IMPACT OF CORONAVIRUS FACE MASKS ON THE PERCEPTUAL EVALUATION OF HEARING PROTECTORS COMFORT

Olivier Valentin [*1,2,3], **Philippe-Aubert Gauthier** [†2,3], **and Alain Berry** [‡1,2]
[1]Groupe d'Acoustique de l'Université de Sherbrooke, Université de Sherbrooke, Sherbrooke, Quebec, Canada
[2]Centre for interdisciplinary research in music media and technology (CIRMMT), Montreal, Quebec, Canada
[3]École des arts visuels et médiatiques, Université du Québec à Montréal, Montreal, Quebec, Canada

1 Introduction

Conducting research activities involving human participants during the COVID-19 pandemic raised new ethical and practical challenges. When most research activities requiring presence in labs resumed, human research requiring close contact had to comply with COVID-19 health and safety requirements, given the risks associated with potential direct and/or airborne transmission between and among researchers and participants. Therefore, wearing a procedure mask or a N95 mask and adhering to mitigation measures quickly became the new standards to observe. Embracing this new ways of conducting research raised questions among the research community, especially in social and behavioral sciences where scientists start to wonder if wearing a face mask could influence the research being conducted.

Prior to the COVID-19 outbreak, laboratory evaluations of earplugs comfort were conducted at the *Groupe d'Acoustique de l'Université de Sherbrooke*, as part of a multidisciplinary and multi-centric research project on the perceived comfort of hearing protectors. The new mitigation measures shed a new light on this project when it resumed : could the discomfort, annoyance or pain induced by the ear-loop elastics around the auricle interact with the multi-dimensional comfort of earplugs ?

In the absence of sufficient conclusive evidence in the literature, we decided to compare the earplugs' comfort evaluations obtained before (i.e., without mask) and after (i.e., with mask) the implementation of mitigation measures to control the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), in an attempt to conclude to the question "Does wearing a face mask influence the earplugs' comfort evaluation ?". Responses to subjective questionnaires on earplugs' comfort were used to assess the influence of wearing a face mask on the physical, functional, acoustical, and psychological dimension of the earplugs' comfort. Additionally, Personal Attenuation Ratings (PAR) and results from speech in noise tests and alarm detection tests were used to complement the subjective comfort assessments.

2 Material and Method

2.1 Participants

Twenty-three individuals (seventeen males, six females) aged between 22 and 32 and having hearing thresholds below 25 dB HL (pure tone audiometry between 125 to 8000 Hz) participated in this research work. All participants were inexperienced regarding hearing protectors. 3M Classic earplugs were tested by 23 participants (13 without mask, 10 with mask), 3M UltraFit by 23 participants (12 without mask and 11 with mask), and the 3M Push-ins by 20 participants (9 without mask and 11 with mask). The experimental protocol was reviewed and approved by the *Comité d'éthique pour la recherche Lettres et Sciences Humaines*, one of the Internal review Boards at *Université de Sherbrooke* in Sherbrooke, Canada (approval no. 2019-1929). Informed consent was obtained from all participants before they were enrolled in the project.

2.2 Hearing Protectors and Face Masks

The earplugs used by the participants were either roll-down foam earplugs (3M™ E-A-R Classic), premolded earplugs (3M™ E-A-R UltraFit), or push-to-fit earplugs, which are an alternative between the roll-down foam and the premolded earplugs (3M™ E-A-R Push-ins). They were worn in an order randomly chosen prior to the measurement sessions.

The face mask worn by the participants was a single-use procedure mask from AMD-Ritmed®. These pleated style mask with ear-loops meet the current ASTM F2100 standard for "Level 2 Barrier" medical face mask [1] and were provided by *Université de Sherbrooke* for all in-person activities, including research projects involving human participants.

2.3 Sound Environments

Spatial sound synthesis was used to generate the two virtual industrial sound environments that served as background noise during all laboratory measurement sessions. These virtual industrial environments were generated using multichannel Acoustic Background Spectrum (ABS) Synthesis [2] inspired from Tarzia's work [3] on acoustic fingerprints, multichannel uncorrelated noises, and *in-situ* recordings collected at two industrial sites (a granulator and a stacker).

2.4 Subjective Questionnaires

A questionnaire was completed before and after each series of speech in noise and alarm detection tests performed by the participant, using a touchscreen computer monitor. These "Comfort Assessment" questionnaires aimed to evaluate the attributes of the main components of comfort (physical, acoustical, functional, and psychological) as well as comfort as a whole. They are derived from the French version of the COPROD questionnaire [4] which was designed to evaluate the multidimensional aspects of comfort [5, 6].

∗. m.olivier.valentin@gmail.com
†. gauthier.philippe-aubert@uqam.ca
‡. Alain.Berry@usherbrooke.ca

2.5 Speech in Noise Tests

The Speech Perception in Noise Tests were conducted using the *Test de Phrases dans le Bruit* described in [7]. Stimuli consisted of sentences pronounced in French, randomly picked-up from a database of 324 sentences. Each sentence contained a subject, a verb and a color to be identified by the participants from a list displayed on the touchscreen monitor placed in front of them. For example, if the stimulus was *Les amis cherchent des ballons jaunes* ("Friends are looking for yellow balloons") the correct answers to pick using the touchscreen monitor were *Les amis* ("Friends") for the subject, *cherchent* ("are looking") for the verb and *jaune* ("yellow") for the color. The presentation order of the sentences was randomized across participants. The stimulation levels were calibrated at the position of the participants to 62.4, 68.3, 74.9, and 82.3 dB(SPL), which correspond respectively to the level of normal, raised, loud and shouted voice as defined in ANSI S3.5 1997 [8]. A total of sixty (4 stimulation levels $\times$ 15 repetitions) stimuli were presented to the participants using a supplementary M-Audio speaker Studiophile DX4 placed in frontal incidence for the purpose of this task. The two virtual industrial sound environments used as background noise were calibrated at 90.9 dB(SPL) and 93.0 dB(SPL).

2.6 Alarm Detection Tests

The signal used for the alarm detection tests was a tonal gateway alarm captured at an industrial workstation using an Edirol R09 portable recorder with a FG-23652 condenser microphone (Knowles Electronics). Background noise was removed from the recording using Reaper v6.02 and the plugin "ReaFir." Each alarm detection test included a total of fifty alarms (5 signal-to-noise ratios $\times$ 10 repetitions) with a duration of 10 seconds each. The alarms were presented at five different signal-to-noise ratios (SNRs) (-10, -5, 0, +5, +10 dB) using a Motorola piezo supertweeter CTS KSN-1188. Each SNR was computed relatively to the background noise SPL measured at the center of the test room. The interval between consecutive alarm signals was randomly set between five and ten seconds.

3 Results and Discussion

Prior to being able to move forward on our research question about the perceived comfort of earplugs, it was mandatory to determine whether the earplugs' comfort evaluations performed with a face mask can be aggregated with those obtained without a face mask to avoid introducing a bias due to a potential effect induced by wearing a face mask. Wilcoxon unpaired tests revealed no significant difference between the mask condition and the no mask conditions, with the PAR values and the alarm detection results. No significant difference was found using the speech in noise results, except with the condition "3M™ Classic with shouted voice and the environment #1". Additionally, Fisher exact tests showed no significant difference for 990 of the 993 items of the questionnaires-based evaluations and the observed differences for the three remaining questionnaires' items remain marginal (p-values very close to 0.05). Therefore, as we failed to find significant statistical differences between the condition with mask and without mask, data can be regrouped in a larger data-set.

4 Conclusion

Wearing a face mask does not influence the perceptual evaluation of hearing protectors comfort. Therefore, we think that the most common face masks should not influence the way people use and wear earplugs.

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References

[1] American Society for Testing and Materials. Standard specification for performance of materials used in medical face masks, 2021. ASTM F2100-21.

[2] O. Valentin, P.-A. Gauthier, A. Berry, and F. Proulx. Objective evaluation of sound environment reproduction for comfort of hearing protector devices : Acoustic background spectrum synthesis versus multichannel cross-synthesis. In *Proceedings of Forum Acusticum 2020, Lyon, France*, pages 1–6, 2020.

[3] Stephen P. Tarzia, Peter A. Dinda, Robert P. Dick, and Gokhan Memik. Indoor localization without infrastructure using the acoustic background spectrum. In *Proceedings of the 9th International Conference on Mobile Systems, Applications, and Services, Bethesda, MD, USA*, pages 155–168, 2011.

[4] J. Terroir, N. Perrin, P. Wild, O. Doutres, F. Sgarf, C. Gauvin, and A. Negrini. Assessing the comfort of earplugs : development and validation of the french version of the coprod questionnaire, 2021. Ergonomics, available at : https ://doi.org/10.1080/00140139.2021.1880027.

[5] J. Terroir, O. Doutres, and F. Sgard. Towards a "global" definition of the comfort of earplugs. In *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, pages 108–114, 2017.

[6] O. Doutres, F. Sgard, J. Terroir, N. Perrin, C. Jolly, C. Gauvin, and A. Negrini. A critical review of the literature on comfort of hearing protection devices : definition of comfort and identification of its main attributes for earplug types. *International Journal of Audiology*, 58(12) :824–833, 2019.

[7] Josée Lagacé, Benoît Jutras, Christian Giguère, and Jean-Pierre Gagné. Development of the "test de phrases dans le bruit" (TPB). *Revue canadienne d'orthophonie et d'audiologie*, 34(4) :261–270, 2010.

[8] Caslav Pavlovic. SII—Speech intelligibility index standard : ANSI S3.5 1997. *The Journal of the Acoustical Society of America*, 143(3) :1906–1906, 1997.