Phonak
Field Study News

The masking dilemma: Helping clients communicate during COVID-19

A project conducted at the Phonak Audiology Research Center (PARC) explored the impact of face masks on speech acoustics, the benefit of Roger™ in situations with talkers wearing face masks, and fine tuning recommendations and considerations for HCPs when addressing communication difficulties related to face masks.

David Taylor, Au.D. and Kevin Seitz-Paquette, Au.D. / August 2020

Key highlights

- Face masks present communication challenges, particularly for those with hearing loss, due to loss of visual cues and high-frequency attenuation of the auditory signal.

- Results of this study showed significantly worse speech perception when a talker is wearing a cloth mask compared to no mask, but no significant difference with ClearMask™.

- Roger benefit when talkers are wearing face masks is equivalent to the benefit from Roger when talkers are not wearing masks.

Considerations for practice

- With the current widespread use of face masks, Roger remains a viable hearing solution for overcoming negative effects of background noise and distance.

- Clinicians should consider creating a custom hearing aid program intended to help clients communicate during the pandemic where there is widespread use of face masks.

Introduction

Since the onset of the Coronavirus disease 2019 (COVID-19) pandemic, face masks have become commonplace and are a crucial component of mitigating the spread of COVID-19 through the population. Public health officials have reinforced the need for all individuals to wear a face mask at all times when in public, particularly when in a place where 6 feet (approx. 2 meters) of distance between individuals cannot be maintained (US Centers for Disease Control, 2020).

Although face masks are important for public health and reducing the spread of disease, they have a deleterious effect on the acoustic properties of speech. Research has shown, depending on the type of mask, the high-frequency content of speech may be attenuated by as much as 12 dB (Golden, Weinstein, and Shiman, 2020). This may pose additional challenges to the hearing impaired population, the majority of whom experience the greatest hearing impairment in the high frequencies—precisely where the attenuation from a face mask is greatest (Pittman and Stelmachowicz, 2003).

In addition to the attenuation of high frequencies, face masks also block access to visual cues normally present in spoken communication. Visual cues are an important component of speech perception, and listeners rely more on visual cues when the acoustic speech signal is degraded (Stacey, Kitterick, Morris, and Sumner 2016). More specifically, populations with hearing loss have been shown to rely more on visual speech cues relative to normal hearing populations to disambiguate the identity of a target speech signal (Desai, Stickne, and Zeng, 2008; Walden, Montogomery, Prosek, and Hawkins, 1990). Thus, face masks not only remove a hearing impaired individual's access to the facial cues he relies on, but they also degrade the speech signal, making those cues *even more* important.

The primary purpose of this study is to investigate how the loss of high frequency information caused by a face mask affects the benefit of using a Roger microphone for individuals with moderate to severe hearing loss. The authors hypothesize that Roger benefit will not be impacted by the talker's use of a face mask. The secondary objective of this study was to provide HCPs with strategies intended to help clients communicate during the pandemic where there is widespread use of face masks.

Preliminary measures

Prior to any human subject research, preliminary technical measures were performed to investigate the acoustic impact of face masks on speech (see figure 1 for illustration of setup). A GRAS 45BC KEMAR head and torso with mouth simulator was used to present broad spectrum speech stimuli, and the signal was measured with and without a surgical mask using an additional KEMAR head and torso at six feet away for recording (see figure 2 for results).

Figure 1 Setup for preliminary technical measurements.

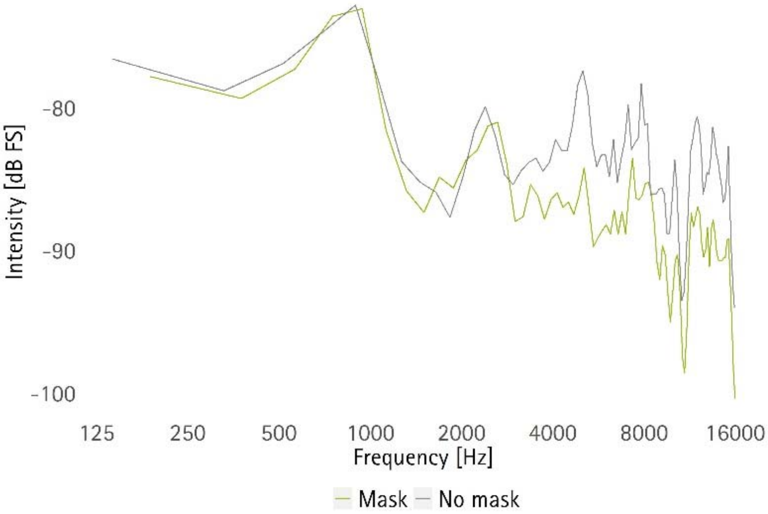

Figure 2 Comparison of frequency response for broad spectrum speech stimuli presented by KEMAR head and torso with (green) and without a surgical mask (grey), as measured by an additional KEMAR head and torso at a distance of six feet.

These results aligned with previous literature from Dr. Barbara Weinstein and colleagues, which showed 3-4 dB attenuation from 2-7 kHz for a paper surgical mask (Golden, Weinstein, and Shiman, 2020). These results highlight acoustic differences only.

When clients experience difficulties in challenging situations, particularly across distance and in noise, remote microphones can be a useful tool for hearing care professionals. Roger solutions have been proven to improve communication in these types of situations (Thibodeau, 2014), but until now, it was unknown how a face mask may affect the benefit of Roger technology.

Methods

Participants

To investigate the effect of face masks on the benefit of Roger, 17 adult participants with moderate to severe hearing loss (see figure 3) were recruited. The population yielded an average age of 69.7 years (sd. 13.1 years), and included six females.

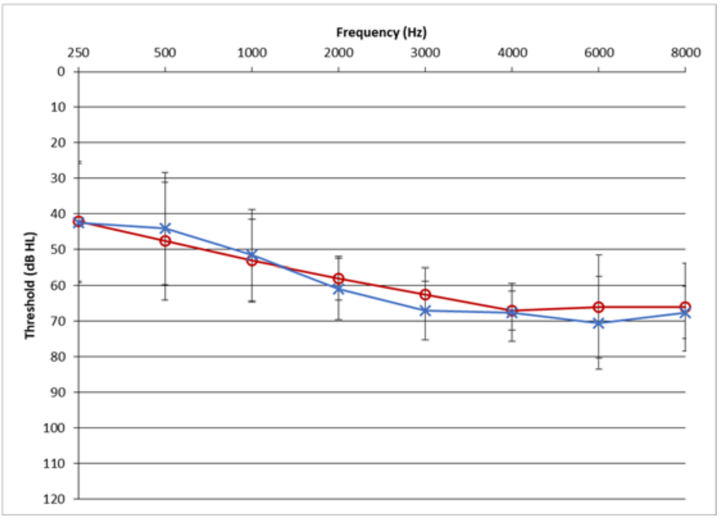

Figure 3 Average audiogram data for the 17 participants included in the investigation of Roger benefit (error bars show minimum and maximum values).

Four internal participants were recruited for the secondary component of the study, which aimed to provide HCPs with general fine tuning recommendations. The audiometric characteristics of this population are not relevant, as this portion of the study sought to validate fine tuning changes to compensate for of mask related changes to speech, regardless of type and severity of hearing loss.

Hearing aids, devices, and programming

Each participant was seen for one appointment lasting approximately two hours. Each individual was fit bilaterally with Audéo™ P90 devices. All participants were fit to their default recommendations using APD 2.0 gain calculations. Roger was installed in these devices and a RogerDirect™ program was set to activate automatically, receiving the signal from a Roger Touchscreen Mic when switched on.

Two styles of masks were used in this investigation, a cloth fabric mask and a ClearMask™. See figure 4 for visual examples of the two styles of masks investigated.

Figure 4 Representation of style and fit of cloth mask (left) and ClearMask™ (right).

Setup and procedure

An acoustic scene was designed to surround the participants in diffuse cafeteria noise at 70 dB(A). The background noise was generated by four loudspeakers, one in each corner of the room. The participant was seated in this loudspeaker array, and KEMAR was placed six ft. (approximately two meters) away from the participant at zero degrees azimuth, facing the listener. KEMAR was equipped with the Roger Touchscreen Mic, placed 20 cm below the loudspeaker in lapel mode. See figure 5 below for a visual depiction of this setup.

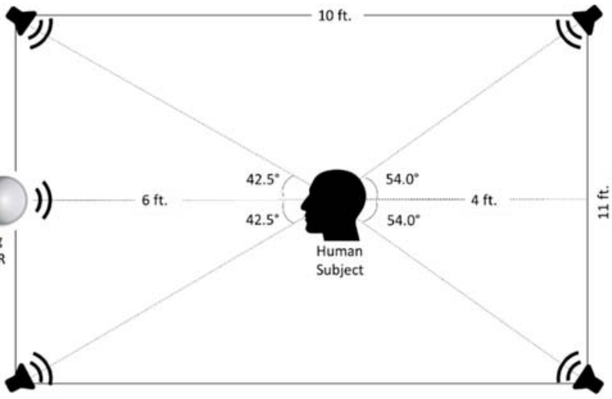

Figure 5 Laboratory setup for investigation of Roger benefit.

The American English Matrix test was used to assess speech perception in noise. The test constructs test sentences from five lists of ten words each; each sentence follows the same structure (name, verb, number, adjective, noun). In constructing sentences in this way, the test features syntactically valid but semantically unpredictable sentences. As such, the participant is unlikely to guess any word not heard or understood, even though he might be able to guess the correct part of speech (Kollmeier et al. 2015). Testing was preceded by one familiarization run, and the test was performed twice for each of the following conditions:

1. No mask / no Roger
2. No mask / with Roger
3. Cloth mask / no Roger
4. Cloth mask / with Roger
5. ClearMask™ / no Roger
6. ClearMask™/ with Roger

The score from each trial was averaged, such that each participant had a single score for each of the six experimental conditions. Test lists were randomized, and conditions were counterbalanced for both mask type and Roger condition. The American English Matrix test was set to adapt the level of the speech stimuli in constant 70 dB(A) cafeteria noise to find the SNR at which participants achieved 50% of all words correct (SNR50).

To investigate the secondary objective, a similar setup was used. The GRAS 45BC KEMAR head and torso with mouth simulator, in this case, was used as an external loudspeaker in conjunction with the Audioscan© Verifit2, and the background noise was negated for this part of the investigation. KEMAR was placed 6 ft. (approx.. 2 meters) away from the participant at 0 degrees azimuth, facing the listener. ISTS stimuli were used to perform speech mapping with inputs of 50 dB SPL and 65 dB SPL as measured by the Audioscan© reference microphones. Speech mapping was performed without masks, and then performed again with the two styles of masks, while the researcher performed fine tuning adjustments to best match the output response to that of the first signals (without a mask). Participants underwent real ear probe tube measurements using an Audioscan© Verifit2. Each individual was fit bilaterally with Audéo P90 devices, programmed to a flat 40 dB hearing loss. For comparison of fine tuning adjustments and as basis for appropriate fine tuning recommendations, frequency response measures (represented graphically as intensity as a function of frequency) were elicited by the Audioscan© Verifit2.

Statistical analysis

Upon initial inspection of the American English Matrix test results, two participants were found to be outliers (defined as a z-score greater than +/- 3) and were removed from the data subjected to further analysis. The remaining data were analyzed via a linear mixed effects (LME) model using the 'lme4' package in the R statistical computing environment (Bates, Maechler, Bolker, and Walker, 2015; R Core Team, 2020). Visualizations were built using 'ggplot2' (Wickham, 2016). Data from real-ear measures in support of the secondary objective were not subjected to statistical analysis.

Results

To understand the benefit of Roger with masked talkers, an LME model was constructed with a dependent variable of SNR50, fixed effects of mask type and presence/absence of Roger (with an interaction term), and random effect of participant. Model results indicate a significant degradation of performance with the cloth mask ($\beta = 0.981$, 95% CI = [0.053, 1.909], $p = 0.046$), but no significant impact of the ClearMask. Roger use resulted in a substantial, statistically significant improvement ($\beta = -20.172$, 95% CI = [-21.01, -19.243], $p < 0.001$). There were no significant interactions between Roger use and either type of mask. These results suggest that cloth face masks have a deleterious impact on speech perception (even without accounting for lost visual cues), and Roger benefit is neither heightened nor degraded by the use of a face mask. In other words, clients can expect to receive at least the same degree of benefit from Roger whether the talker wears a face mask or not. See figure 6 for a box plot representation of this data set across conditions.

A non-significant trend was observed during this study; better speech perception with ClearMask™ when compared to the no mask conditions. This trend was only observed and did not elicit a statistically significant difference. This trend is more than likely attributed to the acoustic properties that were observed with the ClearMask™, more specifically, the resonance at approximately 1 kHz. The ClearMask™ used in this study has soft foam seals on the chin and the nose, with a clear plastic panel that is open on both sides. When measuring real ear output for hearing aids with an ISTS signal through the ClearMask™, a slight high-frequency attenuation was observed, in addition to a boost at approximately 1 kHz. These results were also observed in a student-led research project sponsored by Phonak (Warren, 2020). The increased level of speech content at or near 1 kHz is the likely cause of the trend for improved speech perception for the ClearMask™.

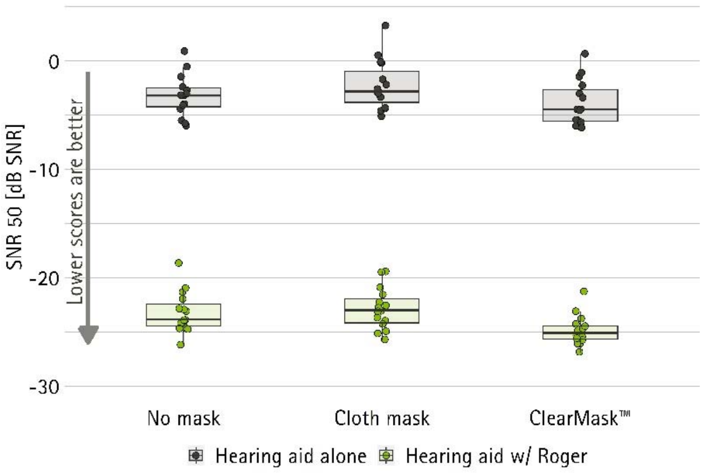

Figure 6 **Box plot illustrating SNR 50 (dB SNR) across experimental conditions for two different styles of masks, and for a talker without a mask (n = 15). The boxes extend from the first to third quartile with a center line at the median. Whiskers extend to 1.5 times the inter-quartile range. Individual data points show participant-specific results and were jittered to prevent overlap.**

Discussion

The preliminary measures performed at PARC bring awareness to the impact of face masks and show that there is reasonable concern for those with hearing loss in the global pandemic where face masks are commonplace.

Research has found that visual speech cues are highly important, even more so when the acoustic signal is degraded (Stacey, Kitterick, Morris, and Sumner, 2016). This is an important consideration for clinical practice, as the research questions posed in this paper do not address the loss of visual cues directly, and this may affect clients in the clinic differently on a case-by-case basis.

The current importance of infection control in daily life may preclude the use of Roger in situations where a transmitter would typically be passed around to multiple parties. While this study has proven that there is no degradation to the benefit of Roger with talkers wearing face masks, the researchers also sought to provide hearing aid fine tuning recommendations for instances in which Roger may not be a viable option.

The investigation of fine tuning adjustments, combined with the trends seen in the preliminary measures, created a basis for general guidelines for clinicians interested in creating a mask program for their clients. Clinicians should consider creating a mask program using these steps:

1. Increasing gain at G50 and G65 by 3 steps at 3-4 kHz and by 6 steps (total) above 4 kHz.
2. Particularly small ears may require no increase at 3-4 kHz and only 3 steps above 4 kHz.
3. Increasing G50 and G65 gain may raise compression ratios (CR). If a lower CR is needed for a given client, G80 can be increased by 1-2 steps to reduce the CR.

In our four-subject experiment, these adjustments removed any appreciable difference in real ear output for speech with and without a mask.

Conclusion

This study has shown equivalent benefit of Roger in instances where talkers are wearing masks, relative to situations in which talkers are not wearing a mask. Thus, it is reasonable to assume that Roger is a viable option for typical use-case situations, despite the current challenges of communicating with people using face masks. Roger technology allows people with hearing loss to hear and understand speech in the most challenging of environments, particularly in noise and over distance. In fact, this technology enables hearing aid users to understand speech in loud noise and over distance by up to 62% better than people with normal hearing in the same condition (Thibodeau, 2014).

As always, clinicians should consider best practices and the gold standards for fitting hearing instruments and assistive listening devices. Given the climate of today's world, it is understood that alternative approaches such as remote support and curbside programming may be worthy of consideration. These recommendations should be used at the clinician's discretion, alongside their best judgement for each individual client.

While it is outside the scope of this paper, it is important to consider the big picture when presented with client complaints. For example, missing visual cues may negatively impact clients in situations where talkers are wearing masks. Finally, it is important to consider infection control recommendations by the appropriate experts, as again, this particular consideration is outside the scope of this paper.

As always, it can be useful to reference communication strategies apart from the potential solutions outlined here. Some communication strategies for an individual with hearing loss include (Munoz, et al. 2015):

1. Facing the individual speaking to you.
2. Decrease as much environmental/background noise (e.g. TV, radio) as you can so that it does not

interfere with your hearing and understanding speech.
3. Ask for clarification.
4. Advocate – make sure your communication partners are aware of your hearing loss.

References

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48.

Desai, S., Stickney, G., & Zeng, F.-G. (2008). Auditory-visual speech perception in normal-hearing and cochlear-implant listeners. The Journal of the Acoustical Society of America, 123, 428–440.

Goldin, A., Weinstein, B., & Shiman, N. (2020). How do medical masks degrade speech reception? Hearing Review. May 2020. Accessed on 10-Aug-2020 from www.hearingreview.com/hearing-loss/health-wellness/how-do-medical-masks-degrade- speech-reception

Kollmeier, B., Warzybok, A., Hochmuth, S., Zokoll, M. A., Uslar, V., Brand, T., & Wagener, K. C. (2015). The multilingual matrix test: Principles, applications, and comparison across languages: A review. International Journal of Audiology, 54(sup2), 3-16. https://doi.org/10.3109/14992027.2015.1020971

Munoz, K., Nelson, L., Blaiser, K., Price, T., & Twohig, M. (2015). Improving support for parents of children with hearing loss: Provider training on use of targeted communication strategies. Journal of the American Academy of Audiology, 26(2), 116-127.

Pittman, A. L. & Stelmachowicz, P. G. (2003). Hearing loss in children and adults: Audiometric configuration, asymmetry, and progression. Ear and Hearing. 24(3), 198-205

R Core Team. (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Stacey, P., Kitterick, P., Morris, S., & Sumner, C. (2016). The contribution of visual information to the perception of speech in noise with and without informative temporal fine structure. Hearing Research. 336, 17-28.

Thibodeau, L. (2014). Comparison of speech recognition with adaptive digital and FM wireless technology by listeners who use hearing aids. American Journal of Audiology, 23, 201-210.

Walden, B. E., Montgomery, A. A., Prosek, R. A., & Hawkins, D. B. (1990). Visual biasing of normal and impaired auditory speech perception. Journal of Speech and Hearing Research, 33, 163–173.

Warren, E. (2020). Acoustic effects of several common face masks. Phonak Insight, in preparation. Will be available on www.phonakpro.com/evidence in Fall 2020.

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag, New York.

Authors

David Taylor received his doctorate of Audiology at Rush University in Chicago, Illinois. Prior to receiving his doctorate, he pursued a Bachelor of Arts degree in the field of audio arts & acoustics at Columbia College Chicago. David joined Phonak in 2019 and is currently a Research Audiologist at the Phonak Audiology Research Center in Aurora, Illinois.

Kevin Seitz-Paquette received an M.A. in Linguistics from Indiana University (Bloomington, IN, USA) and an Au.D. from Northwestern University (Evanston, IL, USA). He joined Phonak as Director of the Phonak Audiology Research Center in April, 2020. Prior to his arrival to Phonak, he held roles in clinical research and product management within the hearing industry, helping to define new hearing aid features and study their benefit to hearing aid users.