Medical Research Archives

ESMED
European Society of Medicine

OPEN ACCESS

Published: July 31, 2022

Citation: Hulzen, Richard D. Ten and Fabry, David A, 2022. Impact of Hearing Loss and Universal Face Masking on Communication and Accessibility in the COVID-19 Era and beyond, Medical Research Archives, [online] 10(7). https://doi.org/10.18103/mra.v10i7.2890

DOI
https://doi.org/10.18103/mra.v10i7.2890

ISSN: 2375-1924

RESEARCH ARTICLE

Impact of Hearing Loss and Universal Face Masking on Communication and Accessibility in the COVID-19 Era and beyond.

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Abstract

During the coronavirus disease 2019 (COVID-19) pandemic, health and government officials encouraged community-wide face mask wearing (i.e., universal masking) to reduce potential pre-symptomatic or asymptomatic transmission of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) to others. Universal face mask use, in combination with physical distancing, while effective, also places considerable burden on communication, particularly for those with hearing loss. This manuscript provides evidence of the impact on speech audibility provided by facemask type, increased physical distance (>2 m), and background noise.

Introduction

According to the World Health Organization (2021), more than 5% of the population (approximately 430 million people) have a "disabling" degree of hearing loss that would benefit from treatment and/or rehabilitation.[1] By 2050, that number is estimated to grow to 700 million, impacting nearly one in ten people worldwide.[1] Although hearing loss affects people of all ages, its prevalence increases with age; 43% of those aged 70+ years report some degree of hearing loss.[2] Even so, hearing loss is often taken for granted, despite increasing links between untreated hearing loss and many chronic health conditions.[3] Previous research suggests that modifiable risk factors for cardiovascular disease (CVD) may play a role in the development of age-related hearing loss.[4] More recently, significant attention has been focused on the link between hearing loss and cognitive decline. Compared to individuals with normal hearing, persons with a mild, moderate, and severe hearing impairment, respectively, had a 2-, 3-, and 5-fold increased risk of incident all-cause dementia over more than a decade of follow-up.[5,6] In fact, The Lancet Commission reported that hearing loss is the *largest* modifiable risk factor for the prevention of dementia.[7] Furthermore, they reported that hearing loss is a risk factor that should be addressed in midlife – not toward the end of life – for optimal benefit.[7] For many individuals with hearing loss, however, the decision to pursue amplification is often delayed 4-6 years from the moment that they are diagnosed with hearing loss.[8] The factors relating to this delay vary, but are often attributed to accessibility, affordability, stigma, and lack of perceived benefit, among others.[9]

The impact of facemask use and social distancing on speech audibility

In the current novel coronavirus disease 2019 (COVID-19) pandemic, health and government officials are encouraging, even mandating, community-wide face mask wearing (i.e., universal masking) to reduce potential pre-symptomatic or asymptomatic aerosol transmission of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) to others. This practice, in combination with "social distancing" (>6 feet apart) has helped "flatten the curve" for those most vulnerable to the disease, but it has also provided a barrier to clear, empathetic communication, particularly for those with hearing loss.[10]

Figures 1-4 demonstrate the impact on speech audibility measured using "real-ear measurements" when face masks are worn, and physical distancing is used between talkers and listeners. In Figure 1, the green curve represents the long-term speech levels for conversational speech (The Rainbow Passage) recorded at the ear drum for a "typical" conversational distance of three feet between talker and listener (green curve). Figure 2 compared the reduction in audibility at the eardrum under the same conditions and talker-listener distance when an N95 face mask is worn (teal curve). Figure 3 shows the impact of increasing the talker-listener distance from three to six feet (orange curve). Clearly, the use of face masks and physical distancing reduces audibility for speech, even for individuals with normal hearing, as audibility is decreased by up to 15 dB relative to the condition when no mask is worn for "typical" physical distancing.

The additional impact of hearing loss on speech audibility

This situation is compounded for a person with a "typical" mild age-related hearing loss; Figure 4 illustrates for an individual with a gradually sloping high-frequency hearing loss (red curve), the reduction in audibility for the same conditions as represented in Figure 3 may render critical high-frequency speech information to be inaudible when a mask is used and six-foot physical distancing is used. The resulting decrease in Speech Intelligibility Index (SII) from 0.65 to 0.52 may reflect a reduction of up to 25% in speech intelligibility.

Hearing aids can help

Figures 5-6 demonstrate the impact of social distancing and face mask use on speech audibility for a person with properly fit hearing aids. Figure 5 illustrates the amplified speech spectrum for a talker-listener distance of three feet when no mask is worn. Figure 6 demonstrates how the combination of use of an N95 mask and social distancing (six feet) reduces audibility relative to the aided condition depicted in Figure 5; therein lies the "face-masking dilemma": while protecting against the aerosol spread of COVID-19, the use of face masks and social distancing with attendant loss of lipreading cues and sound audibility make communication difficult - even with properly-fitted hearing instruments.

All facemasks are not created equal

Because of the pandemic, individuals now have an array of face mask choices available to them, including disposable medical face masks, washable cloth masks, and masks with a clear window for lipreading restoration. For many, the solution reflects the best combination of protection, comfort, convenience, and proper fit. Another factor, particularly for those with hearing loss, is increasingly focused on acoustic performance and preservation of visual cues.

To assess differences in sound attenuation across face masks, acoustic measurements were made on many of the latest commercially available styles; Figure 7 illustrates the differences for a range of mask types. The data are normalized relative to when NO mask is worn, which is depicted by "zero" line on the x-axis. While all of the masks reduce important high-frequency sound information, there is significant variation across fabric, medical, and paper masks, especially those equipped with a plastic "window". One unexpected finding was that face masks and face shields that used clear plastic had an enhancement of several dB in the low/mid frequencies along with a reduction in the high frequencies.[11-13] These data illustrate the challenge of using a predetermined compensation scheme, with fixed high-frequency gain adjustment, to adapt for the impact of social distancing and face mask use. New technologies continue to provide innovations for the use of facemasks that preserve lipreading cues, through the use of clear plastic panels, that provide prevention and safety benefits both for individuals with hearing loss and with normal hearing.[14-16] In addition, hearing aid technologies incorporate increasingly sophisticated signal processing strategies for enhancing speech recognition in quiet and noisy listening environments[17] when social distancing and facemask-wearing policies are in place.

Additional technologies for improved communication and accessibility during COVID-19

Additional benefits that were identified or advanced during the COVID-19 pandemic included real-time automated captioning for use with videoconference calls and virtual presentations,[18] subtitles, and expanded use of telehealth, which allows for "unmasked" communication.[19] More conventional approaches included written scripts or using a tablet and pen. Although each of these techniques were used prior to 2020, their adoption increased considerably the pandemic. Even so, there remain significant areas for improvement for "unmasked" communication with all activities of daily living: grocery or retail shopping, convenience stores and gas stations, restaurants, transportation, government, and public buildings, etc. The potential of virtual and real-time, speech-to-text captioned interfaces (whether via smart phones or kiosks) lies ahead.

Future concerns

These communication challenges often lead to social-withdrawal and curtailing of necessary medical visits. As we enter the third year of the COVID-19 pandemic/endemic, infection and death rates are on the decline thanks to herd immunity whether via illness, vaccination(s), or both. Concern still exists for whether these face-masking and social distancing policies should be removed, and when. Additionally, there is the concern that these policies may return if another pandemic occurs. It behooves us all to reflect and learn from our observations and experiences during the current pandemic, especially its impact on communication for those with hearing loss, and how we can institute systems and policies to improve communication in the future.

Figure 1. Long-term speech levels (green curve) measured at the listener's eardrum for conversational-level speech measured at a talker-listener distance of three feet when no facemask is worn.

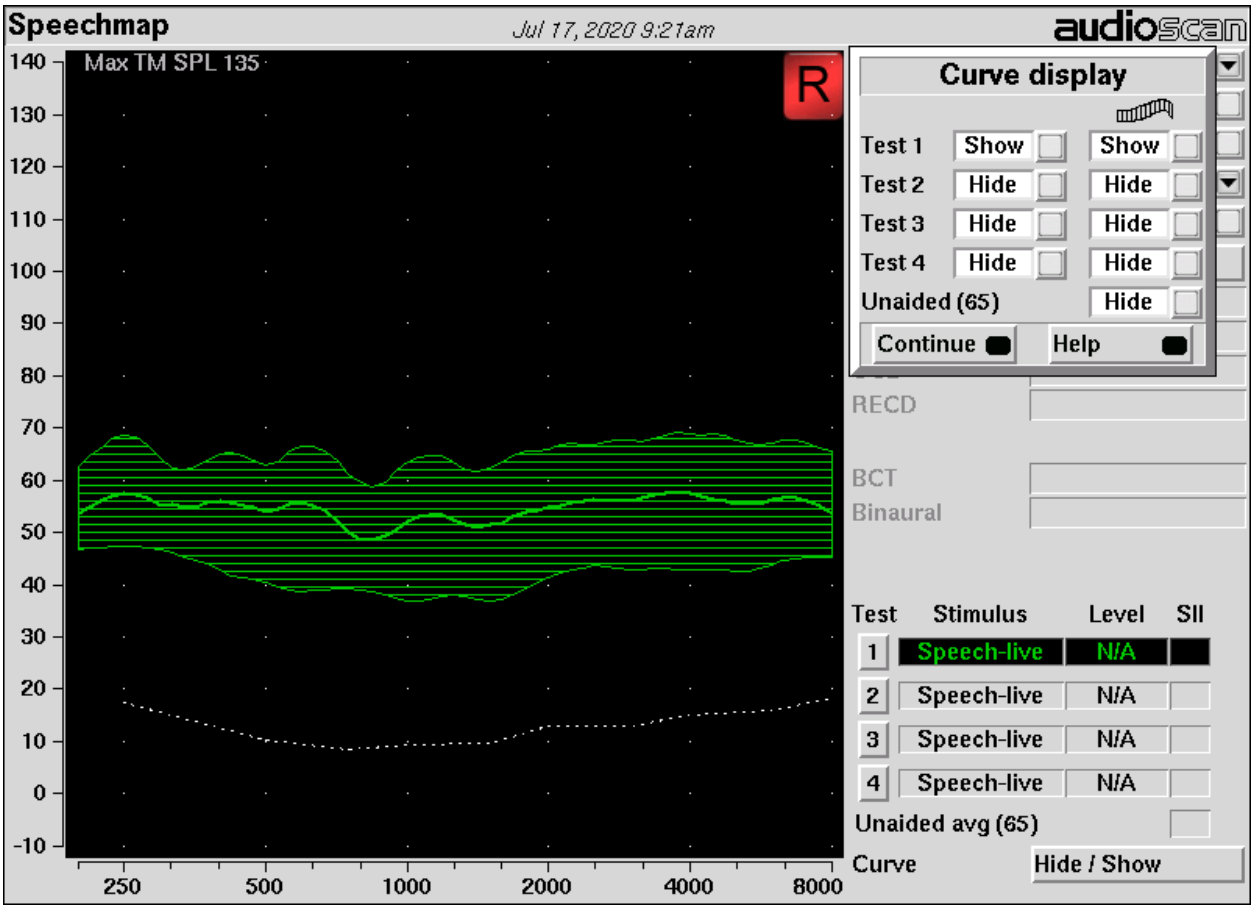


Figure 2. Long-term speech levels measured at the listener's eardrum for conversational-level (65 dB SPL) speech measured at a talker-listener distance of three feet when no facemask is worn (green curve) versus when an N95 facemask is worn (teal curve). Normal hearing thresholds are depicted by the dashed line.

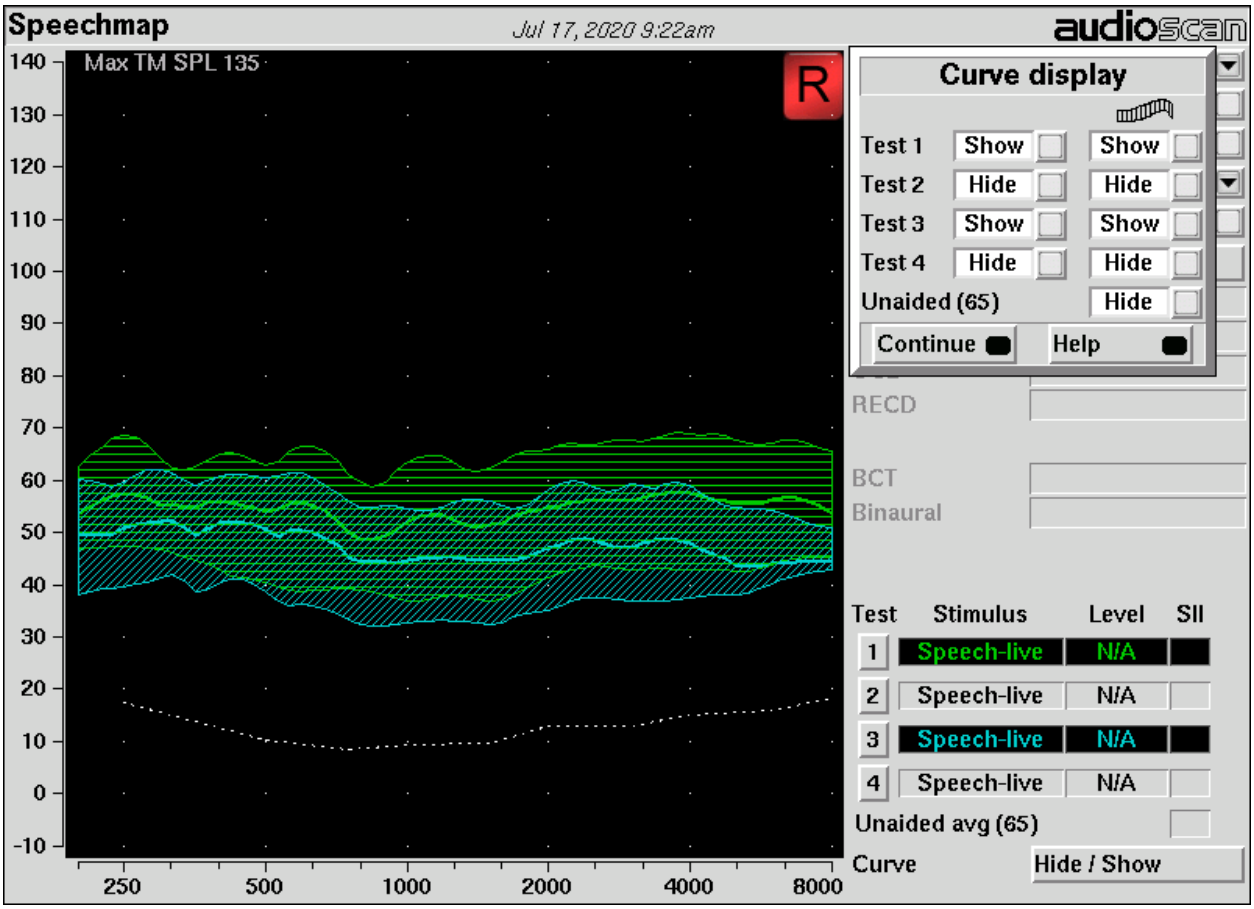


Figure 3. Long-term speech levels measured at the listener's eardrum for conversational-level (65 dB SPL) speech measured at a talker-listener distance of three feet when no facemask is worn (green curve) versus when an N95 facemask is worn for a six feet talker-listener distance (orange curve), illustrating reduced overall speech audibility when a facemask is used in combination with increased social distancing.

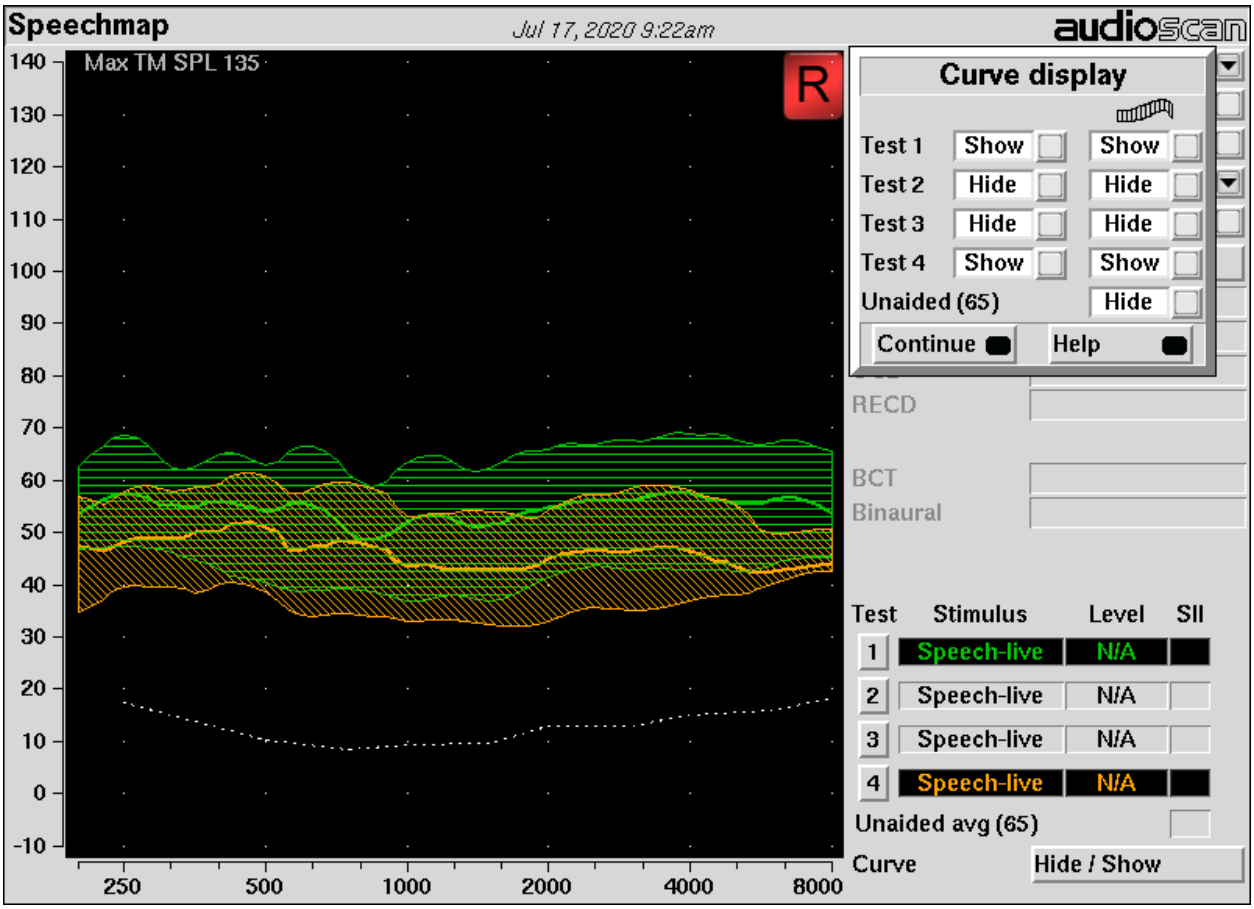


Figure 4. Long-term speech levels measured at the listener's eardrum for conversational-level (65 dB SPL) speech measured at a talker-listener distance of three feet when no facemask is worn (green curve) versus when an N95 facemask is worn for a six feet talker-listener distance (orange curve) for a person with a mild, sloping, high-frequency hearing loss (red curve). Area above the red curve is audible, and below is inaudible.

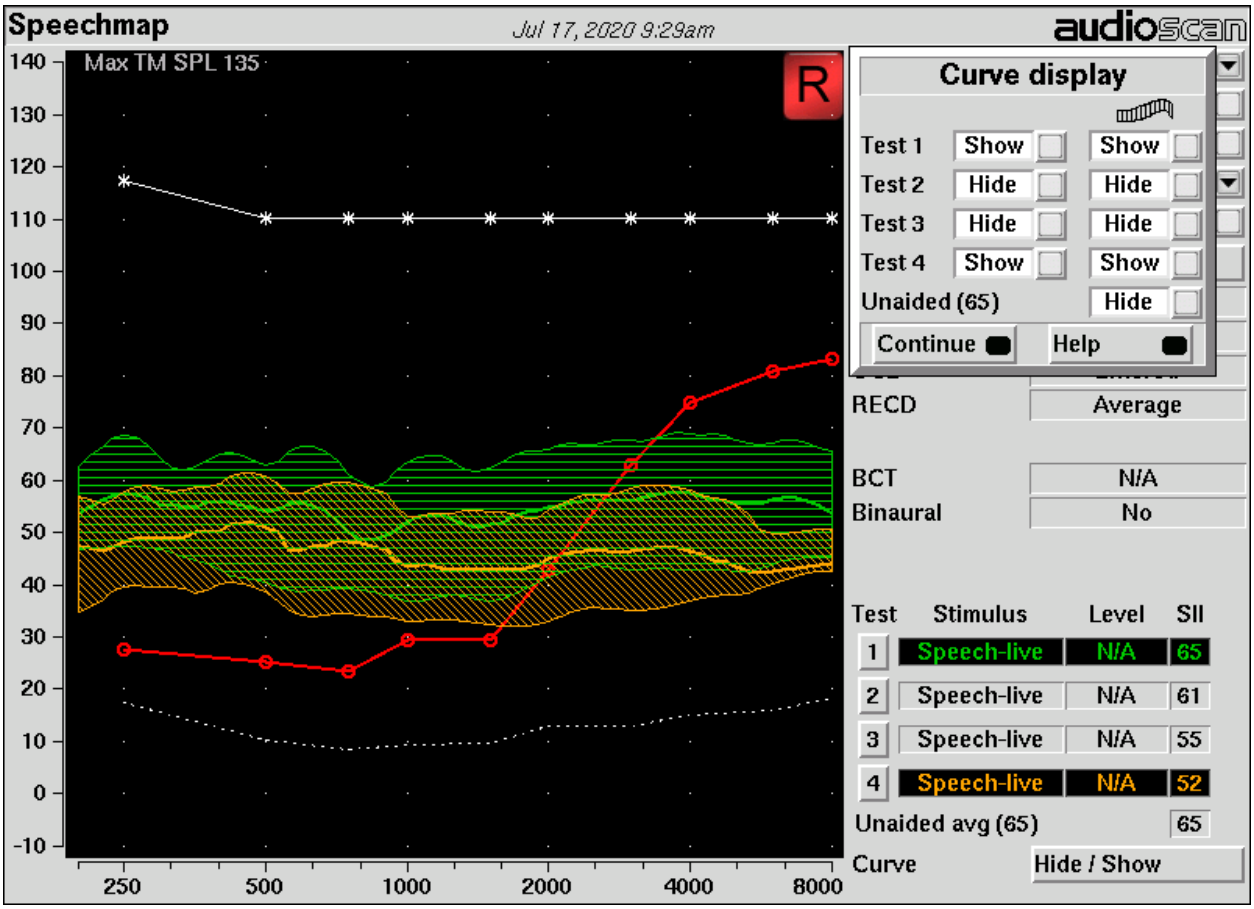


Figure 5. Amplified speech levels (green curve) for a person with mild-to-moderate sloping high-frequency hearing loss, measured at the listener's eardrum for conversational-level (65 dB SPL) speech measured at a talker-listener distance of three feet when no facemask is worn.

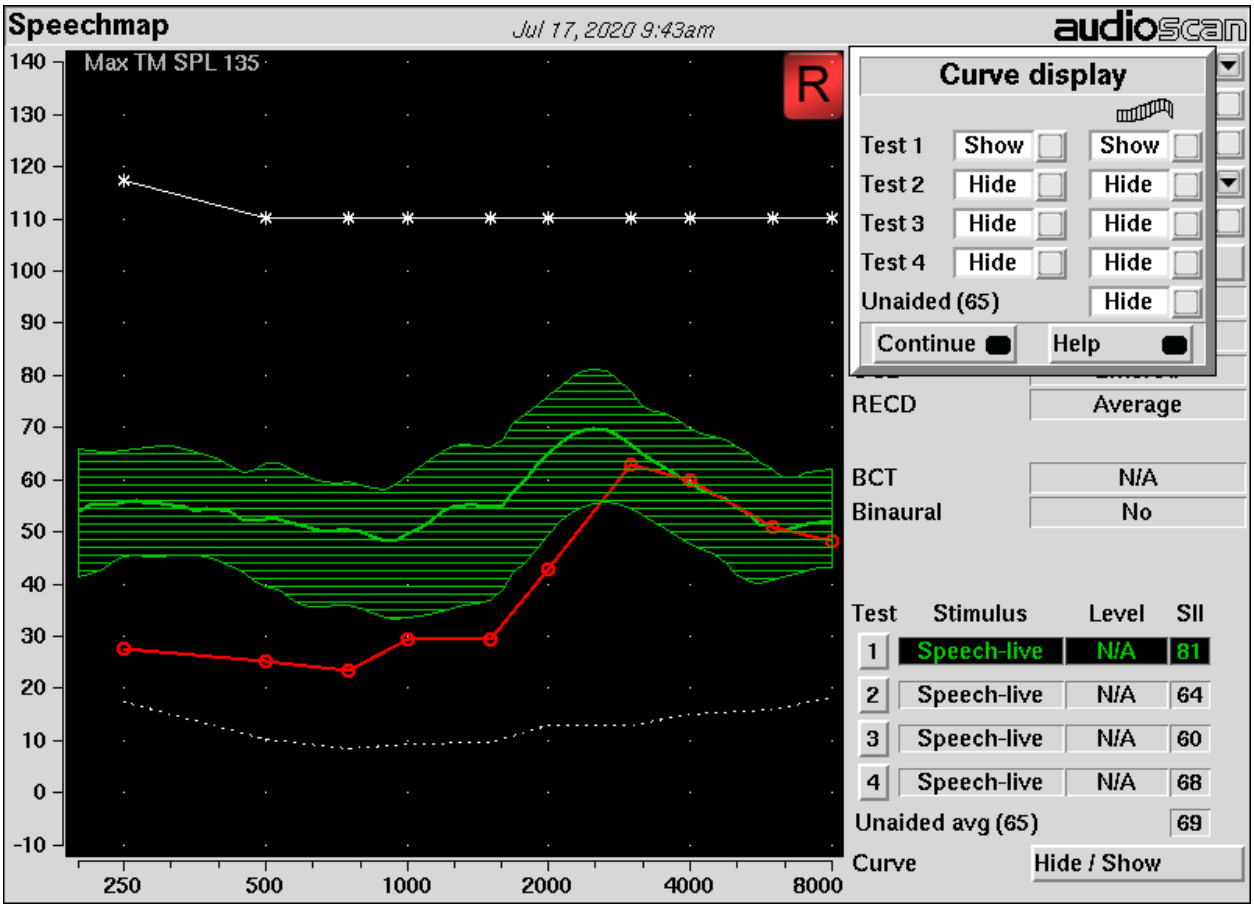


Figure 6. Amplified speech levels (green curve) for a person with mild-to-moderate sloping high-frequency hearing loss, measured at the listener's eardrum for conversational-level (65 dB SPL) speech measured at a talker-listener distance of three feet when no facemask is worn, versus when an N95 facemask is worn by the talker for a talker-listener distance of six feet (purple curve).

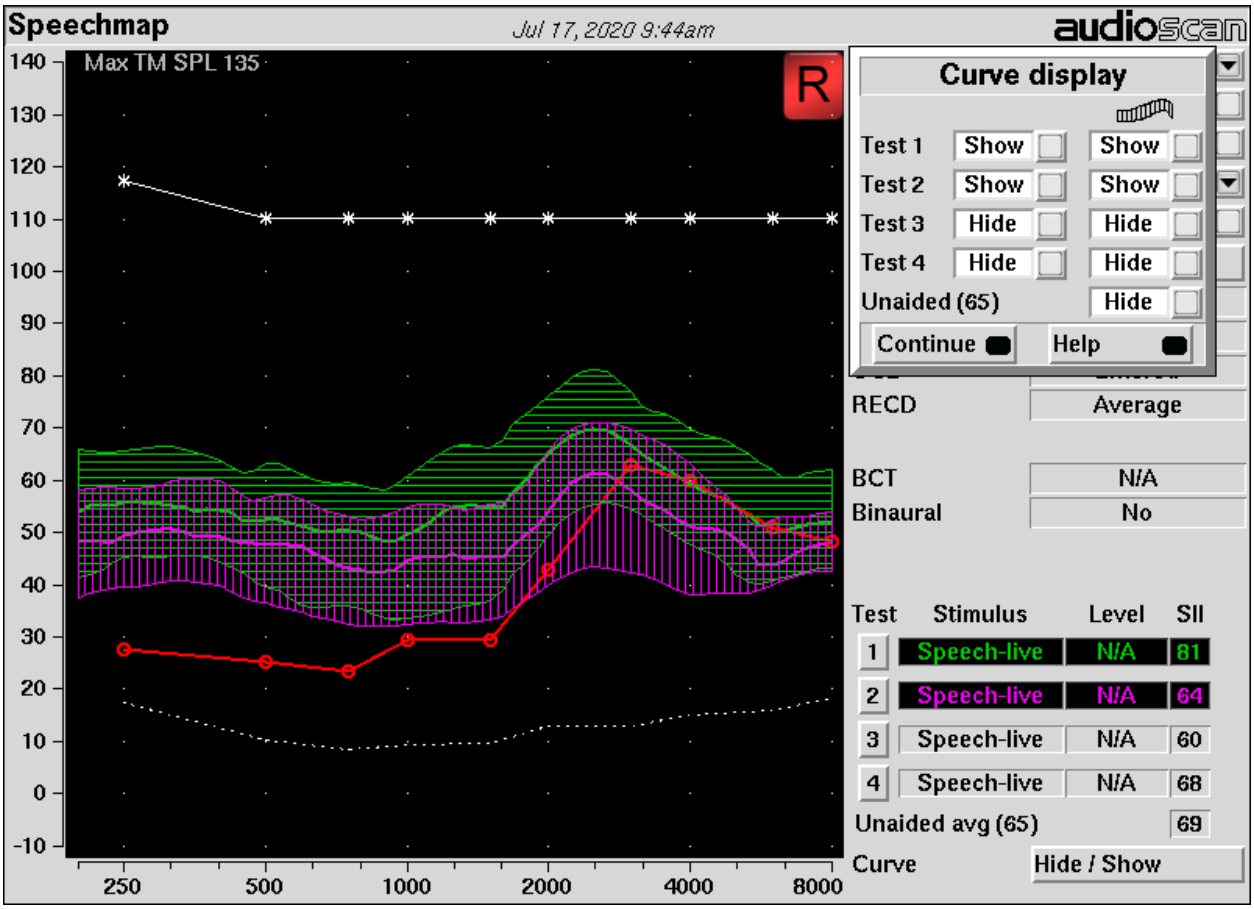
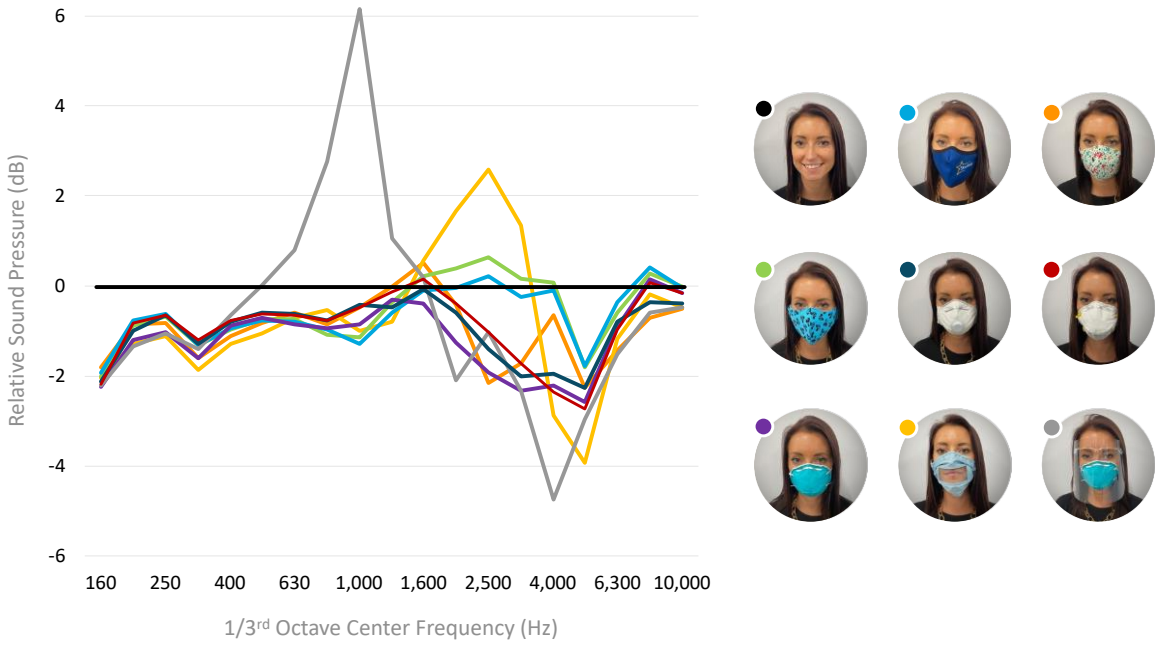


Figure 7: The acoustic impact of different face masks, relative to when no face mask is worn (black curve).



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