videoconferencing design. For example, several interviewees (P1, P8) deliberately lifted
 914 the position of their camera to the eye level so that they could mimic the in-person eye contact. Almost all of our
 915 interviewees indicated that they were making an effort for maintaining eye contact over video conferences, and some
 916 even turned off the self view to better direct their gaze to the conversation partners. Some interviewees tried to make
 917 their facial expression more salient by lightening up their faces (P1, P8), putting on make-up (P3), and positioning the
 918 camera for a close-up view (P8, P10). And some interviewees (P1, P8, P10, P13) leveraged the reaction feature on Zoom
 919 to both give and gather direct, positive emotional feedback. Despite potential speech challenges, some interviewees
 920 actively describe their body language and the intention behind it to avoid misinterpretations. For example, P13 would
 921 explicitly tell the speaker that he was looking away only to open up the document the speaker just mentioned.
 922

923 Our interviewees also sometimes leveraged their identity as PWS to better connect with others in virtual meetings.
 924 Most of the interviewees had proactively disclosed their stutter in high-stake situations such as job interviews, pre-
 925 sentations, and oral exams, and found that effective at reducing mental stress and bringing in audience’s emotional
 926 support. P13 purposefully embraced the vulnerability that came with the identity as a person who stutters, as a way to
 927 invite others to become more open and collaborative in virtual meetings:
 928

929 *As soon as I say something deeply personal about my stutter, they go, ‘this guy is being open, okay, maybe I*
 930 *will be open, too!’ I think the whole modeling behavior is huge over Zoom, and over virtual communications.*
 931 *I always want to model the behavior of being open and collaborative. (P13)*
 932

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 categorized these ideas into some major categories and present them below.

4.4.1 Mask Stutter. Many interviewees found it desirable to have more control over their speech and secondary stuttering behavior, envisioning technologies to better “masking” 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.

Visually, P1 also proposed the use of virtual cartoon mask or digital avatars to soften the appearance of facial tension and make eye contact more easily for PWS.

As pointed out by P7, when it comes to masking stuttering speech or behavior over videoconferencing, PWS need to consider the trade-off 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 common practice of appending one’s pronouns after the name displayed by VC technologies, P11 proposed to also have one’s PWS status displayed manually or automatically based on speech recognition. P7 suggested to add a button “I’m not finished” into Zoom, to allow PWS to keep their speaking turn through stuttering blocks. P8 had the idea to have the videoconferencing system detect and show that “X is stuttering” to generate greater awareness for stuttering.

Culturally, P11 advocated for broader acceptance and norm around self-disclosing, even beyond stuttering, as believed that as 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 design to serve this purpose, our interviewees found the emojis underused by VC meeting participants and salient enough to the speaker to convey the emotions.

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 moment if that is something they are working on, or display tips like “keep moving forward” when a severe speech block is detected.

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

989 people with [74, 86] or without disabilities [5, 29], people who stutter are more likely to pay disproportional attention
990 to “negative” behaviors (e.g. stuttered words, facial tension) that reinforce existing self stigma and social anxiety [39].
991 The increased difficulty with cutting into conversations using one’s voice over videoconferencing platforms posed
992 structural barriers for people who stutter to have their voices heard and points across, deepening people’s existing
993 feeling of social isolation and reject, and preventing interviewees such as P6 and P12 from seeing themselves as leaders.
994 The uncertainty with turn taking and audience reactions further contributes to the sense of loss of control, one of
995 the defining characteristics of stuttering and a direct cause of many negative emotional and cognitive reactions when
996 people stutter [76]. While the emotional connection with their conversation partners was highlighted by several of our
997 interviewees as the hallmark of their most rewarding communication experience, our interviewees are systematically
998 disadvantaged in seeking and sharing emotional support now, as their previous strategies - such as physical proximity,
999 hugs, and good eye contact - were largely unsupported by today’s videoconferencing technology.

1000 To overcome these VC challenges, people who stutter had to adopt strategies that often require extra time, labor,
1001 and mental efforts, on top of the existing cognitive and emotional loads associated with stuttering. For example, our
1002 interviewees made an effort to put on make-up, well-position themselves in front of the camera, give others more
1003 verbal and non-verbal feedback, and over-prepare themselves with the content and agenda of meetings. As P11 put it,
1004 “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
1005 of the hand-raising feature and a predetermined speaking order worked at the expense of *spontaneity*, one of the top
1006 predictors for how satisfying a speaking experience is to people who stutter [21]. It is perhaps not surprising that our
1007 interviewees reported feeling videoconferencing particularly “*exhausting*”, “*draining*”, and “*unrewarding*”, something
1008 that they - while still participating in - did “*not look forward to*”.

1009 Even the named benefits of videoconferencing could lead to questionable long-term outcomes for the stuttering
1010 community. For example, the convenience and comfort of a familiar, controlled videoconferencing environment could
1011 potentially disincentivize PWS from engaging in in-person meetings and social interactions. The ability to hide one’s
1012 stuttering behaviors and identity via videoconferencing is also a double-edged sword: although it does serve PWS
1013 with better impression and identity management at the moment, it could also hold people back from accepting their
1014 stutter and stuttering identity, reinforcing negative emotions associated with stuttering [18]. Collectively, if people who
1015 stutter all manage to pass as “fluent” during video calls, speech-related challenges would be even less understood and
1016 further marginalized by the mainstream society. While VC reduced the barriers for PWS to find and join the stuttering
1017 community, the bonding and commitment within the community might be weakened due to the difficulty in forming
1018 emotional connections via video conferences, making the community more fragmented and superficial.

1019 To summarize, videoconferencing and videoconferencing technologies have substantially changed the dynamics
1020 and the structure of interpersonal communications, charging potentially profound emotional, cognitive, and social
1021 costs to people who stutter. The very design of the videoconferencing technologies that induced such costs (e.g. lack of
1022 non-verbal communication support), has also helped render these costs **invisible**, preventing public awareness on the
1023 structural barriers for PWS to participate and engage in the age of videoconferencing.

1024 While the research on technology-mediated communications tend to evaluate the effectiveness of communication
1025 from the perspective of a 3rd party observer, the importance of communication interviewees’ subjective experience
1026 is often overlooked. Similarly, mainstream assistive technologies were typically designed to enhance “productivity,
1027 efficiency, normalcy, and speed” [43], without sufficiently attending to the user’s emotional needs [51]. We argue that
1028 the subjective experiences of marginalized users - such as people who stutter - should be respected and prioritized over
1029 external observations in the research and design of videoconferencing technologies, in order to create an inclusive

1041 and equitable communication environment for all. Foregrounding the lived experiences of people who stutter not only
1042 offers us insights of communication technologies that were inaccessible from an observer perspective, but also serves
1043 epistemic justice to the stuttering community which - similar to many other historically marginalized groups - had
1044 long been treated as epistemic subjects rather than the knowers [76].
1045
1046

1047 5.2 Design Implications 1048

1049 Our research reveals the needs of PWS in VC meetings that are not fully aligned with other user populations and under
1050 supported by existing videoconferencing technologies. It points us to a few areas where the design of videoconferencing
1051 can be further improved or customized to be more inclusive for all.
1052

1053
1054 *5.2.1 Self View.* Self-view is a major struggle for our interviewees, bringing them significant amount of mental stress
1055 and distractions. With similar phenomenon identified in populations with or without disabilities [5, 29, 74, 86], it
1056 is important to question and evaluate the very existence of self-view in videoconferencing technologies. While a
1057 recent work by Miller *et al.* [42] examined the effect of self-view on social anxiety through a series of controlled
1058 experiments, reporting no evidence for increased social anxiety level with self-view in video calls, their experiments
1059 were time-boxed and with specific context (ice-breaking conversation), which might not reflect the real impact during
1060 more stressful/formal situations (e.g. work) over a long period of time.
1061

1062 While most commercial videoconferencing technologies today have the self-view always on (e.g. Facetime, Messenger
1063 Room) or as a preset feature that could be turned off through multiple steps, we recommend videoconferencing
1064 technologies to only offer a quick view of one’s video stream for quality assurance purpose before joining the meeting,
1065 and hide self-view by default during the meetings. Leveraging current face detection technology, videoconferencing
1066 platforms can easily give the user some feedback when they are out of the frame or focus.
1067
1068

1069
1070 *5.2.2 Enhance Non-verbal Communications.* Our findings highlight the importance of non-verbal communications for
1071 people who stutter in offline and online settings. While the current design of videoconferencing technologies tend
1072 to over-index on verbal channels, non-verbal cues should be better incorporated into videoconferencing platforms.
1073 For example, the camera can detect and communicate meaningful body movements and facial expressions, such as
1074 leaning forward, clapping, and smiling. A recent work has explored detecting and conveying the emotional state of
1075 conversation partner to BLV users in video calls through audio channels, but found it challenging to differentiating
1076 most of the emotional states without overwhelming the audio channel [70]. Future work is needed to further explore
1077 this direction.
1078

1079
1080 To reduce the mental stress from “Zoom gaze” while maintaining communicative facial expression and eye contact,
1081 VC systems could deploy filters/avatars that capture and exaggerate these features in a context appropriate way. Such
1082 design can also benefit other populations such as people with neurodiversity, empowering them through mental stress
1083 from close-up camera view and better interpret the emotional state of others [74, 86].
1084
1085

1086 *5.2.3 Support For Atypical Speech.* Consistent with previous research, our work highlights some problematic assump-
1087 tions embedded within existing videoconferencing systems. For example, the assumption about the synchronicity
1088 of video and audio streams makes is difficult for populations such as DHH [65] and people who stutter to cut into
1089 conversations and have a turn. With the same assumption, the speech-activated speaker view would thus structurally
1090 marginalize people with no or reduced speech, such as DHH [48, 65], people with aphasia [56], and in our case, people
1091
1092

1093 who stutter. Future design could consider supporting ways for VC participants to attract the spotlight by naturalistic
1094 gestures and body language.

1095 Videoconferencing platforms also need to accommodate and empower diverse verbal inputs. While DHH users
1096 reportedly struggle with auto-generated captions when the audio quality is poor [48, 65], several of our interviewees
1097 also noted that Zoom’s auto-captioning and translation function worked poorly for people who stutter. Although
1098 there have been some recent efforts in improving the performance of speech recognition models for stuttering speech
1099 (e.g. [53, 55, 71]), more investment is required in this domain to close the performance gap between stuttering and
1100 fluent speeches, especially in a more dynamic setting like video conferences.
1101

1102 Similarly to how the hand-raising button signals one’s intention to speak, videoconferencing platforms could also
1103 design a non-intrusive way for the user to express their intention to pause and take a break. The message could
1104 potentially be customized to provide more context about the needs of people with verbal diversity and educate others on
1105 respectful ways to support someone during the struggling moments (e.g. stop repeatedly asking “*are you still there?*”).
1106
1107

1108 5.3 Intersectionality

1109 Our research also highlights the need for intersectionality [24] in understanding and designing technological experiences
1110 with marginalized communities. For instance, over half of our interviewee were women, and surfaced the tension
1111 between “taking up space” with their speech disfluencies and the socialized “supportive” role in conversations for
1112 women [85]. A third of our interviewees were first-generation immigrants and non-native English speakers
1113 working in an English environment. They have experienced confusion by others of their stuttering with a lack of
1114 language proficiency. They also reported higher levels of pressure to perform and establish themselves in the workplace,
1115 which could cause additional stress in both virtual and in-person meetings on top of the challenges brought on by
1116 stuttering and language barriers. Many of our female interviewees and interviewees with ethnic and racial minorities
1117 also recalled being talked over at video conferences or being labeled as “quiet” by their colleagues - an experience
1118 well-documented for minority groups at work [40, 83] but extra difficult for our interviewees to push against when
1119 they are already burdened with existing speech and emotional challenges from stuttering.
1120

1121 Although the intersectionality theory was originally framed around race and its intersection with other marginalized
1122 identities, none of our interviewees brought up race in their reflection and discussion of videoconferencing experiences,
1123 thus we chose not to share the race information about interviewees in Table 1.
1124

1125 6 LIMITATIONS AND FUTURE WORK

1126 This work has a few limitations. First, the fact that our interviewees were recruited from stuttering community events
1127 and group therapy program determined that all the interviewees had at least partially accepted their identity as people
1128 who stutter, and were comfortable enough to talk about their experience and vulnerability with stuttering. As a highly
1129 stigmatized identity, many adults who stutter do not self identify as a person who stutters or speak openly about their
1130 stuttering experiences [10], and their perspectives and needs with videoconferencing technologies might be different
1131 from the interviewees in our study. Second, although we did not set recruitment criteria on stuttering severity, all
1132 interviewees had relatively mild speech disfluencies, with a large percentage of the interviewees stuttering covertly. For
1133 future work, more efforts are needed to reach out to the PWS population with more speech challenges, as they might
1134 have different types of communication challenges within the videoconferencing context. Third, while our recruitment
1135 was targeted at adults with videoconferencing experiences, all our interviewees were relatively young (the oldest
1136 interviewee is in their 40s). The intersectional experiences with older adults who stutter would be an interesting
1137

1145 topic for future research. Finally, although we tried to cover diverse demographics in our study, all interviewees
1146 were recruited from and resided in the US and UK, a geographical region with a relatively greater awareness and
1147 acceptance of stuttering [75]. Future work should explore and compare the videoconferencing experiences for PWS
1148 across countries/cultures.
1149
1150

1151 7 CONCLUSION

1152 Although typically considered a speech disorder, stuttering comes with strong emotional and cognitive reactions, and
1153 can have a profound effect on how people engage and experience conversations in-person and virtually. In this paper,
1154 we present one of the first studies that examines the experience of people who stutter with videoconferencing and
1155 videoconferencing technologies, based on interviews of 13 adults who stutter.
1156
1157

1158 Our findings reveal that, despite benefits, videoconferencing presents extra challenges for people who stutter due
1159 to the reduction of non-verbal communication channels and the constant surveillance by self and others in the call.
1160 Although these issues also exist for fluent people, they are greatly exacerbated by the characteristics and nature of
1161 stuttering. Confronted with the social stigma and negative assumptions associated with stuttering, people who stutter
1162 spend more time and efforts curating their physical environment and virtual presence for video conferences, and have
1163 adopted different strategies to compensate the lost non-verbal cues and seek/provide emotional support in video calls.
1164 Besides being technically challenging, videoconferencing is also an mentally draining experience, creating significant -
1165 yet invisible - emotional, cognitive, and social barriers for people who stutter to engage and enjoy. Even though most
1166 of our interviewees have generally accepted their speech and their identity as PWS, videoconferencing brings new
1167 struggles when their speech behavior violates the hardcoded assumptions made by current technology about human
1168 speech and communication behaviors (e.g. the length of a pause, the use of utterances to initiate speech). They are also
1169 more likely to be emotionally impacted by the lack of attention and feedback from the audience, and further develop
1170 social anxiety and negative self-image as a result.
1171
1172

1173 We hope our findings and discussion shed light on the gap between current videoconferencing technologies and the
1174 needs of people who stutter, and inform future research and development of more inclusive communication environment
1175 for all.
1176
1177

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1182
1183

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