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Original articles

Use of masks in the oral communication of hearing device users

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A study conducted at the Specialized Otorhinolaryngology and Speech-Language-Hearing Department of the Clinics Hospital of Ribeirão Preto with the Medical School of Ribeirão Preto at the Universidade de São Paulo, Ribeirão Preto, SP, Brazil.

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ABSTRACT

Purpose: to assess the influence of wearing a mask on auditory-visual speech recognition, in a favorable listening situation, in hearing devices users.

Methods: a cross-sectional observational study comprising 52 hearing aid users, whose speech recognition was assessed with six video-recorded lists of sentences with and without masks. The mean test results in the various situations were compared using the Friedman test with Bonferroni post hoc, the significance level being set at 5%.

Results: speech recognition assessment results differed between the situations with and without masks and between mask types, with a small effect size. The post hoc, with p-values adjusted with the Bonferroni method, showed a difference between transparent masks and others. The transparent one had a higher mean (77.8%) of auditory-visual sentence recognition between the various situations. There were statistically significant differences, as the transparent mask provided a better performance than the others.

Conclusion: the auditory-visual recognition of the hearing-impaired people was better with the transparent mask.

Keywords: Persons With Hearing Impairments; Communication; Speech, Language and Hearing Sciences; Audiology

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INTRODUCTION

The COVID-19 pandemic required safety measures to reduce the spread of the virus. One of the strategies was wearing masks, recommended by international centers[1] as an important precaution to protect against easily transmissible respiratory diseases. However, their use has been associated with significant social, communication, and behavioral challenges for hearing impaired people[2].

Older adults are among those affected by mask use, as they are widely exposed to hearing loss, according to the study by Brotto et al.[3]. The authors point out that the COVID-19 pandemic has affected verbal communication, especially in people who have greater difficulty perceiving speech even under normal conditions. Likewise, it has affected the users of hearing aids (HAs) and cochlear implants, as speech intelligibility and comfort may decrease when these devices are used along with face masks[3].

Hence, review studies have aimed to provide more elements for clinical practice and point out both extant gaps and future perspectives in research. A review study conducted by researchers from North Carolina, in the United States, to investigate the challenges faced by people with hearing impairment during the COVID-19 pandemic highlighted a lack of information, communication hindered by face masks, physical and mental health affected by social distancing, and stigmas and barriers related to the health system[4].

Another literature review by Iranian researchers addressed problems faced by people with hearing impairments during the pandemic, as well as some useful solutions that can be implemented by healthcare professionals and other members of society[2]. The lack of orofacial and facial expression reading and decrease in acoustic cues stood out among the problems they pointed out, leading to greater physical and social distancing and impaired quality of life[2].

The negative impact of masks on human communication was also highlighted in the review by Oosthuizen et al.[5], which aimed to understand how mask-wearing and social distancing affect communication. They found that speech is more affected in noise than in quiet and that people with hearing loss are more affected than those with normal hearing. As for types, surgical masks had little impact on speech understanding, unlike cloth masks and acrylic face shields. Transparent masks can benefit people with hearing loss, despite attenuating sound more than opaque ones[5].

From an acoustic perspective, masks can reduce voice signal transmission and perception, as identified in the study by Corey et al. at the University of Illinois[6]. It evaluated the acoustic attenuation with different face masks, including surgical, cloth, and transparent ones, using a head-shaped loudspeaker and a live human speaker. The results suggested that all masks attenuate frequencies above 1 kHz, that attenuation is greatest in front of the speaker, and that there is substantial variation between mask types, especially cloth masks with different materials and weaves. Transparent masks performed acoustically worse than surgical and cloth ones. Most masks have little effect on lapel microphones, suggesting that the existing sound reinforcement and assistive listening systems may be effective for verbal communication with masks[6].

These findings invite industrial designers and acoustic engineers to design and produce face masks with less communication impairment without compromising disease protection. Such masks would benefit both the general public and healthcare professionals who communicate directly with patients, as shown in a scientific publication that reported the case of a doctor with hearing impairment at the time of the pandemic[7].

Although government agencies responsible for public health recognize that transparent masks facilitate oral communication (as they enable facial expressions and orofacial reading)[1,8], they do not ensure the necessary protection against contagious respiratory diseases. This occurs because vinyl, normally used in this type of mask, does not absorb microorganism particles[8].

Given the need for further research on how different mask types impact the oral communication of people with hearing impairment, this study aimed to compare auditory-visual speech recognition in a favorable listening situation (in quietness) without a mask and with five mask types in hearing device users presented with different degrees of hearing loss.

METHODS

The project was approved by the Research Ethics Committee of the Clinics Hospital of Ribeirão Preto, SP, Brazil (CAAE: 52538921.3.0000.5440; Evaluation Report 5.150.532/HCRP Process no. 6442).

This is an observational study with a cross-sectional design and a convenience sample.

The study was carried out between May and September 2022 at the Outpatient Clinic for Electronic Hearing Device Verification of the Specialized

Otorhinolaryngology and Speech-Language-Hearing Department of the Clinics Hospital of Ribeirão Preto.

The sample comprised 52 hearing device users who attended the Hearing Health Program at the said outpatient clinic.

The inclusion criteria were being a hearing device user for at least 5 months (if it was their first device), using properly functioning devices, being at least 18 years old, and having postlingual hearing loss. The exclusion criterion was the presence of comorbidities (psychiatric, neurological, or behavioral disorders that hindered the procedures).

Participants in the Hearing Health Program were selected and invited to participate in the research during their follow-up visit, previously scheduled by the service. Those who were interested were invited to read the informed consent form, which those in agreement were asked to sign.

Each participant's data were collected in a single day, taking about 30 minutes.

Auditory responses were initially surveyed in a free field, in an acoustic room with modulated warble stimuli, to check whether the hearing devices were functioning properly. Thus, it was verified that all users had access to speech sounds and met the service criteria, benefitting from their devices.

Auditory-visual recognition in quietness was assessed by presenting audio and video recordings of Brazilian Portuguese sentences. They had been recorded by a researcher (female voice), using a Samsung mobile phone, model Galaxy S20. After recording, the material was edited with pauses for responses between each sentence.

The sentences were extracted from the List of Sentences in Portuguese test[9], whose six lists have 10 sentences each, all with the same degree of difficulty[9]. One of the researchers recorded the six lists in two situations, with and without a mask, the former with five different mask types: surgical, KN95, N95, cloth (opaque), and transparent (vinyl).

Before starting data collection, each video-recorded sentence was presented to three hearing volunteers and three volunteers with hearing loss who benefited from their devices, according to routine assessment results at the Hearing Health Program's audiology service where the study was carried out.

The sound intensity level of the video presentation was checked for its decibel range (which should be 60 dBSPL) with a calibrated decibel meter manufactured by Instrutemp, model ITDEC 4000.

Participants were individually assessed in a well-lit and acoustically treated room. Wearing their hearing devices, they sat in front of an 11-inch computer monitor placed 80 cm away from them and connected via Bluetooth to a JBL speaker. The video recordings were presented randomly via computer at the speech intensity of 60 dBHL (average speech sound intensity in spontaneous conversation), measured with a decibel meter in a mobile phone application – which in turn was tested with a properly calibrated decibel meter, with no measurement variations. The sentence lists were different for each situation with the said mask types and without a mask.

Participants were instructed to repeat each sentence immediately after it was emitted. The percentage of sentences successfully recognized in quiet was calculated at the end, based on Costa's recommendations[10], with greater weight for content words (two points) and less weight for functional words (one point), following the values provided by the authors in the instrument validation.

The researchers chose the no-mask as the baseline situation, as the literature[6,11,12] indicates it can be easier than with a mask.

Data were analyzed and organized in an Excel spreadsheet and presented in tables and charts. Descriptive statistics, including the mean, median, and standard deviation, were used to demonstrate performance in the tests applied with each recording, separately for the lists with and without masks. The Friedman non-parametric test was applied to compare auditory-visual recognition performance with the five mask types and without a mask. The Friedman Test was also applied to verify whether the degree of hearing loss was related to speech comprehension with the five mask types and without a mask. The effect size between the degree of hearing loss and the mask types was measured with the Dunn method. The effect size of mask types regarding auditory-visual recognition was measured with the Bonferroni method. The significance level was set at 5% for data analysis, and all statistically significant p-values were marked with an asterisk (*).

RESULTS

Characterization of the participants

The study included 52 hearing device users, 30 of whom (57.69%) were females and 22 (42.30%) were males. The participants' mean age was 25.76 years. The oldest one was 93 years old, and the youngest one was 15 years old.

Bilateral sensorineural hearing loss was the prevalent type, affecting 24 participants in the right ear and 25 participants in the left ear (Table 1).

Table 1. Type of hearing loss per ear (n = 52)

Type of hearing loss	RE	LE
Conductive	1	1
Mixed	16	18
Sensorineural	24	25
No hearing loss	2	0
Total	47	50

Captions: RE = right ear; LE = left ear.
The total does not match n = 52 because the cases whose information in the records was incomplete were excluded.

Severe hearing loss was the most prevalent degree.

Most participants' devices were HAs (Table 2).

Table 2. Type of hearing devices used by the patients and type of fitting

Hearing devices	RE	LE	Bilateral
Hearing aid	8	8	25
Cochlear implant	5	4	0
BAHA	1	0	0
CROSS system	1	0	0
Total	15	12	25

Captions: RE = right ear; LE = left ear; BAHA = bone-anchored hearing aid.
N = 52 participants

Auditory-visual recognition

The best mean performance out of all mask types was with the transparent one (Table 3).

Table 3. Descriptive data of performance percentage values regarding mask types in auditory-visual recognition

MASK	n	min	max	median	mean	Standard deviation
SURGICAL %	52	2.3	100	80.1	67.9	32
KN95 %	52	4.7	100	79.9	67.3	30.2
N95 %	52	0	100	73.2	65.1	30.8
NO MASK %	52	3.3	100	71	69.5	25.3
CLOTH %	52	0	100	74.4	65.3	30.8
TRANSPARENT %	52	17.8	100	83.2	77.8	20.9

Captions: n = number of participants; min = minimum; max = maximum

In Figure 1, the Friedman test indicated a difference between the masks in terms of the percentage of auditory-visual sentence recognition and mask types ($p < 0.001$), with a small effect size (Kendall W = 0.084). The post hoc, with p-values adjusted with the Bonferroni method, showed a difference in the comparison between the transparent mask and the other ones (Table 4).

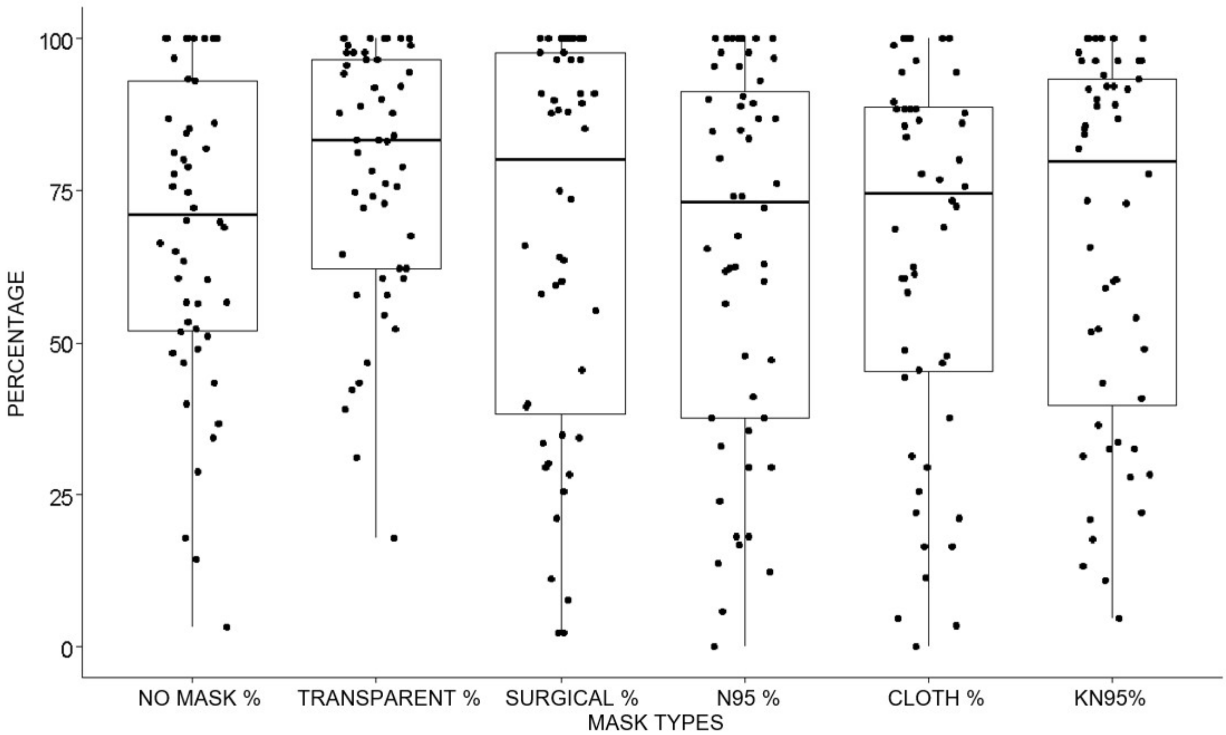

Figure 1. Distribution of the percentage values of auditory-visual recognition per mask type

Table 4. Post hoc of the Friedman test using Wilcoxon multiple comparisons with Bonferroni correction

Mask Types		p-value
SURGICAL %	KN95 %	0.451
SURGICAL %	N95 %	0.081
SURGICAL %	NO MASK %	0.958
SURGICAL %	CLOTH %	0.191
SURGICAL %	TRANSPARENT %	0.002*
KN95 %	N95 %	0.123
KN95 %	NO MASK %	0.828
KN95 %	CLOTH %	0.161
KN95 %	TRANSPARENT %	<.0001*
N95 %	NO MASK %	0.362
N95 %	CLOTH %	0.966
N95 %	TRANSPARENT %	<.0001*
NO MASK %	CLOTH %	0.332
NO MASK %	TRANSPARENT %	0.002*
CLOTH %	TRANSPARENT %	<.0001*

Caption: Asterisks indicate statistically significant results when $p < 0.005$

Statistically significant differences were found, in which the transparent mask performed better than the other mask types: surgical ($p = 0.002$), KN95 ($p < 0.001$), N95 ($p < 0.001$), and cloth ($p < 0.001$). Statistically significant differences were also found between the mask types and mild and moderate hearing loss ($p = 0.025$) and severe hearing loss ($p = 0.012$). No statistically significant difference was found for profound hearing loss ($p = 0.073$).

DISCUSSION

This study verified better auditory-visual recognition performance with the transparent mask – which is consistent with results from other studies regarding the significant benefit of using transparent face masks for individuals with hearing loss[11,12].

Another relevant aspect was that the hearing impaired performed worse in auditory-visual recognition with opaque masks. Similar evidence was reported in another study that indicated the adverse effects of surgical masks on audiovisual speech intelligibility in individuals with hearing loss[13]. Conventional surgical masks block visual access to the mouth and other possible facial cues, which makes communication difficult not only for those without hearing loss but even more so for individuals with hearing loss[5].

The transparent mask also had a positive effect on normal-hearing people, with a 30% improvement in auditory-visual recognition (thanks to the support from orofacial reading in this situation) in comparison with auditory recognition alone[14]. The cited study highlighted the potential benefits of wearing a clear face mask, even for people with normal hearing[14].

Researchers from the United Kingdom[15] state that both normal-hearing and hearing-impaired groups benefited from the visual input of transparent masks. Findings confirm improved speech perception performance in noise for normal-hearing and hearing-impaired people when visual input is provided by using a transparent mask. Most importantly, the use of the transparent mask did not negatively affect speech perception performance in noise[15].

Thus, transparent masks are an option with greater advantage and efficiency, according to the results demonstrated in this and other studies[7,11,12,16].

Contrary to the findings of the present study, Brown et al.[16] found that surgical masks performed better for auditory recognition, rather than transparent ones. According to the authors, this can be justified by the occasional air condensation in transparent ones, obscuring visual information. This phenomenon did not occur in the present study.

The results differ from the initial hypothesis that the no-mask situation would perform best in auditory-visual recognition. This possibly happened because the no-mask presentation was the first one, not included in the randomization of recorded sentence lists – which may have interfered with performances. It was believed that the baseline situation would make it easier for the hearing impaired to understand the task and repeat each sentence with the facilitating cue of orofacial reading, as they would often do in their pre-pandemic everyday lives. However, better results were seemingly found after the first presentation (no mask) due to either an emotional assessment factor or process learning.

No information was found in the literature regarding the randomization of the order in which situations were presented to assess facial recognition. A single study reported on the method that it found no significant difference between the lists after randomizing them in the Hearing-in-Noise Test (HINT)[17]. Therefore, the no-mask recording may have worked as a training for participants, leading to a better performance with the transparent mask recording than without a mask.

Another hypothesis for the result is that, according to the literature, both normal-hearing and hearing-impaired people tend to pay more auditory attention to situations with masks on, as they assume that mask use may hinder oral comprehension by removing visual cues in orofacial reading.

The impossibility of orofacial reading for 55.9% of hearing-impaired people interviewed in southern Italy in a hospital emergency department is a warning for healthcare professionals and hearing-impaired service users[18].

The present study corroborates the findings of Atcherson et al.[11] concerning the comparison of mask types in auditory-visual recognition by people with different degrees of hearing loss. Their study verified that patients with moderate hearing loss performed better with transparent masks.

It is believed that, especially in healthcare, oral comprehension is essential to ensure the quality of treatment. Therefore, orofacial reading, provided by wearing transparent masks, helps improve communication for those with hearing loss[7,11,12].

American researchers investigated the use of masks and the communication difficulties they can cause in healthcare environments regarding both listening effort and cognition. Their questions addressed two conditions, “wearing a mask” and “not wearing a mask”. They noticed greater listening effort by patients and professionals and changes in the clinical efficiency of professionals when wearing masks, which were generally more pronounced among those with hearing loss[19].

It has been likewise described that mask use can compromise the efficiency, effectiveness, equity, and safety of therapeutic intervention services. Patients report difficulty in understanding conversations and remembering information and greater listening effort in clinical environments. Thus, mask use can be considered a significant predictor of greater difficulty in remembering information given in consultations, which suggests that additional listening effort can probably increase cognitive load, making it difficult for them to retain information from clinical consultations[7].

Among the limitations of the study, the following stand out: the prevalence of severe sensorineural hearing loss, which may have influenced the importance of visual cues to facilitate performance with transparent masks; and the non-inclusion of a normal-hearing group to compare with hearing-impaired ones.

On the other hand, this study helped draw the attention of researchers and health professionals to the importance of transparent masks to improve speech recognition for people with hearing loss, especially when it is severe.

Given the global tendency to wear masks as a protective barrier against the contamination of emerging diseases, transparent ones can preventively mitigate the effects of oral communication difficulties for people with hearing loss.

CONCLUSION

It is concluded that wearing a mask influences human communication regarding auditory-visual recognition by hearing-impaired people, even in favorable listening situations. Hearing device users performed better with the transparent masks than with other mask types. Furthermore, the mask type influenced auditory-visual recognition in mild/moderate and severe hearing loss.

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Authors contributions:

MERAF: Investigation; Data curation; Visualization; Writing - Original Draft.

TMJ: Visualization; Supervision; Writing - Review & editing.

SZ, ACMBR: Data curation; Formal analysis; Supervision; Writing - Review & editing.

NEZA: Conceptualization; Data curation; Formal Analysis; Investigation; Methodology; Project administration; Supervision; Validation; Writing - Original Draft; Writing - Review & editing.