Original Article

Perceived Listening Difficulties of Adult Cochlear-Implant Users Under Measures Introduced to Combat the Spread of COVID-19

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Abstract

Following the outbreak of the COVID-19 pandemic, public-health measures introduced to stem the spread of the disease caused profound changes to patterns of daily-life communication. This paper presents the results of an online survey conducted to document adult cochlear-implant (CI) users' perceived listening difficulties under four communication scenarios commonly experienced during the pandemic, specifically when talking: with someone wearing a facemask, under social/physical distancing guidelines, via telephone, and via video call. Results from ninety-four respondents indicated that people considered their in-person listening experiences in some common everyday scenarios to have been significantly worsened by the introduction of mask-wearing and physical distancing. Participants reported experiencing an array of listening difficulties, including reduced speech intelligibility and increased listening effort, which resulted in many people actively avoiding certain communication scenarios at least some of the time. Participants also found listening effortful during remote communication, which became rapidly more prevalent following the outbreak of the pandemic. Potential solutions identified by participants to ease the burden of everyday listening with a CI may have applicability beyond the context of the COVID-19 pandemic. Specifically, the results emphasized the importance of visual cues, including lipreading and live speech-to-text transcriptions, to improve in-person and remote communication for people with a CI.

Keywords

cochlear implants, COVID-19, listening difficulties, facemasks, social distancing, remote communication, visual cues

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Introduction

The outbreak of the Coronavirus (COVID-19) pandemic in early 2020 profoundly changed patterns of daily life communication. The imposition of social-distancing measures, together with a rapid shift towards remote online communication methods, transformed social interactions with family and friends, access to essential services, and ways of working. Individuals with hearing loss are thought to have been disproportionally affected by some of these developments (Chodosh et al., 2020; Grote & Izagaren, 2020; Ideas for Ears Ltd, 2020; Maru et al., 2021; Naylor et al., 2020; Saunders et al., 2020; Tavanai et al., 2021; Ten Hulzen & Fabry, 2020). Among people with hearing loss, those who use a cochlear implant (CI) may have been particularly affected by the public-health measures introduced to combat the spread of COVID-19, because of the greater degree of hearing loss (i.e. severe-to-profound hearing loss) associated with this intervention. We sought to document, through an online survey, the perceived listening difficulties experienced by adult CI users during this unprecedented period, and to see whether transferable lessons could be learned to guide future research aimed at alleviating the challenges of listening with a CI.

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We had a particular interest in probing participants' daily-life perceptions of listening effort during, compared with before, the COVID-19 pandemic, as well as possible sequelae of elevated perceived listening effort, such as listening-related fatigue and risk of disengagement (McGarrigle et al., 2014; Pichora-Fuller et al., 2016). Prior research has shown that listening to speech is more cognitively demanding for CI users than for people with normal hearing (Perreau et al., 2017; Russo et al., 2020), even under favourable acoustical conditions (Pals et al., 2020; Winn et al., 2015). Indeed, pre-pandemic, CI listeners reported experiencing high levels of listening effort and listening-related fatigue in everyday life (Alhanbali et al., 2017; Hughes et al., 2018). This increased mental exertion may negatively affect people's ability to focus and sustain attention (Zekveld, Kramer, & Festen, 2011), as well as to retain important information in memory (McCoy et al., 2005; Tun et al., 2009). Such difficulties may in turn impair communication success (Hetu et al., 1988; Wie et al., 2010), social participation (Barker et al., 2017; Hughes et al., 2018; Kramer et al., 2006; Mick et al., 2014; Nachtegaal et al., 2009), long-term cognitive health (Lin et al., 2013; M. Pichora-Fuller et al., 2015) and overall quality of life (Carlsson et al., 2015; Chia et al., 2007; Dalton et al., 2003; McRackan et al., 2019).

Early reports, in the media and the scientific literature, suggested that the public-health measures introduced to combat the spread of SARS-CoV-2 (the virus responsible for the COVID-19 disease) had a disproportionate impact on people with hearing loss (Chodosh et al., 2020; Grote & Izagaren, 2020; Ideas for Ears Ltd, 2020; Naylor et al., 2020; Saunders et al., 2020; Tagupa, 2020; see Tavanai et al., 2021, for a recent review). The use of facemasks, which became mandatory in many countries (on public transport, in healthcare settings, and in other public spaces), received particular attention. Studies showed that facemasks could hinder speech intelligibility because they muffle sounds and attenuate the voice (Goldin et al., 2020; Magee et al., 2020; Ribeiro et al., 2020), and increase listening effort in the presence of background noise (Rahne et al., 2021). Moreover, masks create a visual barrier that obscures the speaker's mouth and lower part of the face. This was shown to further affect communication, especially among people with hearing loss, who often rely on lipreading and facial cues to aid speech comprehension (Atcherson et al., 2017; Chodosh et al., 2020; Grote & Izagaren, 2020; Naylor et al., 2020; Saunders et al., 2020; Ten Hulzen & Fabry, 2020). Indeed, even experienced CI users with good overall proficiency in understanding speech still rely on visual cues to optimise communication performance in real-world listening situations (Moberly et al., 2020). The widespread use of facemasks was therefore expected to have a negative impact on communication for CI users especially.

Compounding the uptake of facemasks, social distancing rules also became established internationally after the COVID-19 outbreak, since increased physical distance between people was proven to reduce the risk of droplet transmission (Jones et al., 2020). However, the requirement to remain several metres apart (commonly two metres) could also have led to less favourable acoustical conditions, since, with a greater distance between conversational partners, the level of the target speech relative to background sound (the "target-to-background" or "signal-to-noise" ratio) is reduced. Similarly, a greater distance leads to a reduction in the direct-to-reverberant ratio, which is an indicator of the level of the direct sound from talker to listener compared to the level of the reverberant sound that has reflected off a room's surfaces. Listening in noise is known to be more challenging for people with hearing loss than for people with normal hearing (Dimitrijevic et al., 2019; Koelewijn et al., 2015; Needleman & Crandellt, 1995; Pang et al., 2019; Shukla et al., 2020), and people with hearing loss are especially sensitive to the deleterious effects of room reverberation on speech intelligibility (Badajoz-Davila et al., 2020; Eurich et al., 2019; Hazrati & Loizou, 2012; Kressner et al., 2018). Physical distancing measures were therefore expected to have a further negative impact on communication for CI users.

At various stages throughout the COVID-19 pandemic, most people were obliged or advised to spend periods of time self-isolating in their home, whether to shield themselves from the virus or to reduce community transmission. Accordingly, the pandemic saw a rapid replacement of in-person interactions by remote communication. Healthcare services, for instance, in many cases underwent a rapid transition to telemedicine and virtual care during the pandemic (Bokolo, 2020; Reay et al., 2020; White et al., 2021). Many patients experienced a reduction of in-person visits to access primary care, mental-health counselling, and other health services, that increasingly switched to remote delivery. Working from home also became the "new normality" for many employees all over the world (Kniffin et al., 2021; Wang et al., 2021), with interactions with peers and colleagues relying almost exclusively on virtual online meetings. Even communication with family and friends took place predominantly online during the pandemic.

Virtual communication, especially online video calling, offers some advantages in terms of being able to control the acoustic environment during communication (e.g., adjustable volume, live captioning, visual indication of who is speaking), which could potentially benefit people with hearing loss. A recent survey of 120 audiologists in the UK showed positive experiences of teleaudiology (Saunders & Roughley, 2021) during the pandemic, nonetheless some concerns about poor internet connection and patients' technology familiarity were highlighted. Indeed, despite the advantages of video calls, previous studies showed that the increased reliance on remote communication may impose an additional burden on people with hearing loss (Ideas For Ears, 2018; Ideas for Ears Ltd, 2020; Naylor et al., 2020; Tavanai et al., 2021). Naylor et al.'s study found that

people with greater hearing loss reported inferior hearing performance during video calls compared to in-person communication. Likewise, video calls and telephone calls were considered an issue for communication during the pandemic as reported by a survey on 249 respondents with hearing loss (Ideas for Ears Ltd, 2020).

It must be noted that, for many, living through the pandemic will have had a variety of consequences for health and wellbeing outside of listening challenges. Aside from potential long-term health effects of the virus itself, the lockdown and quarantine measures around the world imposed a forced social isolation that is associated with negative psychological effects. Brooks et al. (2020) reviewed the psychological impact of quarantine based on 24 studies from multiple countries including the United States of America, Canada, Sweden, Australia, Taiwan, and China. They concluded that the psychological impact of quarantine is wide ranging, substantial, and potentially long-lasting. Some of the psychological effects that have been reported include moderate-to-severe stress, anxiety, loneliness and depression (Brooks et al., 2020; Hyland et al., 2020; Razai et al., 2020; Wang et al., 2020). Individuals with hearing loss or other communication disabilities may have been at increased risk of experiencing these psychological effects during the pandemic (Razai et al., 2020). Indeed, Naylor et al. (2020) concluded that COVID-related restrictions may have created an additional emotional burden that is stronger among people with greater hearing loss. Moreover, it is plausible that the risk of social isolation that is already attributed to hearing loss (Chia et al., 2007; Mick et al., 2014; Pronk et al., 2011; Shukla et al., 2020) may have been worsened as a result of the COVID-19 restrictions (Tagupa, 2020).

To the best of our knowledge, no research has so far investigated the potential impact of COVID-19 public-health measures on CI users' everyday listening experiences, covering both in-person and remote social interactions. Nor has much attention been given to the perceived listening effort (and potential sequelae) associated with communicating under these measures. Therefore, we designed an online survey to investigate perceived listening difficulties of adult CI users under four commonly occurring communication scenarios during the pandemic, specifically when communicating: with someone wearing a facemask, under social/physical distancing guidelines (~2 m), via telephone, and via video call. Participants' listening experiences were examined based on six communication items (intelligibility, listening effort, need of repetition, disengagement, anxiety/stress, and listening-related fatigue), designed to probe both acute listening challenges and medium-term consequences. Where relevant, we asked whether participants' listening experiences during the pandemic were better or worse than they had been beforehand. We planned to perform comparisons within both in-person communication scenarios (facemask vs. social distancing) and remote communication scenarios (telephone vs. video call) to examine the importance of visual cues under these two modes of everyday communication. Finally, the survey sought CI users' views about strategies and technological solutions that may help to improve communication in in-person and remote scenarios. Results of the study could inform interventions and provide reliable advice to help people with severe-to-profound hearing loss to communicate during these challenging times. Such lessons could also be applicable in post-pandemic society where online communication, for instance, may remain prevalent.

Methods

Survey Development

The survey was designed to explore adult CI users' perceived listening difficulties during in-person and remote communication under the measures introduced to combat the spread of COVID-19. The survey design was informed by validated questionnaires, such as the Speech, Spatial and Qualities of Hearing Scale (SSQ) (Gatehouse & Noble, 2004) and the Effort Assessment Scale (EAS) (Alhanbali et al., 2017), that retrospectively evaluate respondents' real-world listening experiences. However, given the unique context and purpose of our survey within the COVID-19 pandemic, we did not use, nor intend to develop, a standardised questionnaire in the present study.

The survey was implemented using the Jisc online survey platform (https://www.onlinesurveys.ac.uk/) and comprised 37 items in total (see Appendix 1 for a full reproduction of the survey items). Following an adaptive questioning procedure, some items (conditional questions) were only displayed where relevant according to a participant's prior responses (i.e., only participants who use a contralateral hearing aid (HA) were asked about the frequency of HA use). Participants were required to answer all questions, with the exception of conditional and open (free-text) questions. The survey items were grouped into four sections: 1) demographic (age, gender, education, employment, and country of residence) and hearing information (hearing-device usage and experience, onset of hearing loss, and ways of communication in daily life); 2) measures affecting in-person communication; 3) remote communication; and 4) potential solutions to minimise any impact.

In the in-person communication section, we asked separately about the impact of two public-health measures introduced to control the spread of COVID-19: the use of face masks and the imposition of social/physical distancing (based on the instruction in the United Kingdom to keep at least 2 metres away from others, a widely adopted rule at the time the survey was conducted). Please note that as the recommended distance changed over the course of the pandemic, participants were instructed to answer the questions considering their overall experiences of having to maintain a minimum distance from others. In the remote

communication section, we asked about participants' experiences using two modes of remote communication: telephone and video calls.

Both sections 2 and 3 followed a similar structure. Firstly, participants were asked to evaluate their current listening experiences during the COVID-19 pandemic (e.g., Q10.1. "For each question below, please select the option that best reflects your experience in this or these situation(s)"). Secondly, participants were asked about how their listening experiences have changed since the introduction of COVID-19 related measures (e.g., Q10.2. "Considering your listening experiences before and after the COVID-19 outbreak, how much do you think your communications have changed due to the speaker wearing a face mask?"). Thirdly, they rated which specific issues were causing them difficulty in a certain communication scenario (e.g., Q11. "The following is a list of potential challenges associated with listening to someone who is wearing a facemask. Please rate how relevant they are according to your experience"). Finally, they reported the degree to which they were avoiding certain communication scenarios because of adverse listening experiences (e.g., Q12. "How often do you find yourself avoiding face-to-face communication because of difficulty hearing someone who is wearing a face mask or covering?").

In total, six communication items were used to assess participants' listening experiences: intelligibility ("how much of the person's speech are you able to understand?"); effort ("how much mental effort do you have to put in to achieve this level of understanding?"); need of repetition ("how often do you ask the speaker to repeat (part of) the message?"); disengagement ("how often do you give up trying to communicate because the effort required was too great?"); anxiety/stress ("did you experience any feelings of anxiety or stress as a result of difficulty communicating?"); and fatigue ("to what extent did the communication leave you feeling tired/fatigued?").

For most survey items, responses were given on a five-point scale with appropriate labels as anchors at the endpoints. For example, for the questions enquiring about listening effort, the endpoint anchors were "no effort" and "lots of effort". Survey items enquiring about frequency of occurrence used five-point scales with category labels "never", "rarely", "sometimes", "often", and "almost always". Similar five-point scales are used in validated questionnaires commonly employed in the literature to assess self-reported fatigue (Fatigue Assessment Scale) (Michielsen et al., 2004) and hearing handicap (Hearing Handicap Questionnaire) (Gatehouse & Noble, 2004). Survey items enquiring about changes in perceived listening difficulties from before to during the pandemic used five-point Likert scales with labels "much less", "less", "no difference", "more", and "much more".

A small number of open questions (free-text answers) were also included to collect: i) additional details about participants' hearing devices; ii) participants' listening experiences; and iii) potential solutions to improve daily-life communication. In the final section, participants rated a list of potential solutions according to the extent that they felt they might benefit from each.

Seven members of the Patient and Public Involvement group of the NIHR Nottingham Biomedical Research Centre (BRC) reviewed and provided feedback on the content and technical functionality of the survey during development. The study was approved by the North West - Greater Manchester Central Research Ethics Committee (REC reference: 20/NW/0141).

Participants

The survey was aimed at adults aged 18 or over, who had at least one CI, spoke fluent English, had capacity to give informed consent and had no known cognitive impairments. Participation was voluntary and no incentives were offered. To access the survey, participants had to read the participant information sheet, confirm that they met the inclusion criteria as defined above, and provide informed consent. The survey took approximately twenty minutes to complete. However, there were no time restrictions and thus respondents could take as much time as they needed to answer all questions. A "previous" button was included throughout the survey allowing participants to go back and modify their answers if needed.

Distribution

The online survey was open for recruitment from July to October 2020. A link to the questionnaire was emailed to all members of the NIHR Nottingham BRC participant database who met the inclusion criteria. The questionnaire was further disseminated by national and regional hearing charities and organisations in the United Kingdom including the Royal National Institute for Deaf People (https://rnid.org.uk/), the National Cochlear Implant Users Association (https://www.nciua.org.uk/) and Ideas for Ears (https://www.ideasforears.org.uk/). The survey was also publicised on NIHR Nottingham BRC social media feeds.

Analysis

Ninety-four responses in total were coded and exported from the Jisc online survey system into a Microsoft Excel spreadsheet. The response data were anonymised, and participants were identified by a unique code. Descriptive statistics and analyses were performed using R software (Version 4.1.2; R Core Team, 2021). Non-parametric paired comparisons (Wilcoxon signed-rank test with continuity correction) were performed to test for differences between measures in the same category (e.g. facemask use vs. social distancing), while single-sample Wilcoxon signed-rank tests (with

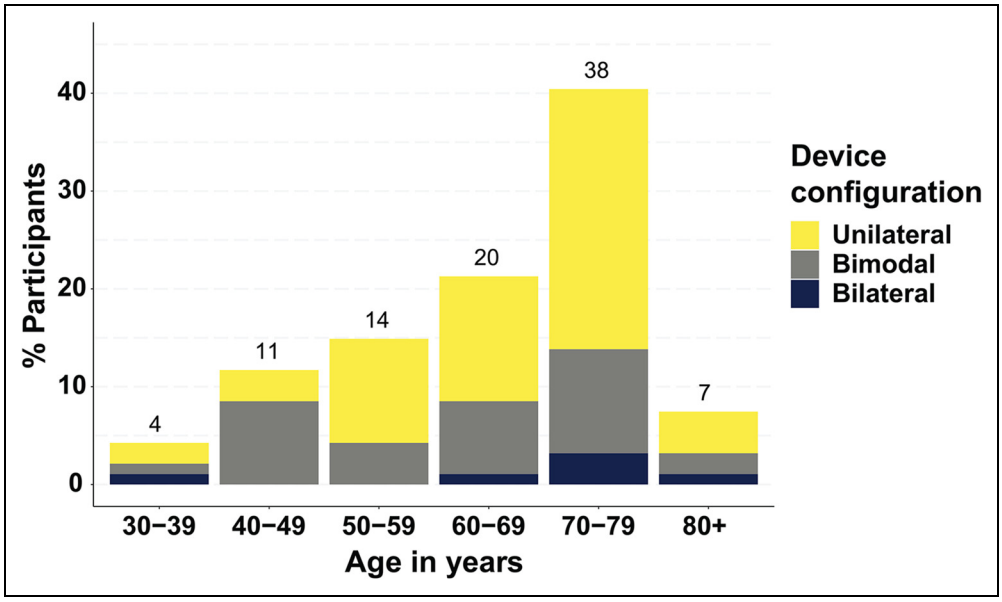

Figure 1. Participants' hearing device configuration by age group. Number of participants in each age group is shown at the top of each bar.

continuity correction) were used to test for significant changes from before to during the COVID-19 pandemic. The Holm method (Holm, 1979) was applied to account for multiple comparisons across the full set of tests performed in this study. All p-values reported in the text are the corrected values, meaning that they can be compared against a conventional $p < .05$ threshold for statistical significance.

Exploratory factor analysis (EFA) was conducted using the 'psych' package (Revelle, 2020) in order to determine the number of underlying constructs assessed by the six communication items. The non-graphical Cattel's scree test (Cattell, 1966) from 'nFactors' package was used to determine the number of factors to retain. An ordinary least squares estimation procedure was used to find the minimum residual (minres) solution using the 'fa' function. Bootstrapped confidence intervals for factor loadings were calculated with one thousand iterations. Scores on the "intelligibility" item were reversed prior to factor analysis, so that greater scores would in all cases reflect a worse listening experience.

Participants' (optional) responses to the three open (free-text) questions were analysed using a simple descriptive approach, with themes and categories selected based on Elo and Kyngäs's guidelines for inductive content analysis (Elo & Kyngäs, 2008).

Results

Demographics and Hearing Profile

Ninety-four participants completed the survey, 73 women and 21 men. Most participants were older adults, with the modal age category being 70–79 years old (Figure 1). Participants spanned age categories from 30–39 to 80+. Most participants were UK residents (92%), currently retired (56%), and with higher or postgraduate level of education (57%).

On average, the onset of hearing loss (HL) in the implanted ear occurred at age 30–40, although 16% of participants had been deaf since birth or within the first year of life, and 8% lost their hearing later in life (over 60 years old). Most participants had more than 10 years' experience with a CI (minimum 6 months). Attending to participants' device configuration, 60% were unilateral CI users (one CI), 6% were bilateral CI recipients (two CIs) and 34% were bimodal users (one CI and a contralateral HA). Device configuration did not appear to vary systematically across age groups (Figure 1). For participants with a unilateral CI, concerning the non-implanted ear, 30% reported being completely deaf, 67% reported having severe-to-profound HL, and 3% reported having mild or moderate HL.

On average, bimodal listeners had more than ten years' HA experience and 72% reported using their HA more than eight hours a day. Around one-third of bimodal listeners reported making use of a special feature to facilitate coordination between their hearing devices (Table 1), most commonly, a wireless link between the CI and the HA allowing an audio signal to be transferred between them (e.g., a contralateral routing of signals solution).

Nearly all respondents reported relying mainly on auditory speech for communication, typically with significant support from visual cues including lip reading and facial expressions (Figure 2). Around one-half of respondents reported making regular use of text transcriptions to support communication, which included subtitles and speech-to-text transcriptions. Very few participants made use of sign language to communicate with others.

Perceived Listening Difficulties During in-Person Communication

Nearly all (99%) participants reported having experienced communicating in-person with someone who was wearing a facemask and, separately, whilst maintaining a distance of at least 2 metres. Figure 3 shows participants' ratings regarding their current listening experiences under each of these two public-health measures.

Under COVID-19 restrictions, many participants reported experiencing moderate to high levels (scores of 4 or 5 out of 5, see Figure 3) of listening effort (90% and 74% of participants for facemasks and social distancing, respectively), need to ask for repetition (55% and 42%), listening-related anxiety/stress (54% and 45%), and fatigue (58% and 45%). Some, but not all, participants also reported frequently disengaging from listening (31% and 20% for facemasks and social distancing, respectively). Alongside these challenges, many participants reported achieving no better than moderate speech understanding (intelligibility scores ≤3 out of 5) during in-person communication (76% and 48% of participants for facemasks and social distancing, respectively).

The use of facemasks was considered more detrimental for communication than social/physical distancing. Significantly worse ratings ($p < .05$) for all items (listening effort, intelligibility, repetition, disengagement, anxiety/stress, and fatigue) were given in relation to facemasks compared with social distancing (see Table 2 for statistical test results).

As well as experiencing significant listening difficulties under COVID-19 public-health measures in place at the time of survey completion, participants reported that their listening experiences had significantly worsened, compare to before the COVID-19 outbreak, specifically because of the widespread use of facemasks and the imposition of social/physical distancing rules (Figure 4). This worsening of listening experiences (less perceived intelligibility and more perceived effort, need of repetition, disengagement, anxiety/stress, and fatigue) from before to during the pandemic was statistically significant for all communication

Table 1. Themes, Categories, Number of Mentions, and Example Statements in Response to Question Q8.2.3. "Do you use any special feature that makes the coordination between your hearing aid and your cochlear-implant easier? (If yes) Please give more details".

Theme	Category	Number	Example
Special feature to coordinate hearing devices	Contralateral routing of signals solution	10	"Have a Naida link which allows sounds to be transferred from CI to HA, it enables me to hear environmental sounds that I wouldn't normally pick up in my non implant ear"
	External microphone	1	"I wear an Advanced Bionic CI and Phonak hearing aid that dual access my Rogers Pen"

Participants' statements are reproduced verbatim.

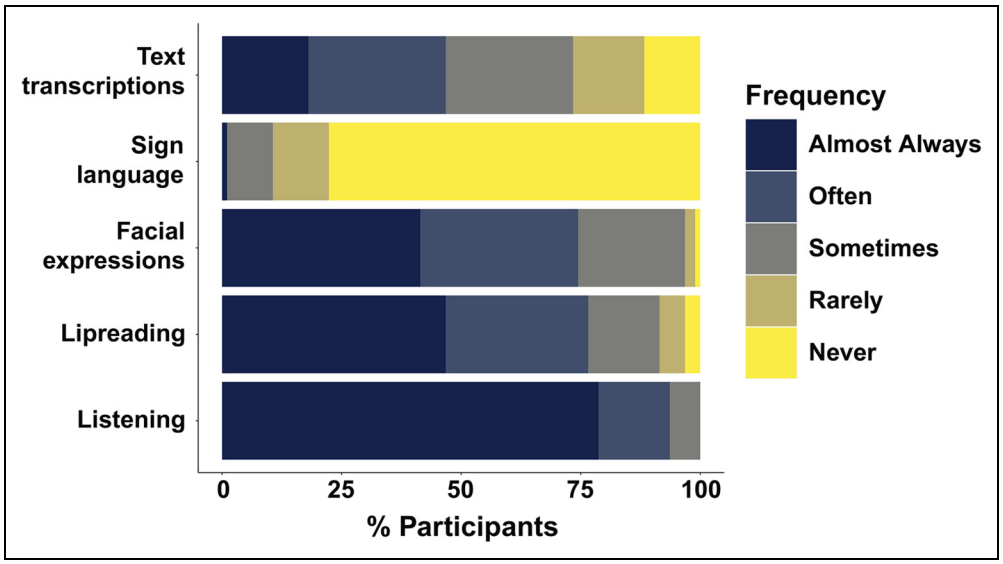

Figure 2. Percentage of participants who rely on different ways of communicating (listening, lip reading, facial expressions, sign language and text transcriptions) in everyday life. Q9: "In everyday life, to what extent do you rely on these ways of communication?".

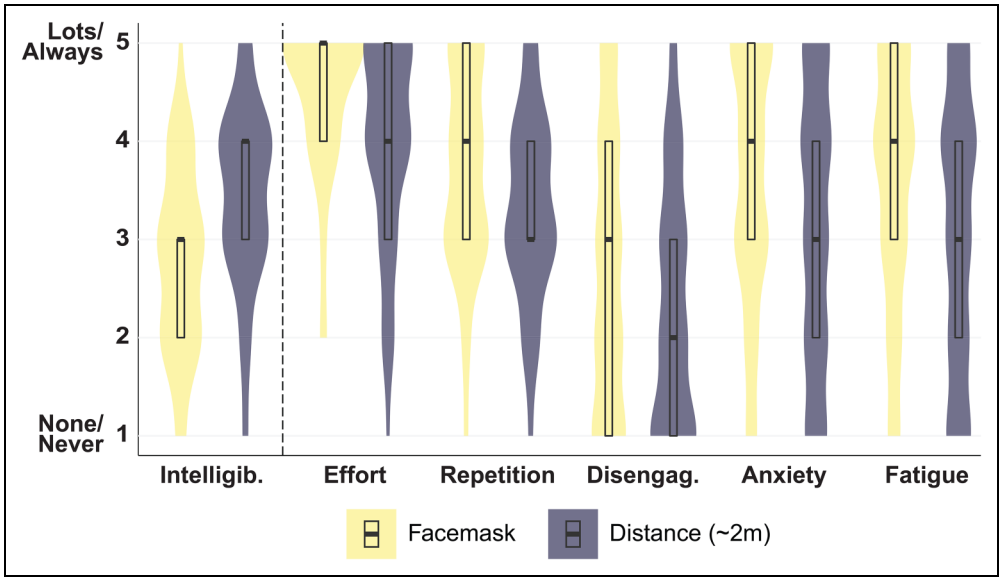

Figure 3. Participants' listening experiences regarding facemasks and social distancing in response to questions Q10.1 and Q13.1. Refer to the main text (under Methods) for the full wording of the questions corresponding to each labelled item on the x-axis. The box represents the inter-quartile range (IQR), with thick lines representing the median. The shaded area illustrates data distribution (as per kernel density function).

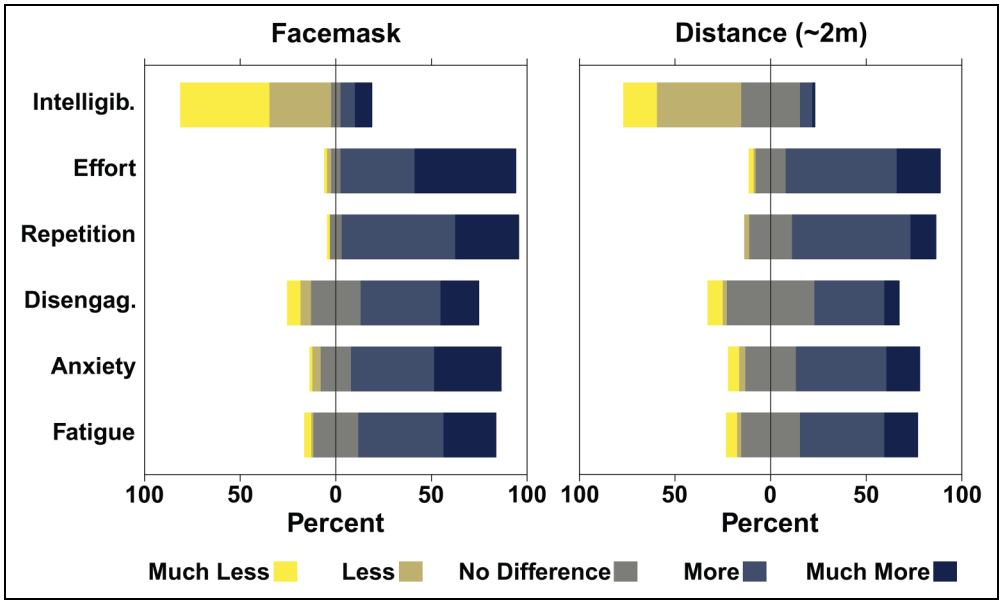

Figure 4. Diverging stacked bar chart showing changes in perceived listening difficulties (before versus after COVID-19 outbreak) due to facemasks and social distancing. Q10.2 and Q13.2: "Considering your listening experiences before and after the COVID-19 outbreak, how much do you think your communications have changed due to the speaker wearing a face mask/due to having to keep 2 metre away from others?". The percentages of participants who perceived "more" or "much more" of each communication item are shown to the right of the zero line in dark blue shades; the percentages of participants who noticed "less" or "much less" of each communication item are shown to the left of the zero line in yellow shades; the percentage of participants who perceived "no difference" are shown centred around the zero line in grey colour.

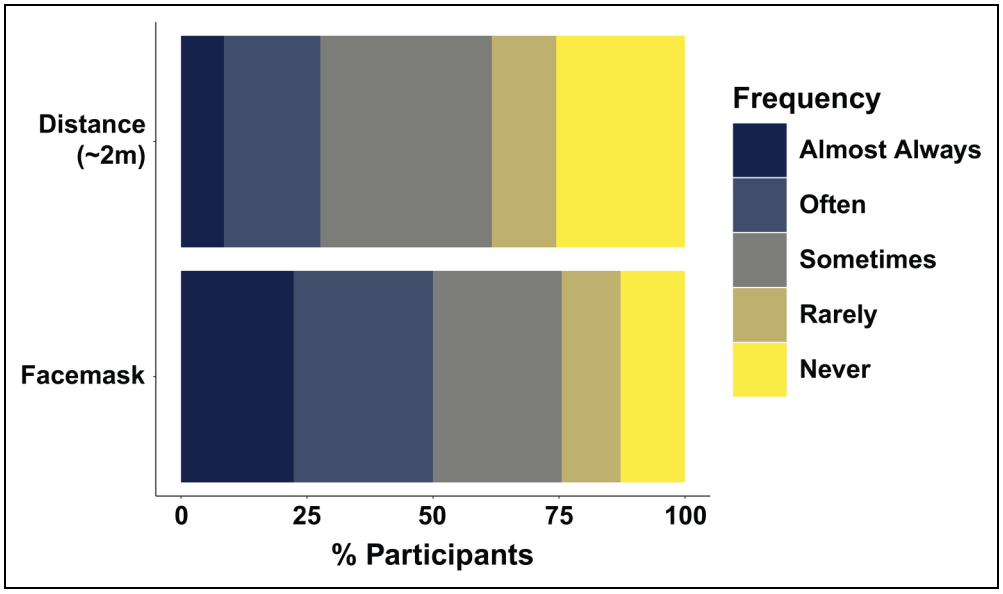

Figure 5. Frequency of communication avoidance due to facemasks and social distancing. Q12 and Q15: "How often do you find yourself avoiding face-to-face communication because of difficulty hearing someone who is wearing a face mask /who is 2 metres apart?"

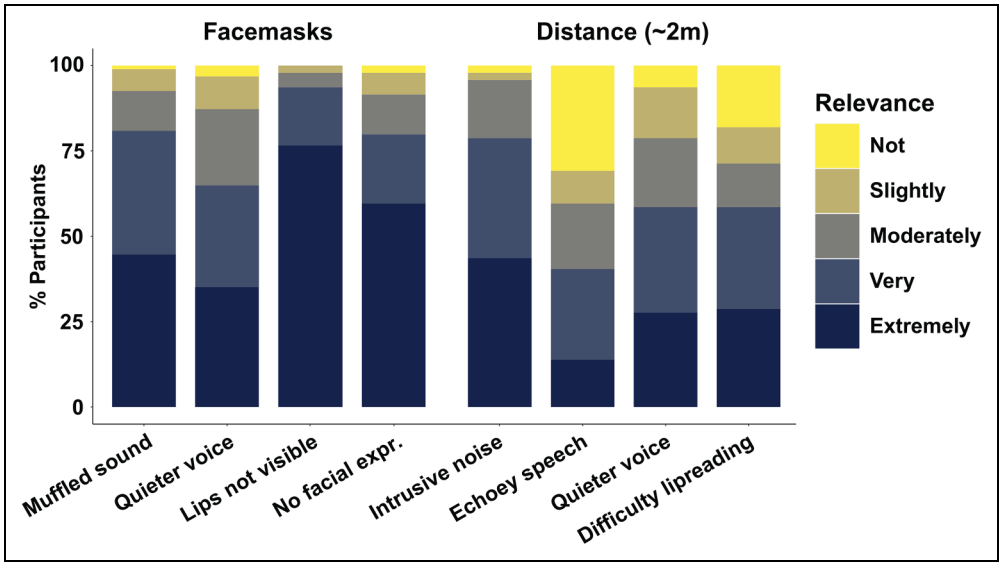

Figure 6. Relevance of listening challenges associated to facemasks and social distancing. Q11 and Q14: "The following is a list of potential challenges associated with listening to someone who is wearing a facemask/ from 2 metre distance. Please rate how relevant they are according to your experience".

items and for both the facemask and social distancing measures (Table 2).

Most participants reported avoiding in-person communication scenarios at least some of the time if either facemask use or social distancing would be required (Figure 5). Participants were significantly more likely to avoid scenarios due to the challenges associated with facemask use compared with the challenges associated with maintaining a minimum distance ($p < .0001$).

Participants identified multiple factors contributing to the listening challenges associated with COVID-19 public-health measures (Figure 6). For facemask use, the predominant factors were "Lips not visible" (94% of participants rated it as extremely or very relevant), "no facial expressions" (80%), "muffled sound" (81%) and "quieter voice" (65%). Regarding social/physical distancing, "intrusive background noise", "quieter voice", "difficulty lipreading" and "echoey

Table 2. Pairwise and Single-Sample Comparisons using Wilcoxon Signed-Rank Test with Continuity Correction.

	Variable	N	Comparison	Z	*p* value adjusted (two-sided)	*p* value Significance
In-person Communication	Effort (EF)	92	Facemask vs. ~2 m distance	926	0.000019	****
	Intelligibility (INT)	92	Facemask vs. ~2 m distance	184.5	0.000002	****
	Repetition	92	Facemask vs. ~2 m distance	897	0.018	*
	Disengagement (DISG)	92	Facemask vs. ~2 m distance	824.5	0.019	*
	Anxiety	92	Facemask vs. ~2 m distance	1,053	0.018	*
	Fatigue	92	Facemask vs. ~2 m distance	956.5	0.012	*
	EF Change (Facemask)	93	Communication change due to facemask vs. "No difference"	3,813.5	<.000001	****
	EF Change (~2 m distance)	93	Communication change due to social distance vs. "No difference"	2,919	<.000001	****
	INT Change (Facemask)	93	Communication change due to facemask vs. "No difference"	637	<.000001	****
	INT Change (~2 m distance)	93	Communication change due to social distance vs. "No difference"	200	<.000001	****
	Repetition Change (Facemask)	91	Communication change due to facemask vs. "No difference"	3,585	<.000001	****
	Repetition Change (~2 m distance)	92	Communication change due to social distance vs. "No difference"	2,496	<.000001	****
	DISG Change (Facemask)	91	Communication change due to facemask vs. "No difference"	1,835	0.000074	****
	DISG Change (~2 m distance)	93	Communication change due to social distance vs. "No difference"	933.5	0.018	*
	Anxiety Change (Facemask)	92	Communication change due to facemask vs. "No difference"	2,852	<.000001	****
	Anxiety Change (~2 m distance)	93	Communication change due to social distance vs. "No difference"	1,984	0.000003	****
	Fatigue Change (Facemask)	92	Communication change due to facemask vs. "No difference"	2,294	<.000001	****
	Fatigue Change (~2 m distance)	93	Communication change due to social distance vs. "No difference"	1,766	0.000006	****
	Avoidance	94	Facemask vs. ~2 m distance	1,341.5	0.000067	****
Remote Communication	Effort (EF)	54	Telephone vs. Video call	331.5	0.018	*
	Intelligibility (INT)	54	Telephone vs. Video call	149	0.321	ns
	Repetition	54	Telephone vs. Video call	507	0.000186	***
	Disengagement	54	Telephone vs. Video call	334.5	0.026	*
	Anxiety	54	Telephone vs. Video call	490	0.001	**
	Fatigue	54	Telephone vs. Video call	299.5	0.321	ns
	Frequency Change	94	Telephone & Video call frequency change vs. "No difference"	1,666	<.000001	****
	Avoidance	94	Telephone vs. Video call	1,576	0.000002	****

N represents the number of complete observations included in each test. *P* values are adjusted for multiple comparisons. Significance code: ns (not significant), * ($p < .05$), ** ($p < .01$), *** ($p < .001$), **** ($p < .0001$).

speech" were rated as extremely or very relevant by 79%, 59%, 59% and 40% of participants, respectively.

Responses to the open question about in-person communication were provided by 48% of participants. Examples of participants' responses per theme and category can be found in Table 3. Most comments (62%) were related to facemask use. Overall, facemasks were identified as the predominant challenge to successful communication during the COVID-19 pandemic due to the inability to lipread and see facial expressions. Some participants commented that facemask use in healthcare settings is especially concerning since it prevents them from understanding important medical information. Some respondents (11% of participants who provided free-text responses) considered that people's collaboration (e.g., temporary removal of facemasks) was needed to overcome the limitations imposed by facemask use. A few participants (7%) stated that avoiding going into places where facemasks would be required had led to

Table 3. Themes, Categories, Number of Mentions, and Example Statements in Response to Question Q16. "If you have any additional comments, please write them here: (e.g. comments about the previous measures mentioned or other physical measures that make communication difficult)".

Theme	Category	Number	Example
Facemasks	Major problem	17	"Face mask coverings make life very hard", "The voice muffling is the most difficult thing"
	In medical settings	5	"I had to go for a scan and the nurses insisted on keeping their masks on. Very stressful and I think they skimped on what info they gave me because of the difficulties"
	People collaboration	5	"Thankfully, people are following U.K. guidance and removing their mask if they need to speak to me"
	No major impact	3	"I have not had major problems understanding people wearing face masks. I do need to slightly increase the number of tomes I ask them to repeat, but that is a consequence of face masks for mostly everyone"
	Low confidence/loneliness	3	"Avoid going anywhere where you have to wear a mask. Lose my confidence"
	Clear visor	1	"Clear visor masks are helpful, face coverings impossible- terrible situation for deaf people"
Social distancing	No major impact unless noisy environment	7	"I don't find the 2 m rule a problem unless is a noisy environment"
	Difficult to lip-read	4	"Being outside at 2 metres apart just doesn't work for using Lipreading to help with communication. Many times I have told the person I am with that I cannot keep 2 metres"
Combination of facemask and social distancing	Impossible to communicate	2	"Combination of 2 metre distance PLUS face mask = nightmare!"
Shields	Muffled sounds	2	"Shields at counters, especially those made up of strips cause issues due to muffled sound and light glare"
Listening training	Helpful	2	"I spend hours to train what I hear and less dependence on other form of communication which allow me to feel more confidence in these times"
Other feelings/attitudes	Lack of people collaboration	3	"people give up"
	Perseverance	1	"My nature is not to give up"

Participants' statements are reproduced verbatim.

loss of confidence, increased feelings of loneliness, and social isolation.

Participants expressed varying opinions regarding social/physical distancing. Although some participants (9%) indicated that it is difficult to lipread and understand speech at two-metre distance, others commented (15%) that it was not a problem unless the background noise level was high. Two participants commented that the use of facemasks and social distancing in combination made communication no longer possible. Plastic shields at counters were also identified (by 4% of participants who provided free-text responses) as a further barrier to successful communication.

Perceived Listening Difficulties During Remote Communication

Responses to question Q18: "how has the frequency of telephone and video calls changed since the COVID-19 outbreak?" showed that participants reported a significant increase ($p < .0001$) in the frequency of telephone and video calls since the beginning of the pandemic (see "frequency change" under "remote communication" in Table 2). Specifically, as shown in Figure 7, participants reported that this increased reliance on remote communication, at the time of survey completion, was needed to speak with family and friends (50% often or always), to access essential services (20% often or always), and for work-related reasons (28% often or always). It is worth noting that most participants in our sample were retired, which may account for 37% of participants reporting never having telephone or video calls for work.

Figure 8 illustrates participants' listening experiences when having telephone and video calls. Since not all participants made use of remote communication technologies, only 70% of participants answered questions about telephone calls while 74% answered questions about video calls.

Although most participants reported achieving moderate to good levels (scores of 3 or 4 out of 5) of speech

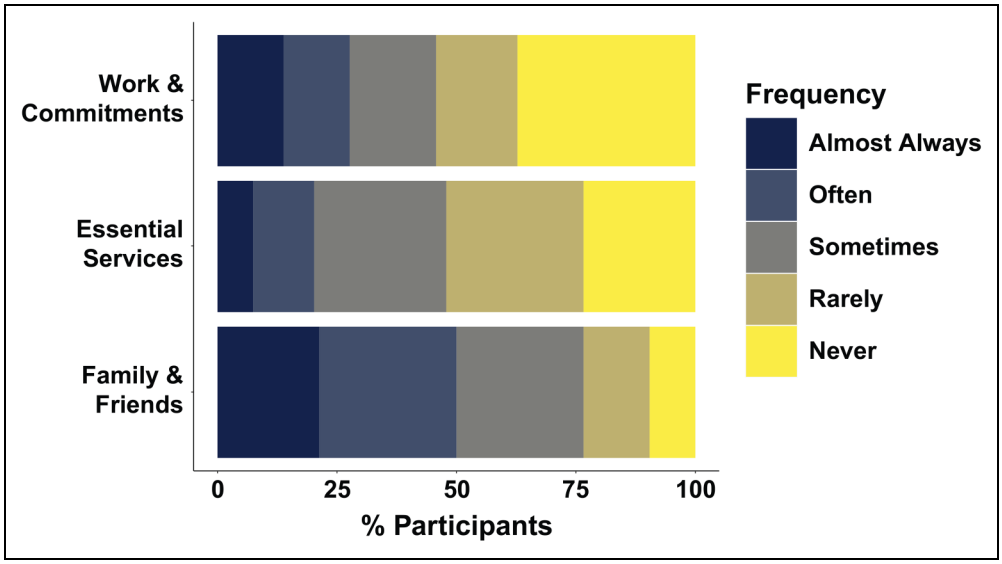

Figure 7. Frequency of telephone and video calls during the COVID-19 pandemic to communicate with family and friends, essential services and for work and other commitments. Q17: "How often do you have telephone or video calls… to communicate with family and friends/… to access essential services (such as health and care consultations, shops, pharmacy, etc.)/…for work or other commitments?"

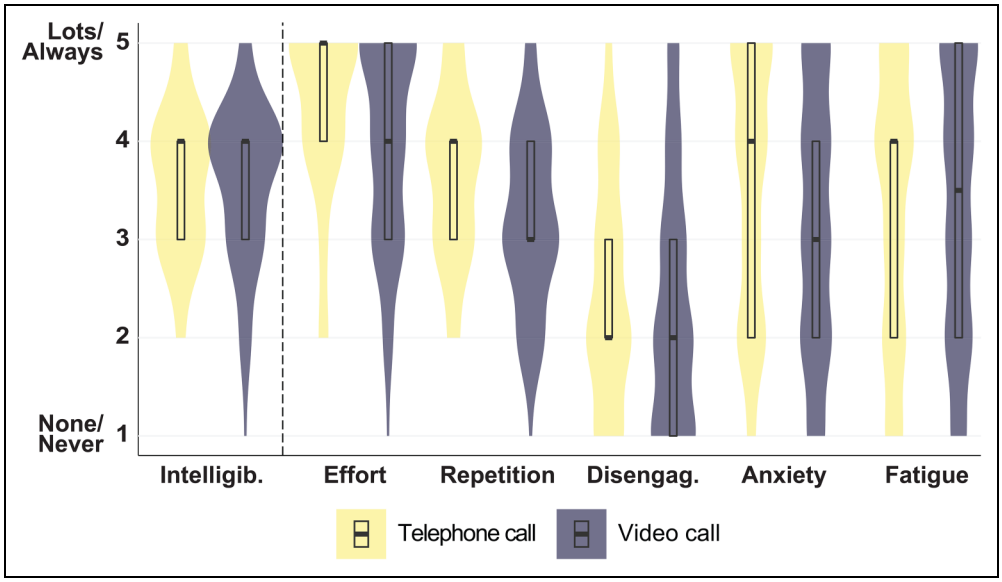

Figure 8. Participants' listening experiences regarding telephone and video calls during COVID-19 pandemic in response to questions Q19.1 and Q21.1. Refer to the main text (under Methods) for the full wording of the questions corresponding to each labelled item on the x-axis.

intelligibility in both modes of remote communication (85% and 83% of participants for telephone and video calls, respectively), they at the same time reported experiencing relatively high levels (scores of 4 or 5 out of 5) of listening effort (86% and 67% of participants for telephone and video calls, respectively), need to ask for repetition (59% and 37%), listening-related anxiety (58% and 43%), and fatigue (53% and 50%). Despite these difficulties, most respondents reported rarely disengaging (scores ≤2 out of 5) while communicating via telephone (58%) or video call (61%).

Participants' listening experiences were worse when having telephone calls compared to video calls. Pairwise comparisons (Table 2 under "remote communication") yielded significant differences in effort ($p < .05$), frequency of repetition ($p < .001$), disengagement ($p < .05$) and anxiety ($p < .01$) between telephone and video calls. No significant differences were found in intelligibility or listening-related fatigue.

As illustrated in Figure 9, most participants avoided both modes of remote communication at least some of the time.

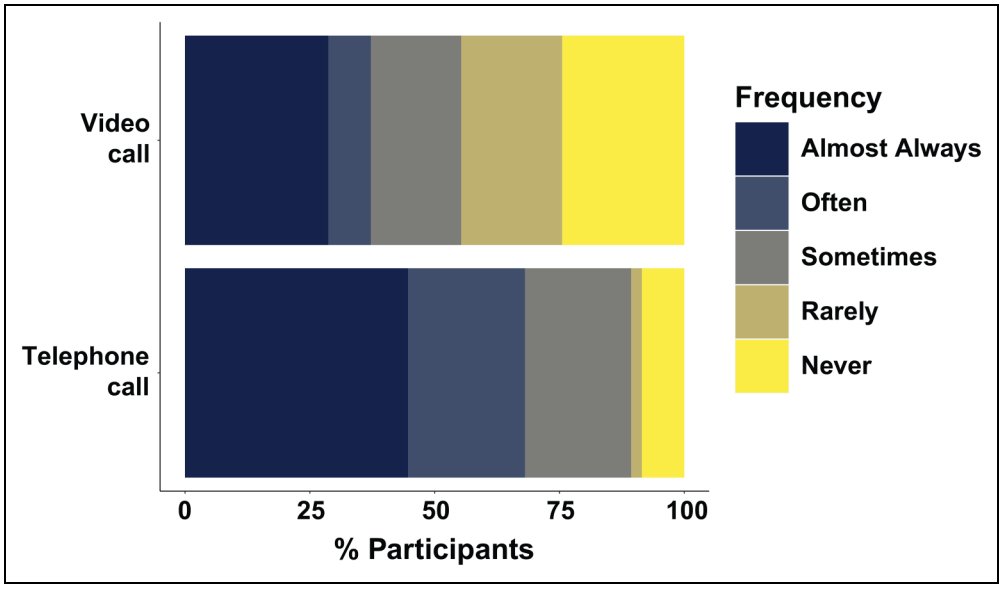

Figure 9. Frequency of telephone and video calls avoidance during the COVID-19 pandemic. Q20 and Q22: "How often do you find yourself avoiding telephone calls/video calls because of difficulty understanding what is being said?"

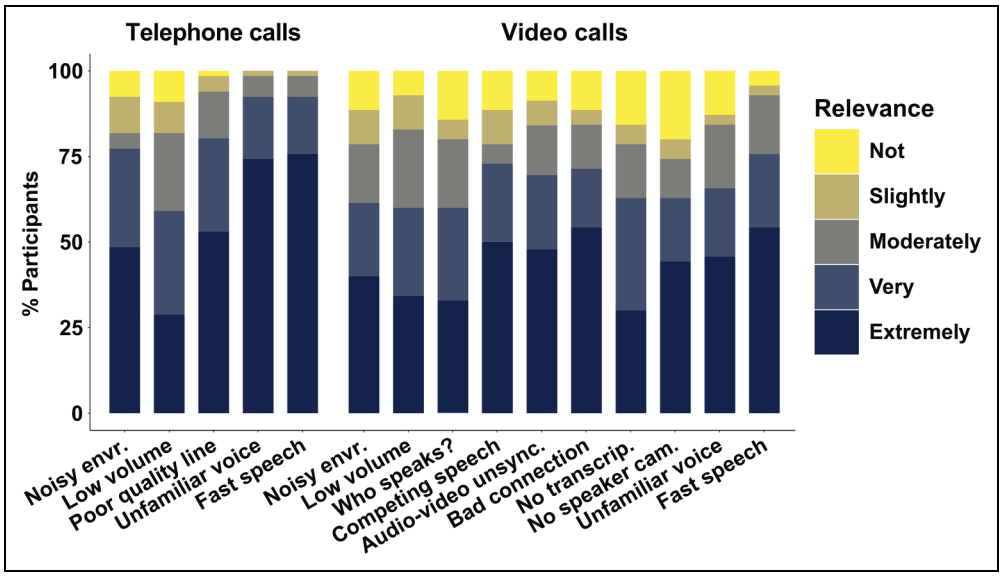

Figure 10. Relevance of potential challenges associated with telephone and video calls. Q19.2 and Q21.2: "The following is a list of potential challenges associated with telephone conversations/ video calls or conferences. Please rate how relevant they are according to your experience".

However, participants were more likely ($p < .0001$) to avoid telephone calls than video calls.

All potential challenges associated with remote communication proposed in the survey were considered to be very or extremely relevant by more than 50% of participants (Figure 10). The primary problems associated with telephone calls were related to the speaker's voice ("unfamiliar voice or accent") and pace ("fast speech"). Also relevant were "poor quality line", background noise in the participant's environment ("noisy environment") and "volume too low". With respect to video calls, once more "fast speech pace" was the most relevant challenge, followed by competing speech in multitalker conversations ("too many people speaking at the same time") and connection problems ("audio or video cutting in and out"). Other relevant problems were background noise ("noisy environment"), "volume too low", unclear who was speaking during group conversations ("who speaks?"), "audio and video out of

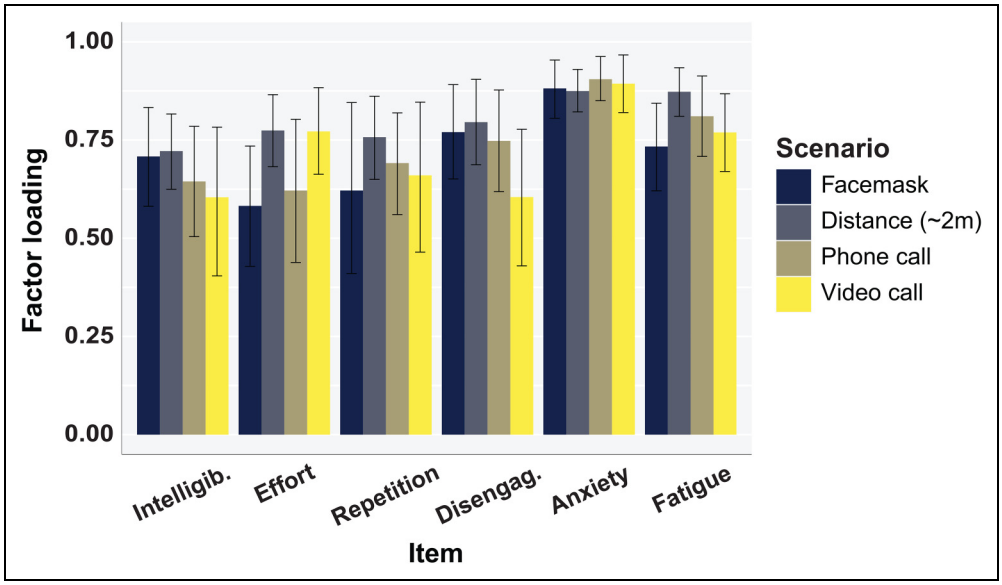

Figure 11. Factor loadings resulting from exploratory factor analysis across four communication scenarios (facemask, social distance, phone and video calls). Error bars represent 95% bootstrap confidence intervals.

sync", "poor or lack of transcriptions", "no access to the speaker's video camera", and "unfamiliar voice or accent".

Factor Analysis

EFA was conducted to explore whether the six communication items that we used to probe participants' listening experiences each provided unique information, or whether they tapped into one or more common underlying constructs.

Separate EFA analyses were conducted for each communication scenario: participants' experience communicating with someone wearing a facemask (Q10.1), at two-metre distance (Q13.1), having telephone calls (Q19.1), and video calls (Q21.1). In all cases, the solutions provided by the function 'nScree' (Kaiser rule, parallel analysis, acceleration factor and optimal coordinates index) indicated a clear one-factor structure. The one-factor model explained 52%, 64%, 55% and 53% of the total variance for each scenario, respectively. The models showed a consistent pattern of factor loadings as revealed by a Tucker's congruence coefficient (ϕ) $\geq$ 0.99 across all pairwise comparisons (Lorenzo-Seva & ten Berge, 2006).

Figure 11 shows the resulting factor loadings for each communication scenario with 95% bootstrap confidence intervals. The factor loading of a variable quantifies the extent to which the variable is related with the underlying factor. All items had broadly similar loadings on the principal underlying factor across the four scenarios, with the confidence intervals generally overlapping. A possible exception was the "anxiety/stress" item, which showed a consistently high loading across the four scenarios, with relatively small confidence intervals compared to the other items.

Overall, the results of the EFAs suggest that, across multiple communication scenarios, the six communication items all tapped into a single underlying construct that reflected both immediate listening difficulties (reduced intelligibility and increased listening effort) as well as short-term (need for repetition and risk of disengagement) and longer-term consequences (anxiety and fatigue).

Solutions to Minimise the Impact

Most participants considered, as illustrated in Figure 12, that the solutions proposed in the survey could help them greatly to improve their everyday life communication.

As can be seen in Table 4, the most highly rated solutions to improve in-person conversations were the reduction of background noise in public places (91% of participants rated it as highly effective) and the use of transparent face masks (82%). Also relevant were having more access to in-person services (79%), and the use of speech-to-text apps (68%).

For remote conversations, the most highly rated solutions were: the speaker talking at a slower speech pace (75%), real-time transcriptions during video conferences (72%), streaming sounds from phone and video call directly to their hearing devices (69%), and making sure that the speaker's camera is turned on during video calls (62%). Other solutions rated as highly effective by at least half of participants were improved bandwidth during video calls, improved confidence using video conferencing, and increased volume in phone and video calls.

Around one half of participants provided additional free-text comments about solutions that they were already using to improve daily-life conversations (see Table 5 for description of themes, categories and statement examples). Regarding

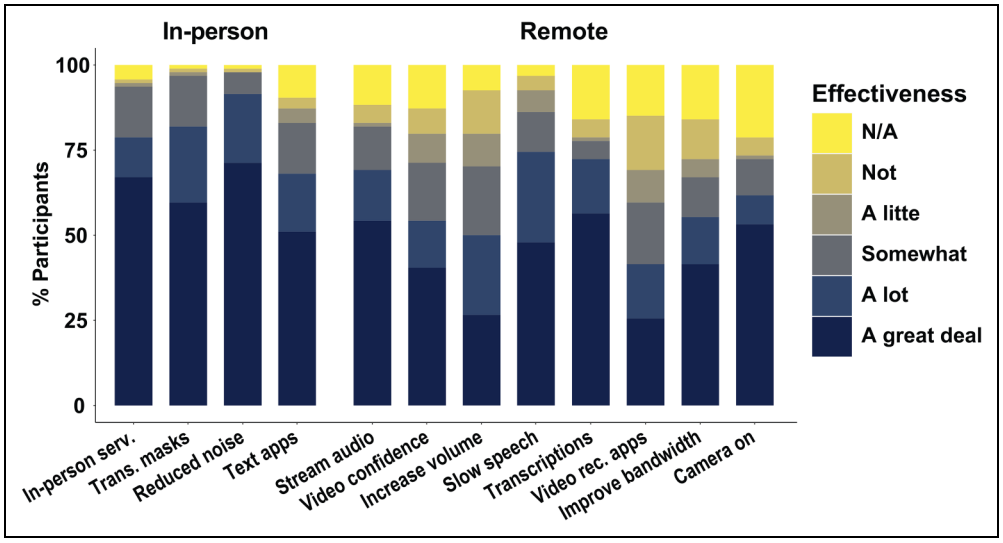

Figure 12. Effectiveness of potential solutions to improve in-person and remote communication. Q23: "To what extent do you think these solutions could help to improve your everyday life communications? If any of these solutions doesn't apply to you, please check the "Not applicable" option". Proposed solutions: "In-person serv." (more access to face-to-face services); "Trans. mask" (transparent face masks); "Reduced noise" (reduced background noise in public places); "Text apps" (speech-to-text apps); "Stream audio" (stream sounds from phone and video call directly to hearing devices); "Video confidence" (improved confidence to use video calling); "Increase volume" (increased volume in phone and video calls); "Slow speech" (slower speech pace); "Transcriptions" (real-time transcriptions during video calls); "Video rec. apps" (video call recording apps); "Improve bandwidth" (improved bandwidth during video calls); and "Camera on" (speaker's camera turned on during video calls).

Table 4. Potential Solutions to Improve In-Person and Remote Communication and Percentage of Participants Rating Each Solution as Being Expected to be Highly Effective, Slightly Effective, or Not Effective/Not Applicable.

		% of Participants		
Type	Potential Solutions	Highly effective *(A lot/A great deal)*	Slightly effective *(A little/somewhat)*	Not effective/Not applicable
In-person Communication	More access to face-to-face services	78.7	16	5.3
	The use of transparent face masks	81.9	16	2.1
	Reduced background noise in public places	91.5	6.4	2.1
	Use of speech-to-text (live transcription) apps	68.1	19.1	12.8
Remote Communication	Stream sounds from phone and video call directly to hearing devices	69.1	13.8	17
	Improved confidence to use video calling	54.3	25.5	20.2
	Increased volume in phone and video calls	50	29.8	20.2
	Slower speech pace	74.5	18.1	7.4
	Real-time transcriptions during video calls	72.3	6.4	21.3
	Video call recording apps (allowing re-watching of the call afterwards)	41.5	27.7	30.9
	Improved bandwidth during video calls (less cutting out of audio or video)	55.3	17	27.7
	Making sure that the person speaking always has their camera turned on during video calls	61.7	11.7	26.6

in-person communication, the use of an external mini microphone connected to the hearing device was mentioned (8% of comments) as a good option to cope with the difficulties of social/physical distancing. However, one responder expressed concerns about the potential risk of COVID-19 transmission when the microphone is handled by multiple people, which

Table 5. Themes, Categories, Number of Mentions, and Example Statements in Response to Question Q24. "Are there any other solutions you have tried or are thinking of trying to improve your everyday life communications?"

Theme	Category	Number	Example
Text transcriptions/ live subtitles	Essential for video calls but not always available	8	"Video calls with subtitles would make life easier for me", "Zoom should provide free captions like Google does"
	Text transcription apps	6	"When I join a Zoom meeting on my laptop I have the app "Live Transcribe" open on my mobile phone beside the loudspeaker. It's not perfect but fills in some gaps and gives me clues if I lose the thread. Also it is retained on the phone so I could go back and check if necessary provided it is still there (limited time recorded)"
	Not always accurate	1	"I use live captions in video meetings but they aren't very accurate and once told me people were talking about thin crispy zombies!"
Stream sounds to hearing devices	Improve speech clarity	6	"I have purchased a USB headset that streams direct to my cochlear implants via my Roger Select and an adapter. I take numerous Skype calls and meetings daily and can hear almost every word. It has been a life saver"
	Overlapping talk	1	"Other people I struggle to hear at all even with the streamer. When people start talking over each other I tend to give up!"
Telephone and video call Avoidance	Too challenging	5	"I don't use Skype, or the telephone too challenging"
	Use of text messaging and other services	2	"I use RelayUK to make calls and sometimes receive them. Texts and emails are my lifeblood!"
Transparent mask/face visors	Allow Lipreading	5	"I wear a visor not a mask,I find pointing to it and saying that I lipread is an instant,constant reminder to people that I have hearing needs. I would quite like to see visors with "please speak clearly!" printed across the headband!
External microphone	Useful for social distancing	3	"I can pass my MiniMic to an individual to use when speaking to me from 2 m away as will pick up on Bluetooth that way"
	Covid transmission risk	1	"Have been unable to use Mini-mike for speakers because of Covid transmission risk."
Ask people collaboration	Remove facemasks	3	"Being very specific saying I cannot Lipread with a mask and I need them to remove it when talking to me. Sometimes it works!"
	Help from family/friends	2	"My wife is my hearing support. If she were not here my life would be very very different!"
Speakers' camera during video calls	Camera on/ correct placement	2	"Camera placement to see speaker faces is a big problem. I hate seeing just top of head. Speaker cannot see themselves in little windows and mostly cannot when using mobile devices"
Better bandwidth	Quality of Audio/ Video & Audio in sync	2	"On video more bandwidth to audio to give much better lower frequency transmission would be fantastic"
Previous Knowledge	Topic and people in the conversation	2	"Having a good idea of the subject-matter the other person seeks to talk about enables one to better 'select' the vocabulary base and, thereby, the sense and meaning of what they are saying"
Other solutions	over-the-ear headphones	1	"I wear over the ear headphones for telephone and video calls"
	Perseverance	1	"There is little more I can do but I persevere as much as possible."
	Wear a badge	1	"I wear a badge stating that I am deaf and that has helped as people are aware of my problem"
	Reduce background noise	1	"I'm also much more bothered by background noise than I was before, so being able to cut out background would be really helpful."
	Meditation	1	"Meditation, to accept and get used to the 'new normal'."

Participants' statements are reproduced verbatim.

led that individual to stop using an external microphone. Asking people to briefly remove their facemasks, wearing a badge saying "I am deaf", and encouraging the use of transparent facemasks and face visors were other strategies that individual participants (18%) had employed during the pandemic.

With respect to remote communication, the use of text transcriptions during video calls was commonly mentioned (31%) as a solution that participants were already employing. Participants accessed live subtitles from some video call platforms or from external transcription services and mobile phone apps (e.g. Live Transcribe) that allow capturing speech-to-text in real time. One downside mentioned about live captions was that they are sometimes inaccurate. Another popular solution (14%) used by participants during

telephone and video calls was streaming sounds directly to their hearing devices. This solution however is not as effective when people speak at the same time (competing speech) during group conversations. One participant also found the use of over-the-ear headphones helpful to improve audio quality during remote conversations.

For those who completely avoid telephone and video calls (14%), the preferred communication method was the use of text-messaging apps or other services such as RelayUK that offers an intermediate assistant who can speak on the CI user's behalf.

Discussion

Ninety-four English-speaking adult CI users completed an online survey asking about perceived listening difficulties during in-person and remote communication under public-health measures introduced to control the spread of COVID-19. Respondents also gave their opinions regarding suggested strategies and technological solutions that could help CI users to overcome some of the listening challenges associated with social distancing measures and online communication.

Perceived Listening Difficulties During in-Person and Remote Communication: A Single Underlying Construct

Across multiple communication scenarios, participants reported experiencing a diverse array of listening difficulties during the COVID-19 pandemic, including limited intelligibility, effortful listening, need to ask for repetition of a message, disengagement, and feelings of listening-related stress/anxiety, and fatigue. Statistical analysis confirmed that participants considered their listening difficulties during in-person communication to have become significantly worse (for all communication items queried) compared to pre-pandemic times because of the public-health measures that had been introduced (facemasks and social/physical distancing). These issues were sufficiently troublesome that most participants reported actively avoiding certain communication scenarios.

Although there were some differences across communication scenarios, there were also commonalities. Ratings of listening effort were consistently high for both in-person and remote communication. This finding was observed regardless of the level of speech understanding achieved, which was higher in the remote communication scenarios. This supports the notion that listening through a CI can be cognitively effortful, even when intelligibility remains high (Pals et al., 2013; Pals et al., 2020; Winn et al., 2015; Winn & Teece, 2021)

Whilst participants did report actively avoiding challenging communication scenarios during the pandemic, ratings for listening disengagement were consistently lowest amongst the six items. This suggests that, although most participants were avoiding some situations altogether due to the listening challenges involved, once actually engaged in an interaction, participants generally persevered with trying to keep up communication. This could be explained by motivational factors (Eckert et al., 2016; Herrmann & Johnsrude, 2020), considering that the need to communicate with others during the pandemic (and the benefits that communication can bring) may have surpassed the cognitive cost of doing so.

Despite evidence of a diverse array of perceived listening difficulties experienced by adult CI users during the COVID-19 pandemic, EFA in all cases suggested that the data were best explained by a single underlying factor (interpreted by the authors as representing "overall listening difficulty"). Thus, rather than representing distinct and independent dimensions, our data suggest a strong interconnection between immediate listening challenges (reduced intelligibility, high effort), short-term implications (need to ask for repetition, risk of disengaging), and longer-term consequences (stress/anxiety and fatigue). It is noteworthy that, across the different communication scenarios, the stress/anxiety item received the highest and most consistent factor loading scores. One cannot rule out the possibility that the negative experiences reported by participants in the survey may have been in part influenced by general feelings of stress and anxiety associated with living through the pandemic.

Changes in Communication During the Pandemic

The ways in which people communicate changed dramatically following the outbreak of the COVID-19 pandemic, as governments and institutions adopted widespread public-health measures to limit the spread of the virus. Results of this survey corroborate that the use of facemasks and the imposition of social/physical distancing rules posed additional listening challenges to CI users, which has led to them at times actively avoiding certain communication scenarios. Moreover, much like for the wider population, the adult CI users who completed this study reported a significant increase in the frequency of telephone and video calls. Concerningly, many respondents reported regularly avoiding remote communications due to the listening challenges involved. The World Health Organisation (WHO) issued guidance during the COVID-19 pandemic specifically advising people to stay connected to friends, family and community members via remote communication in order to mitigate the psychological effects associated with sustained periods of isolation (WHO, 2020b). Avoiding remote communication completely may expose an individual to higher risk of suffering psychological harm due to social isolation (Razai et al., 2020). Our results add to a growing body of evidence that the pandemic had a negative and far-reaching

impact on communication, especially amongst people with hearing loss, which contributed to heightened feelings of stress, anxiety, and fatigue (Ideas for Ears Ltd, 2020; Saunders et al., 2020; Tagupa, 2020; Tavanai et al., 2021).

Nonetheless, as previous research has highlighted (Dunn et al., 2020; Naylor et al., 2020), not all changes associated with the COVID-19 pandemic have been negative. Dunn et al. found that social distancing measures promote people spending more time at home and in generally quieter environments, where more favourable signal-to-noise ratios are present. Dunn et al. concluded that CI users' listening experiences under such circumstances were more positive, being associated with better speech understanding and less listening effort. Overall, feelings of social isolation and anxiety due to hearing loss were reduced during the COVID-19 pandemic, compared to before its outbreak, since due to the lack of group interactions there were fewer occasions where participants felt left out of conversations because of their hearing loss. Similar results were found in Naylor et al.'s study: participants with greater hearing loss showed substantial relief at avoiding social gatherings. Nonetheless, the lack of social interactions during the pandemic could also bring increased feelings of loneliness as participants in Dunn et al.'s study reported. These findings highlight the importance of taking a holistic view of CI users' listening experiences, which involves not just the additional burdens imposed by COVID-19 related public-health measures (the focus of the present study), but also possible positive effects associated with individual changes in auditory ecology. The survey administered in the present study captured limited information about wider changes in auditory ecology, beyond the specific scenarios that participants were questioned about.

The Importance of Visual Cues

The results of the present survey evidence the importance of visual cues to CI users as an aid to speech understanding. Most participants reported relying significantly on visual cues, such as lipreading and facial expressions, to support their everyday communication. Therefore, it is unsurprising that the use of facemasks was considered to have the greatest detrimental impact on in-person communication among the COVID-19 measures considered. These results are in line with Naylor et al.'s (2020) study, which found that participants with hearing loss reported better communication performance under social distancing conditions compared to facemask use. Communication difficulties associated with the obscuring of the speaker's mouth and lower part of the face motivated some participants in the present study to avoid scenarios where the use of facemasks would be mandatory. According to participants' free-text comments, the use of facemasks was particularly concerning in medical settings since CI users feared mishearing or misinterpreting important information that could affect their health. Similar results were found by Saunders et al. (2020) who reported face coverings to have a greater negative impact on communication in medical situations (e.g. doctor's appointments, pharmacist and hospital visits) compared to other social interactions (family/friends, shop assistants, at work). Transparent facemasks and clear face visors were identified by participants in the present study as an efficient solution to overcome this issue. Indeed, it is known from previous research (Atcherson et al., 2017) that the use of transparent facemasks significantly improves the level of speech understanding achieved by participants with severe-to-profound hearing loss, even in the presence of background noise.

Similarly, the absence of visual cues meant that participants in the present survey reported telephone calls as being more challenging (and hence more frequently avoided) compared with video calls. Participants did, however, emphasize the importance of the speaker having their video camera turned on for the benefits of video calling to be realised. Live captions during video calls were considered another important feature that provides visual cues to support communication. Indeed, many participants highlighted that live speech-to-text transcriptions should be made available across all video-calling platforms. A similar observation was made in Chodosh et al.'s study (Chodosh et al., 2020), which identified access to free online captions as a priority for innovation and inclusive communication.

Recommendations to make in-person and remote communication easier for people with a CI

As discussed in the preceding sections, the results of the present survey highlight that solutions that offer improved access to visual cues should be adopted wherever practical. For in-person communication, this could involve the use of a transparent facemask, or the use of a clear face visor in place of a facemask. According to the WHO (WHO, 2020a), while face shields and visors provide inferior protection against COVID-19 transmission compared to masks, they are considered valid alternative solutions for the deaf and hard of hearing community. For visors to provide a good level of protection in short exposure situations, they should cover the entire face, above the eyes to below the chin and wrap around from ear to ear (Wendling et al., 2021). Nonetheless, social distance must be maintained in combination to face shield use in order to provide additional protection against smaller particles that can remain airborne for longer periods of time (Lindsley et al., 2014). For remote communication, video calls are to be preferred over telephone calls wherever possible, with care taken to ensure that cameras are turned on allowing clear visibility of the face. In addition to ensuring access to visual speech cues, both in-person and remote communication can potentially be further supported using software or mobile app solutions that offer live speech-to-text transcriptions.

When communicating in person, our results suggest that, where such an arrangement is considered safe, most adult CI users would feel able to communicate more effectively if standing further away from someone who was *not* wearing a facemask, compared to if they were standing closer to someone who *was* wearing a facemask. However, for communication to succeed at greater distances, the quality of the acoustic signal arriving at the listener's ears must be adequately preserved. As mentioned in the introduction, with increased distance between conversational partners comes a reduction in signal-to-noise ratio and a reduction in the ratio of direct to reverberant sound. As CI users are particularly susceptible to the adverse effects of both background noise and reverberation (Badajoz-Davila et al., 2020; Hazrati & Loizou, 2012; Kressner et al., 2018), this can cause significant problems. Background noise can be reduced by directly controlling sound from any unwanted sources, e.g., by turning background music down or off, and by ensuring that air conditioning units are operating quietly and efficiently. Both background noise and reverberation can be controlled effectively through the introduction of simple acoustic treatment in the form of sound absorbing materials (e.g., soft furnishings) or dedicated acoustic wall or ceiling panels. Such measures will be especially effective in rooms that otherwise feature mostly hard, reflective surfaces and which are likely to be excessively reverberant to begin with. However, such solutions cannot be controlled or adopted by CI users first-hand, but only by those responsible for the upkeep and operation of public venues.

A solution that can be directly implemented by CI users to improve the quality of the acoustic signal during in-person communication is the use of an external mini-microphone that can be wirelessly connected to the CI user's hearing device(s). These systems largely overcome the deleterious effects of background noise and reverberation by picking up the target speech signal close to its source and then transmitting it wirelessly (with minimal degradation) to the listener's ears. This is a powerful technological solution, but one that might not always be practical in public locations given that its use typically requires cooperation from the communication partner. Ensuring adequate sanitisation of the equipment to avoid any risk of surface-borne transmission of the virus is often recommended, as long as pandemic conditions continue to prevail.

Maximising the quality of the acoustic signal is also important when it comes to remote communication. Some video calling systems now provide built-in noise reduction to ensure that speech signals are picked up as cleanly as possible at source. Similarly, both passive (e.g., turning off any unnecessary sources of background noise) and active (e.g., use of noise-cancelling headphones) in the CI user's physical environment may be helpful. Similar benefits may be derived from streaming the sound directly from the computer/tablet/phone to the hearing device(s) using a wireless or wired (direct input) connection.

Finally, the importance of simple behavioural adjustments should not be undervalued when it comes to facilitating effective verbal communication. Participants identified a slower speech pace as being beneficial for both in-person and remote communication. This is consistent with prior research which evidenced that slowed speaking rate provides release from listening effort in CI users as measured by behavioural and pupillometry techniques (Winn & Teece, 2020).

Limitations

Recruitment into the present study was conducted online, via email and social media. This may have introduced selection bias, since participants volunteering to complete an online survey may not be representative of the wider population of CI users. Likewise, our sample was unbalanced in terms of gender and age, most participants being females, in their seventies, and retired. This could have influenced the results associated with remote communication since older people may be more likely to avoid these technologies or use them to communicate with family and friends rather than for work. However, the age distribution of our participants may not be entirely unrepresentative given that many adult recipients of a CI are aged 60–69 at the time of implantation according to the UK surgical registration data (Raine, 2014).

Another limitation of the study is the lack of pre-pandemic baseline data, which makes assessment of pre- versus peri-COVID-19 listening experiences subject to possible recall bias. This is a common limitation of retrospective questionnaires. Similarly, the lack of data from a control group, for instance, people with normal hearing or a lesser degree of hearing loss, means that it is not possible to say how specific our findings are to the CI-using population. It is possible that other groups, perhaps even everyone, experienced increased listening difficulties because of the public-health measures introduced to combat the spread of COVID-19.

While EFA suggested that the six communication items all loaded on to a single underlying factor, it is possible that intercorrelation amongst items was elevated by the fact that participants answered all questions at the same time, in a fixed order. A finer distinction between different domains of perceived listening difficulty may have been obtained using an alternative methodology (e.g., ecological momentary assessment).

A further limitation is the assessment of participants' communication experiences of facemask use and social/physical distancing separately, which may not have adequately reflected the everyday reality that these measures tended to be used in conjunction. Open (free-text) questions, however, were able to collect participants' opinions and experiences in that regard, with some people noting that the combination of facemasks plus distancing was especially problematic.

Finally, although all questions were explicitly hearing focused, other psychological factors prevalent during the COVID-19 pandemic such as general health anxiety and loneliness may have influenced participants' responses.

Conclusion

Adult CI users' in-person listening experiences in some common everyday scenarios worsened significantly during the COVID-19 pandemic due to the widespread use of face-masks and the imposition of physical distancing rules to control the spread of the virus. Participants reported experiencing an array of listening difficulties, including reduced speech intelligibility and increased listening effort, which resulted in many CI users actively avoiding certain communication scenarios at least some of the time. CI users also experienced similar listening difficulties during remote communication, though the frequency with which they held telephone and video calls increased significantly during the pandemic. The results suggest ways in which everyday communication might be made easier for people with CIs, both during the pandemic and beyond. The importance of visual cues was evident for both in-person and remote communication. Solutions that offer improved access to visual cues (e.g., transparent instead of opaque face coverings, video calls instead of telephone calls, live speech-to-text subtitling) should therefore be adopted whenever possible. The results also highlighted the potential importance of relatively simple behavioural (e.g., slowed speaking rate) and environmental (e.g., control of background noise and reverberation in public places) modifications that could help to relieve the cognitive burden of everyday listening with a CI.

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Supplemental Material

Supplemental material for this article is available online.

References

Alhanbali S., Dawes P., Lloyd S., & Munro K. J. (2017). Self-Reported listening-related effort and fatigue in hearing-impaired adults. *Ear and Hearing*, *38*(1), e39–e48. https://doi.org/10.1097/AUD.0000000000000361

Atcherson S. R., Mendel L. L., Baltimore W. J., Patro C., Lee S., Pousson M., & Spann M. J. (2017). The effect of conventional and transparent surgical masks on speech understanding in individuals with and without hearing loss. *Journal of the American Academy of Audiology*, *28*(01), 058–067. https://doi.org/10.3766/jaaa.15151

Badajoz-Davila J., Buchholz J. M., & Van-Hoesel R. (2020). Effect of noise and reverberation on speech intelligibility for cochlear implant recipients in realistic sound environments. *The Journal of the Acoustical Society of America*, *147*(5), 3538–3549. https://doi.org/10.1121/10.0001259

Barker A. B., Leighton P., & Ferguson M. A. (2017). Coping together with hearing loss: A qualitative meta-synthesis of the psychosocial experiences of people with hearing loss and their communication partners. *International Journal of Audiology*, *56*(5), 297–305. https://doi.org/10.1080/14992027.2017.1286695

Bokolo A.Jnr. (2020). Use of telemedicine and virtual care for remote treatment in response to COVID-19 pandemic. *Journal of Medical Systems*, *44*(7), 132. https://doi.org/10.1007/s10916-020-01596-5

Brooks S. K., Webster R. K., Smith L. E., Woodland L., Wessely S., Greenberg N., & Rubin G. J. (2020). The psychological impact of quarantine and how to reduce it: rapid review of the evidence. *The Lancet*, *395*, 912–920. https://doi.org/https://doi.org/10.1016/S0140-6736(20)30460-8

Carlsson P.-I., Hjaldahl J., Magnuson A., Ternevall E., Edén M., Skagerstrand Å, & Jönsson R. (2015). Severe to profound hearing impairment: quality of life, psychosocial consequences and audiological rehabilitation. *Disability and Rehabilitation*, *37*(20), 1849–1856. https://doi.org/10.3109/09638288.2014.982833

Cattell R. B. (1966). The scree test For The number Of factors. *Multivariate Behavioral Research*, *1*(2), 245–276. https://doi.org/10.1207/s15327906mbr0102_10

Chia E.-M., Wang J. J., Rochtchina E., Cumming R. R., Newall P., & Mitchell P. (2007). Hearing impairment and health-related quality of life: The blue mountains hearing study. *Ear and Hearing*, *28*(2), 187–195. https://doi.org/10.1097/AUD.0b013e31803126b6

Chodosh J., Weinstein B. E., & Blustein J. (2020). Face masks can be devastating for people with hearing loss. *BMJ*, *370*, m2683. https://doi.org/10.1136/bmj.m2683

Dalton D. S., Cruickshanks K. J., Klein B. E. K., Klein R., Wiley T. L., & Nondahl D. M. (2003). The impact of hearing loss on quality of life in older adults. *The Gerontologist*, *43*(5), 661–668. https://doi.org/10.1093/geront/43.5.661

Dimitrijevic A., Smith M. L., Kadis D. S., & Moore D. R. (2019). Neural indices of listening effort in noisy environments. *Scientific Reports*, *9*(1), 11278. https://doi.org/10.1038/s41598-019-47643-1

Dunn C. C., Stangl E., Oleson J., Smith M., Chipara O., & Wu Y.-H. (2020). The influence of forced social isolation on the auditory ecology and psychosocial functions of listeners with cochlear implants during COVID-19 mitigation efforts. *Ear & Hearing. Publish Ahead of Print*. https://doi.org/10.1097/AUD.0000000000000991

Eckert M. A., Teubner-Rhodes S., & Vaden K. I. (2016). Is listening in noise worth It? The neurobiology of speech recognition in challenging listening conditions. *Ear and Hearing*, *37*, 101S–110S. https://doi.org/10.1097/AUD.0000000000000300

Elo S., & Kyngäs H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Eurich B., Klenzner T., & Oehler M. (2019). Impact of room acoustic parameters on speech and music perception among participants with cochlear implants. *Hearing Research*, *377*, 122–132. https://doi.org/10.1016/j.heares.2019.03.012

Gatehouse S., & Noble W. (2004). The speech, spatial and qualities of hearing scale (SSQ). *International Journal of Audiology*, *43*(2), 85–99. https://doi.org/10.1080/14992020400050014

Goldin A., Weinstein B., & Shiman N. (2020). How Do medical masks degrade speech reception? *Hearing Review*, *27*(5), 8–9. https://www.hearingreview.com/hearing-loss/health-wellness/how-do-medical-masks-degrade-speech-reception

Grote H., & Izagaren F. (2020). COVID-19: The communication needs of D/deaf healthcare workers and patients are being forgotten. *BMJ*, *369*, m2372. https://doi.org/10.1136/bmj.m2372

Hazrati O., & Loizou P. C. (2012). The combined effects of reverberation and noise on speech intelligibility by cochlear implant listeners. *International Journal of Audiology*, *51*(6), 437–443. https://doi.org/10.3109/14992027.2012.658972

Herrmann B., & Johnsrude I. S. (2020). A model of listening engagement (MoLE). *Hearing Research*. https://doi.org/https://doi.org/10.1016/j.heares.2020.108016

Hetu R., Riverin L., Lalande N., Getty L., & St-Cyr C. (1988). Qualitative analysis of the handicap associated with occupational hearing loss. *British Journal of Audiology*, *22*(4), 251–264. https://doi.org/10.3109/03005368809076462

Holm S. (1979). A simple sequentially rejective multiple test procedure. *Scandinavian Journal of Statistics*, *6*(2), 65–70. http://www.jstor.org/stable/4615733

Hughes S. E., Hutchings H. A., Rapport F. L., McMahon C. M., & Boisvert I. (2018). Social Connectedness and Perceived Listening Effort in Adult Cochlear Implant Users: A Grounded Theory to Establish Content Validity for a New Patient-Reported Outcome Measure. 13.

Hyland P., Shevlin M., McBride O., Murphy J., Karatzias T., Bentall R. P., & Vallières F. (2020). Anxiety and depression in the republic of Ireland during the COVID-19 pandemic. *Acta Psychiatrica Scandinavica*, *142*(3), 249–256. https://doi.org/10.1111/acps.13219

Ideas For Ears (2018, February 5). Phone calls are causing frustration and stress. Retrieved 23 February 2021, from https://www.ideasforears.org.uk/blog/phone-calls-are-causing-frustration-and-stress/

Ideas for Ears Ltd (2020). Coronavirus & the unequal impact on people with hearing loss. Retrieved from https://www.ideasforears.org.uk/blog/survey-results-impact-or-masks-and-more/

Jones N. R., Qureshi Z. U., Temple R. J., Larwood J. P. J., Greenhalgh T., & Bourouiba L. (2020). Two metres or one: what is the evidence for physical distancing in COVID-19? *Bmj (Clinical Research Ed)* m3223, https://doi.org/10.1136/bmj.m3223

Kniffin K. M., Narayanan J., Anseel F., Antonakis J., Ashford S. P., Bakker A. B., & Vugt M. v. (2021). COVID-19 and the workplace: implications, issues, and insights for future research and action. *American Psychologist*, *76*(1), 63–77. https://doi.org/10.1037/amp0000716

Koelewijn T., de Kluiver H., Shinn-Cunningham B. G., Zekveld A. A., & Kramer S. E. (2015). The pupil response reveals increased listening effort when it is difficult to focus attention. *Hearing Research*, *323*, 81–90. https://doi.org/10.1016/j.heares.2015.02.004

Kramer S. E., Kapteyn T. S., & Houtgast T. (2006). Occupational performance: comparing normally-hearing and hearing-impaired employees using the Amsterdam checklist for hearing and work. *International Journal of Audiology*, *45*(9), 503–512. https://doi.org/10.1080/14992020600754583

Kressner A. A., Westermann A., & Buchholz J. M. (2018). The impact of reverberation on speech intelligibility in cochlear implant recipients. *The Journal of the Acoustical Society of America*, *144*(2), 1113–1122. https://doi.org/10.1121/1.5051640

Lin F. R., Yaffe K., Xia J., Xue Q.-L., Harris T. B., & Purchase-Helzner E., & Health ABC Study Group, for the. (2013). Hearing loss and cognitive decline in older adults. *JAMA Internal Medicine*, *173*(4), 293. https://doi.org/10.1001/jamainternmed.2013.1868

Lindsley W. G., Noti J. D., Blachere F. M., Szalajda J. V., & Beezhold D. H. (2014). Efficacy of face shields against cough aerosol droplets from a cough simulator. *Journal of Occupational and Environmental Hygiene*, *11*(8), 509–518. https://doi.org/10.1080/15459624.2013.877591

Lorenzo-Seva U., & ten Berge J. M. F. (2006). Tucker's congruence coefficient as a meaningful index of factor similarity. *Methodology*, *2*(2), 57–64. https://doi.org/10.1027/1614-2241.2.2.57

Magee M., Lewis C., Noffs G., Reece H., Chan J. C. S., Zaga C. J., & Vogel A. P. (2020). Effects of face masks on acoustic analysis and speech perception: implications for peri-pandemic protocols. *The Journal of the Acoustical Society of America*, *148*(6), 3562–3568. https://doi.org/10.1121/10.0002873

Maru D., Stancel-Lewis J., Easton G., & Leverton W. E. (2021). Communicating with people with hearing loss: COVID-19 and beyond. *BJGP Open*, BJGPO.2020.0174. https://doi.org/10.3399/BJGPO.2020.0174

McCoy S. L., Tun P. A., Cox L. C., Colangelo M., Stewart R. A., & Wingfield A. (2005). Hearing loss and perceptual effort: downstream effects on older adults' memory for speech. *The Quarterly Journal of Experimental Psychology. A. Human Experimental Psychology*, *58*(1), 22–33. https://doi.org/10.1080/02724980443000151

McGarrigle R., Munro K. J., Dawes P., Stewart A. J., Moore D. R., Barry J. G., & Amitay S. (2014). Listening effort and fatigue: what exactly are we measuring? A British society of audiology cognition in hearing special interest group 'white paper'. *International Journal of Audiology*, *53*(7), 433–445. https://doi.org/10.3109/14992027.2014.890296

McRackan T. R., & Hand B. N., Cochlear Implant Quality of Life Development Consortium, Velozo C. A., & Dubno J. R. (2019). Cochlear implant quality of life (CIQOL): development of a profile instrument (CIQOL-35 Profile) and a global measure (CIQOL-10 global). *Journal of Speech, Language, and Hearing Research*, *62*(9), 3554–3563. https://doi.org/10.1044/2019_JSLHR-H-19-0142

Michielsen H. J., De Vries J., Van Heck G. L., Van de Vijver F. J. R., & Sijtsma K. (2004). Examination of the dimensionality of fatigue: The construction of the fatigue assessment scale (FAS). *European Journal of Psychological Assessment*, *20*(1), 39–48. https://doi.org/10.1027/1015-5759.20.1.39

Mick P., Kawachi I., & Lin F. R. (2014). The association between hearing loss and social isolation in older adults.

Otolaryngology–Head and Neck Surgery, *150*(3), 378–384. https://doi.org/10.1177/0194599813518021

Moberly A. C., Vasil K. J., & Ray C. (2020). Visual reliance during speech recognition in cochlear implant users and candidates. *Journal of the American Academy of Audiology*, *31*(1), 30–39. https://doi.org/10.3766/jaaa.18049

Nachtegaal J., Kuik D. J., Anema J. R., Goverts S. T., Festen J. M., & Kramer S. E. (2009). Hearing status, need for recovery after work, and psychosocial work characteristics: results from an internet-based national survey on hearing. *International Journal of Audiology*, *48*(10), 684–691. https://doi.org/10.1080/14992020902962421

Naylor G., Burke L. A., & Holman J. A. (2020). COVID-19 lockdown affects hearing disability and handicap in diverse ways: A rapid online survey study. *Ear & Hearing*, *41*(6), 1442–1449. https://doi.org/10.1097/AUD.0000000000000948

Needleman A. R., & Crandellt C. C. (1995). Speech recognition in noise by hearing-impaired and noise-masked normal-hearing listeners. *Journal of the American Academy of Audiology*, *6*(6), 414–424. PMID: 8580501

Pals C., Sarampalis A., & Başkent D. (2013). Listening effort With cochlear implant simulations. *Journal of Speech, Language, and Hearing Research*, *56*(4), 1075–1084. https://doi.org/10.1044/1092-4388(2012/12-0074)

Pals C., Sarampalis A., Beynon A., Stainsby T., & Başkent D. (2020). Effect of spectral channels on speech recognition, comprehension, and listening effort in cochlear-implant users. *Trends in Hearing*, *24*, 1–15. https://doi.org/10.1177/2331216520904617

Pang J., Beach E. F., Gilliver M., & Yeend I. (2019). Adults who report difficulty hearing speech in noise: An exploration of experiences, impacts and coping strategies. *International Journal of Audiology*, 1–10. https://doi.org/10.1080/14992027.2019.1670363

Perreau A. E., Wu Y.-H., Tatge B., Irwin D., & Corts D. (2017). Listening effort measured in adults with normal hearing and cochlear implants. *Journal of the American Academy of Audiology*, *28*(8), 685–697. https://doi.org/10.3766/jaaa.16014

Pichora-Fuller M., Mick P., & Reed M. (2015). Hearing, cognition, and healthy aging: social and public health implications of the links between age-related declines in hearing and cognition. *Seminars in Hearing*, *36*(03), 122–139. https://doi.org/10.1055/s-0035-1555116

Pichora-Fuller M. K., Kramer S. E., Eckert M. A., Edwards B., Hornsby B. W. Y., Humes L. E., Lemke U, Lunner T, Matthen M, Mackersie CL, Naylor G, Phillips NA, Richter M, Rudner M, Sommers MS, Tremblay KL, & Wingfield A., (2016). Hearing impairment and cognitive energy: The framework for understanding effortful listening (FUEL). *Ear and Hearing*, *37*(1), 5S–27S. https://doi.org/10.1097/AUD.0000000000000312

Pronk M., Deeg D. J. H., Smits C., van Tilburg T. G., Kuik D. J., Festen J. M., & Kramer S. E. (2011). Prospective effects of hearing status on loneliness and depression in older persons: identification of subgroups. *International Journal of Audiology*, *50*(12), 887–896. https://doi.org/10.3109/14992027.2011.599871

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Rahne T., Fröhlich L., Plontke S., & Wagner L. (2021). Influence of surgical and N95 face masks on speech perception and listening effort in noise. *PLOS ONE*, *16*(7), e0253874. https://doi.org/10.1371/journal.pone.0253874

Raine C. (2014). Access to and uptake of cochlear implants in the UK. *Ent and Audiology News*, *23*(1). Retrieved from www.entandaudiologynews.com

Razai M. S., Oakeshott P., Kankam H., Galea S., & Stokes-Lampard H. (2020). Mitigating the psychological effects of social isolation during the COVID-19 pandemic. *BMJ*, *369*, https://doi.org/10.1136/bmj.m1904

Reay R. E., Looi J. C., & Keightley P. (2020). Telehealth mental health services during COVID-19: summary of evidence and clinical practice. *Australasian Psychiatry*. https://doi.org/10.1177/1039856220943032

Revelle W. (2020). *Package 'psych': procedures for psychological, psychometric, and personality research*. Northwestern University, Evanston, Illinois. Retrieved from Northwestern University. website: https://CRAN.R-project.org/package=psych

Ribeiro V. V., Dassie-Leite A. P., Pereira E. C., Santos A. D. N., Martins P., & Irineu R. d. A. (2020). Effect of wearing a face mask on vocal self-perception during a pandemic. *Journal of Voice*, *S0892–1997*(20), 30356–8. https://doi.org/10.1016/j.jvoice.2020.09.006

Russo F. Y., Hoen M., Karoui C., Demarcy T., Ardoint M., Tuset M.-P., & Mosnier I. (2020). Pupillometry assessment of speech recognition and listening experience in adult cochlear implant patients. *Frontiers in Neuroscience*, *14*, https://doi.org/10.3389/fnins.2020.556675

Saunders G. H., Jackson I. R., & Visram A. S. (2020). Impacts of face coverings on communication: An indirect impact of COVID-19. *International Journal of Audiology*, 1–12. https://doi.org/10.1080/14992027.2020.1851401

Saunders G. H., & Roughley A. (2021). Audiology in the time of COVID-19: practices and opinions of audiologists in the UK. *International Journal of Audiology*, *60*(4), 255–262. https://doi.org/10.1080/14992027.2020.1814432

Shukla A., Harper M., Pedersen E., Goman A., Suen J. J., Price C., & Reed N. S. (2020). Hearing loss, loneliness, and social isolation: A systematic review. *Otolaryngology--Head and Neck Surgery : Official Journal of American Academy of Otolaryngology-Head and Neck Surgery*, *162*(5), 622–633. (PMID: 32151193). https://doi.org/10.1177/0194599820910377

Tagupa H. (2020). Social isolation, loneliness, and hearing loss during COVID-19. *The Hearing Journal*, *73*(5), 46–47. https://doi.org/10.1097/01.HJ.0000666456.65020.b9

Tavanai E., Rouhbakhsh N., & Roghani Z. (2021). A review of the challenges facing people with hearing loss during the COVID-19 outbreak: toward the understanding the helpful solutions. *Auditory and Vestibular Research*, *30*(2), 62–63. https://doi.org/10.18502/avr.v30i2.6091

Ten Hulzen R. D., & Fabry D. A. (2020). Impact of hearing loss and universal face masking in the COVID-19 Era. *Mayo Clinic Proceedings*, *95*(10), 2069–2072. https://doi.org/10.1016/j.mayocp.2020.07.027

Tun P. A., McCoy S., & Wingfield A. (2009). Aging, hearing acuity, and the attentional costs of effortful listening. *Psychology and Aging*, *24*(3), 761–766. https://doi.org/10.1037/a0014802

Wang B., Liu Y., Qian J., & Parker S. K. (2021). Achieving effective remote working during the COVID-19 pandemic: A work

design perspective. *Applied Psychology*, *70*(1), 16–59. https://doi.org/10.1111/apps.12290

Wang C., Pan R., Wan X., Tan Y., Xu L., McIntyre R. S., & Ho C. (2020). A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. *Brain, Behavior, and Immunity*, *87*, 40–48. https://doi.org/10.1016/j.bbi.2020.04.028

Wendling J.-M., Fabacher T., Pébaÿ P.-P., Cosperec I., & Rochoy M. (2021). Experimental efficacy of the face shield and the mask against emitted and potentially received particles. *International Journal of Environmental Research and Public Health*, *18*(4), 1942. https://doi.org/10.3390/ijerph18041942

White S. J., Barello S., Cao di San Marco E., Colombo C., Eeckman E., Gilligan C., & Krystallidou D. (2021). Critical observations on and suggested ways forward for healthcare communication during COVID-19: PEACH position paper. *Patient Education and Counseling*, *104*(2), 217–222. https://doi.org/10.1016/j.pec.2020.12.025

WHO (2020a). *Advice on the use of masks in the context of COVID-19: interim guidance, 6 April 2020*. World Health Organization. WHO IRIS. Retrieved from World Health Organization website: https://apps.who.int/iris/bitstream/handle/10665/332293/WHO-2019-nCov-IPC_Masks-2020.4-eng.pdf?sequence=1&isAllowed=y

WHO (2020b). *Mental health and psychosocial considerations during the COVID-19 outbreak*. World Health Organization. Retrieved from World Health Organization website: https://www.who.int/docs/default-source/coronaviruse/mental-health-considerations.pdf

Wie O. B., Pripp A. H., & Tvete O. (2010). Unilateral deafness in adults: effects on communication and social interaction. *The Annals of Otology, Rhinology, and Laryngology*, *119*(11), 772–781. PMID: 21140638.

Winn M. B., Edwards J. R., & Litovsky R. Y. (2015). The impact of auditory spectral resolution on listening effort revealed by pupil dilation. *Ear and Hearing*, *36*(4), e153–e165. https://doi.org/10.1097/AUD.0000000000000145

Winn M. B., & Teece K. H. (2020). Slower speaking rate reduces listening effort Among listeners With cochlear implants. *Ear & Hearing, Publish Ahead of Print*. https://doi.org/10.1097/AUD.0000000000000958

Winn M. B., & Teece K. H. (2021). Listening effort Is Not the same as speech intelligibility score. *Trends in Hearing*, *25*, 233121652110276. https://doi.org/10.1177/23312165211027688

Zekveld A. A., Kramer S. E., & Festen J. M. (2011). Cognitive load during speech perception in noise: The influence of Age, hearing loss, and cognition on the pupil response. *Ear and Hearing*, *32*(4), 498–510. https://doi.org/10.1097/AUD.0b013e31820512bb