

Speech Communication Problems Wearing Face Mask

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ABSTRACT.

The face masks are one of the best tools to prevent the spread of the SARS-CoV-2 virus. Although these could stop being used in a future, there are plenty of application where their use is needed. For this reason, their study in terms of health effects and speech intelligibility and articulation index could be interesting. In this research, a survey was carried out to know the effect of wearing face mask in different education levels. Besides, a study of the speech intelligibility, articulation index and sound quality evaluations were carried out to research which type of the face mask should be used in education settings.

Additionally, there are significant differences in terms of speech intelligibility, articulation index and loudness depending on the type of face mask used, the distance between students and teachers and if the students have hearing-impaired. Thus, this paper can provide a guidance on how to choose the best face mask to improve speech understanding when communicating with other people, especially in education settings.

RESUMEN.

Las mascarillas son una de las mejores herramientas para prevenir la propagación del virus SARS-CoV-2. Aunque estas podrían dejar de usarse en un futuro, existen multitud de aplicaciones donde se necesita su uso. Por ello, su estudio en términos de efectos sobre la salud y la inteligibilidad del habla y el índice de articulación podría ser interesante. En esta investigación se realizó una encuesta para conocer el efecto del uso de mascarillas en diferentes niveles educativos. Además, se realizó un estudio de las evaluaciones de inteligibilidad del habla, índice de articulación y calidad del sonido para investigar qué tipo de máscara facial se debe usar en entornos educativos.

Además, existen diferencias significativas en términos de inteligibilidad del habla, índice de articulación y volumen según el tipo de mascarilla utilizada, la distancia entre alumnos y profesores y si los alumnos tienen problemas de audición. Por lo tanto, este artículo puede brindar una guía sobre cómo elegir la mejor mascarilla facial para mejorar la comprensión del habla al comunicarse con otras personas, especialmente en entornos educativos.

1. INTRODUCTION

The problems related to acoustics in the classroom, since the advent of the SARS-CoV-2 pandemic the use of the face mask has made teachers more difficult to understand. Previous studies have demonstrated the adverse effects of face masks on speech intelligibility [1,2]. While understanding someone wearing a face mask is a challenge for all people, it is particularly difficult for the hearing impaired. The face mask covers the lips, which play an essential part in communication, as well as affecting facial and tongue movements, thereby impeding aural comprehension. Another important factor is the kind of face mask worn; depending on the material used, the degree to which it attenuates sound will vary. The presence of sources of noise in classrooms can also be a distractor, hindering students' ability to understand. Due to the COVID-19 pandemic, the problems entailed by the use of face masks have been suffered by the general public. The fact is that the face masks are a piece of Personal Protective Equipment (PPE) used in many sectors, such as Medicine, Industry, and Construction, among others, in which they have a negative impact on speech perception. Thus, the study of speech intelligibility is a relevant and pressing topic, especially now due to the pandemic and the widespread use of face masks. For these reasons, the aim of this paper was to study oral communication at a school where teachers and students wore different kinds of face masks. A survey was also conducted of teachers at different educational levels in Spain with the main aim at analysing the correlation between the users' health effects and the use of face mask, as well as with the type of face mask used.

2. MATERIALS AND METHODS

It is possible to find different types of face mask on the market. They can be classified into the following categories, accepted by international standards:

1. Cloth masks.
2. Surgical masks.
3. Disposable respirators (N95, FFP, KN95).

This study will focus on these types of masks, as these are the most commonly used by people. These are described in detail below and, in the interest of simplification, face masks hereinafter are just called "masks".

2.1. Experimental set-up

2.1.1. Speech acquisition

To gauge speech intelligibility in the classroom, a binaural head GRAS 45BB-4 and torso KEMAR with prepolarized 1/2" microphones were used. For the measurement of the background noise in the classroom, a microphone array of 96 MEMS microphones with recommended mapping frequencies between 514 Hz and 24 kHz, from Gfai tech GmbH (Germany), was utilized.

2.1.2. Speech stimuli

Several speech intelligibility tests were carried out in a classroom at a primary school with 25 7-year-olds. The test consists of the reading of the induced phonological register used to detect hearing impairment by a student at different places in the classroom (the nearest and farthest spots) using the face mask mentioned (cloth, surgical and FFP2). In this part of the test, the binaural torso was placed on the teacher's desk. The induced phonological register was then read by the teacher, and the binaural torso was placed at the nearest and farthest points in the classroom. All the participants had given their consent to participate. In cases of minors, their parents had to sign the corresponding consent forms. All the subjects also received instructions to speak in a natural, normal manner during the recording. The main aim of this part of the experiment was to measure speech intelligibility with different parameters (speech intelligibility, articulation index and total loudness).

2.1.3. Survey and statistical analysis

A survey was carried out through social media networks (<https://encuestas.webapps.uco.es/index.php/631871?lang=en>). The survey was divided into four categories of questions. There were two questions about sociodemographic information, like age range, gender and city/country. After this there were questions about the type of contract (temporary, substitute and public worker), teaching activity level (Preschool, Primary School, Secondary/High school, Higher Education and Special Needs Education), and the type of classes (100% online, 50% of students attending class, and 100% in-person). The third group of questions were related to the face mask, including the type used (cloth or hygienic face mask without UNE EN certification; a cloth or hygienic face mask with UNE 0064-0065 filter, FFPX type, KN95, N95, UNE EN 14683 surgical mask, or no mask), the number of hours wearing a face mask at work (<4 hours, 4-8 hours and >8 hours), and outside of work (<4 hours, 4-8 hours and >8 hours). The last group of questions was about the effect of the use of face masks on health (headache, sore throat, anxiety, skin problems, speaking louder, problems with oral communication, and fatigue or breathing problems) and the type of air circulation used during classes (opened windows, air circulation or both).

A total of 238 responses were received from Spain, United Kingdom and Portugal. The dataset was saved in Excel, Version 17; and SPSS Version 25.

The dataset was analyzed using descriptive statistics and the relationships of the qualitative variables.

3. RESULTS

The analysis of the responses showed that most participants (56.3%) were female. 29.9% ranged in age from 41 to 50, 43.3% worked at a university, and 43.3% were public employees. Regarding the usual class types, around a 43.7% were 100% in-person and a 27.3% were with a 50% of the students attending to class. The percentage of women who answered the survey (56.3%) was higher than men (32.4%), and only one response was completed indicating another gender (0.4%). Many of the responses corresponded to tenured professors at an university (43.3%), and secondary school teachers (26.5%). Primary school teachers accounted for 11.3% of the responses; Preschool teachers, 4.2%; followed by Special Education teachers, at 3.4%. Regarding face masks used in classrooms, almost 60% of the survey respondents said that they used FFP-type face masks. The results also showed that teachers' favorite face mask was the FFP type (around 24%). Older people with public contracts ($p < 0.01$) wearing face masks more than four hours ($p < 0.05$) had skin problems. Also, a correlation was found between men ($p < 0.01$) with public contracts ($p < 0.05$) teaching 100% in-person ($p < 0.01$) and wearing a face mask for less than four hours ($p < 0.01$), as they suffered headaches ($p < 0.01$), sore throat ($p < 0.01$), anxiety ($p < 0.01$), skin problems ($p < 0.01$), fatigue ($p < 0.01$) impaired understanding of their oral communications ($p < 0.01$), and having to speak louder in classes ($p < 0.01$). It is possible to see that teachers at the schools ($p < 0.01$) with 100% in-person classes ($p < 0.01$) and more than four hours of face mask usage ($p < 0.05$) all suffered the health complications mentioned above, except skin problems. In the case of substitute teachers, who usually wear a face mask for less than four hours ($p < 0.05$), they only presented skin problems ($p < 0.05$). A relationship between class type and health effects was found. Obviously, in the case of 100% online classes there was no use of face masks ($p < 0.01$), or they were worn for fewer hours ($p < 0.01$), so adverse health effects were less frequent ($p < 0.01$). The type of face mask ($p < 0.05$) and the number of hours it was worn ($p < 0.01$) impacted the impaired understanding of teachers' oral communications ($p < 0.05$). Another important factor was the number of hours that face masks were worn: the greater the number of hours, the more skin problems teachers suffered ($p < 0.05$), and the more they had to speak louder ($p < 0.05$). Health problems or issues was found to be present in 57.1% of the sample using face masks "Always", "Often" or "Sometimes", according to their responses. Moreover, these health issues seem to be linked to multiple variables, according to the chi-test and symmetric measurements. The main health problems found were impaired understanding of their oral communications (almost 90% of the responses), followed by having to speak louder, at 50%; and fatigue or breathing problems, at around 51%. Table 1 shows the Pearson Correlation Coefficient based on type of children, whether they were hearing-impaired or not, the distance to the teacher's desk, and the type of

face mask. It is possible to appreciate that there is a strong correlation between the distance and the total loudness perceived ($p < 0.01$).

Table 1. Correlation between speech intelligibility and other factors in students (distance, type of children and type of face mask).

	Distance (m).	Type of children	Type of face mask	Total loudness level (sone)	Sharpness (Acum)	Articulation Index (%)	Speech intelligibility (dB)
Distance	1.000	.000	.000	.820 **	.493	-.353	.648 *
Type of children	.000	1.000	.000	-.133	.384	.569	.470*
Type of face mask	.000	.000	1.000	.000	.000	.998**	.968*

** . The correlation is significant at the 0.01 level (bilateral).
* . The correlation is significant at the 0.05 level (bilateral).

This means that the farther away the children are, the louder the teacher speaks. Also, a relationship was found between speech intelligibility and distance, indicating that, logically, reduced distances result in greater speech intelligibility ($p < 0.05$). Additionally, the Articulation Index and speech intelligibility were better in children without any hearing impairment ($p < 0.05$). In the case of face masks, this was found to be a key factor affecting the articulation index and speech intelligibility in classrooms. FFP2 and surgical masks were related to better articulation indexes ($p < 0.01$) and speech intelligibility ($p < 0.05$) compared to cloth masks worn by children.

4. CONCLUSIONS

This study has analysed the impact of the use of face masks in the health of the teachers during their classes through a survey. Moreover, the attenuation of the different face masks was evaluated in a classroom using a binaural torso.

Based on the results obtained, it seems that FFP2 masks were the face mask preferred by the teachers in their classes, followed by surgical masks type. Regarding to the related health effects, men had more health effects wearing face masks than women during their classes, showing headache, sore throat, anxiety, skin problems fatigue and impairment of understanding in the oral communication and speaking louder. However, in the case of wearing the mask less than 4 hours a day (like the substitute teachers), the only report was skin problems. The type of the face mask and the number of hours wearing them had influence in the impairment of understanding in the oral communication; FFP being the best one.

Regarding speech intelligibility, articulation index and sound quality parameters, it was found that the distance between students and teacher is an important factor in terms of loudness, articulation index and speech intelligibility, these being better when the distance is shortest. A strong correlation was found between the type of face mask and the results of articulation index and speech intelligibility. The students and teachers were better understanding when they wore FFP face masks. Also, this type of the face mask helped to understand better to children with hearing impairment.

To conclude, our analysis suggests that both surgical or FFP face masks could be the best options to be used in the different levels of education.

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REFERENCIAS

Ribeiro, V.V., A.P. Dassie-Leite, E.C. Pereira, A.D.N. Santos, P. Martins, and R. de Alencar Irineu, Effect of wearing a face mask on vocal self-perception during a pandemic. *Journal of Voice*, 2020.

- [1] Yi, H., A. Pingsterhaus, and W. Song, Effects of wearing face masks while using different speaking styles in noise on speech intelligibility during the COVID-19 pandemic. *Frontiers in psychology*, 12, 2021.