

IMPACT OF FACE MASKS ON ACOUSTIC PARAMETERS FOR FORENSIC SPEAKER RECOGNITION IN THE ARMENIAN LANGUAGE

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The present study investigated how two types of face masks affected seven acoustic parameters, commonly used in forensic speaker recognition, in the Armenian language, complementing a previous work focused on several other languages [1]. The dataset is part of the Forensic Multilingual Voices Database (FMVD), developed under the “Competency, Education, Research, Testing, Accreditation, and Innovation in Forensic Science” (CERTAIN-FORS) project, funded by the European Union (EU) and coordinated by the European Network of Forensic Science Institutes (ENFSI). The results showed no effect of the face masks on the studied acoustic parameters, contrary to the results previously obtained for most other languages. Therefore, more samples in the Armenian language must be collected to better assess the impact of protective masks on acoustic parameters.

Keywords: forensic speaker recognition, face mask, acoustic-phonetic approach, FMVD.

Introduction

Acoustic research on speech with and without face masks has obtained a lot of attention from the field of phonetics and automatic systems for speaker recognition.

The present study aims to analyze the impact of face masks on seven acoustic parameters in Armenian language, namely: F_0 , difference between 1st and 2nd harmonics (H_1-H_2), intensity, speech rate, HNR, jitter, shimmer, as they are some of the most used in acoustic-phonetic

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approach for speaker recognition [1-6], complementing a previous work focused in several other languages [7]. Both studies make use of the Forensic Multilingual Voices Database (FMVD), developed under the “Competency, Education, Research, Testing, Accreditation, and Innovation in Forensic Science” (CERTAIN-FORS) project, funded by the European Union (EU) and coordinated by European Network of Forensic Science Institutes (ENFSI) [8].

Related work

In last years, attention has been given to the impact of face masks in acoustics parameters, primarily during and after the covid-19 pandemic [3, 9-23].

Making use of the FMVD dataset, Saraiva *et al.* [1] evaluated the impact of face masks on acoustic parameters used in acoustic-phonetic approach for speaker recognition. Seven acoustic parameters were chosen to be studied: F_0 , difference between 1st and 2nd harmonics (H_1-H_2), intensity, speech rate, HNR, jitter, shimmer; as they are the most used in forensic speaker recognition [2-7].

The FMVD was developed with the collaboration of several Forensic Institutes, members of the ENFSI Forensic Speech and Audio Analysis Working Group (FSAAWG), representing nine countries: Lithuania (LT), Croatia (HR), Romania (RO), Türkiye (TR), Ukraine (UA), Portugal (PT), Georgia (KA), Hungary (HU), Spain (ES), and Armenia (AM).

All samples were collected from volunteers who signed an informed consent statement designed for the development and distribution of the FMVD among ENFSI FSAAWG members. Each person was recorded reading a selected text without a mask (NM), wearing a surgical mask (SU), and wearing an FFP2 mask (FP). A small number of samples in Russian (RU), Polish (PL), and German (DE) languages were also recorded, given the existence of native speakers in the collaborating Forensic Institutes.

Samples from mobile (MB) communications in Lithuanian, Croatian, Portuguese and Spanish, and landline (LL) communications in Lithuanian, Polish and Russian were also collected, however, in some cases in a small number.

The project provided the masks and the text, controlling as possible the sampling process. An excerpt from “The Little Prince,” written by Antoine de Saint-Exupéry, was selected, avoiding translation issues once this book is already translated in almost every language.

Since it was found that the requirements for carrying out an analysis of variance (ANOVA) were not satisfied, namely the normality of the residuals, for each language and sex, a linear mixed effects model was applied to analyse statistical differences on the above parameters between with and without each face mask type, using subjects as a random factor. A similar approach was used by Geng *et al.* [3]. Statistical analysis was conducted using Minitab Statistical Software (version 21.4.2). Given their reduced size, subsets with less than 10 samples were left out of the presenting study, namely voice samples in German and Polish languages; Spanish, Croatian, and Lithuanian mobile recordings; and landline communications in Russian.

The results showed that F_0 , H_1-H_2 , intensity, speech rate, HNR, jitter, and shimmer were

affected by the presence of face masks, denoting different behaviours depending on mask type, sex, language and recording channel. An increase in F_0 , particularly in males, was observed in the presence of face masks of both types. Also, an overall increase in HNR was detected, as was an increase in intensity, more evident when wearing FFP2 masks. A decrease was denoted in shimmer value, as well as in speech rate, for which females wearing SU masks were more affected. The effect of face masks on H_1-H_2 was characterize by an increase of its value for males and a decrease for female speakers. Jitter was the less affected parameter, still denoting changes in the presence of FFP2 masks in both genders.

These findings support that, in the presence of face masks, which act as a low pass acoustic filter, speakers tend to perform phonetic and acoustic adjustments to compensate for the filter effect, trying to improve speech intelligibility [3, 24-26].

The results for recordings via mobile communications show that F_0 , HNR, and shimmer were affected in a similar way to the samples collected with a microphone or recorder. On the other hand, intensity was more affected by the presence of masks in mobile recordings; speech rate decreased in mobile communications and increased in microphone recordings; jitter was significantly affected in mobile communications when in microphone recordings a small impact was observed; and the impact on H_1-H_2 revealed a different behaviour from the one observed in microphone recordings, increasing its value for females, and decreasing for male speakers. These comparisons were only possible for Spanish and Portuguese voice recordings.

When comparing the obtained results for landline and microphone or recorder samples, different responses were also observed. Only F_0 and intensity were significantly affected in landline communications, while in samples recorded with a microphone or recorder, only jitter and shimmer showed no significant impact in the presence of protective masks. These comparisons were only possible for Lithuanian voice recordings.

Materials and Methods

The Armenian voice samples were recorded in WAV format, mono signal, resolution of 16 bits, with a sample rate of 44.1 kHz, indoors, and approximately 2.5 minutes long.

Table 1 shows the distribution of the 39 Armenian volunteers' speakers.

Table 1.

Armenian volunteers' speakers recorded with microphone or recorder by age and sex.

| Age classes | [18 – 30] | | [31 – 40] | | [41 – 50] | | [51 - +∞) | | Total |
|---------------|-----------|--------|-----------|--------|-----------|--------|-----------|--------|-------|
| | Male | Female | Male | Female | Male | Female | Male | Female | |
| AM - Armenian | 2 | 9 | 7 | 10 | 1 | 5 | 1 | 4 | 39 |

Recordings were pre-processed using a Matlab tool developed for removing silences from voice samples according to a background noise threshold. The computation of the seven chosen acoustic parameters was performed using Praat (version 6.3.06).

Statistical analysis was conducted using Minitab Statistical Software (version 21.4.2). Since it

was found that the requirements for carrying out an analysis of variance (ANOVA) were not satisfied, namely the normality of the residuals, a linear mixed effects model was applied to analyse statistical differences on the above parameters between with and without each face mask type, using subjects as a random factor. A similar approach was used by Geng et al. [24].

Results

The computed results for average and standard error values of the seven acoustic parameters obtained from the samples collected in the Armenian language, by sex and mask type, are presented in Figures 1 and 2.

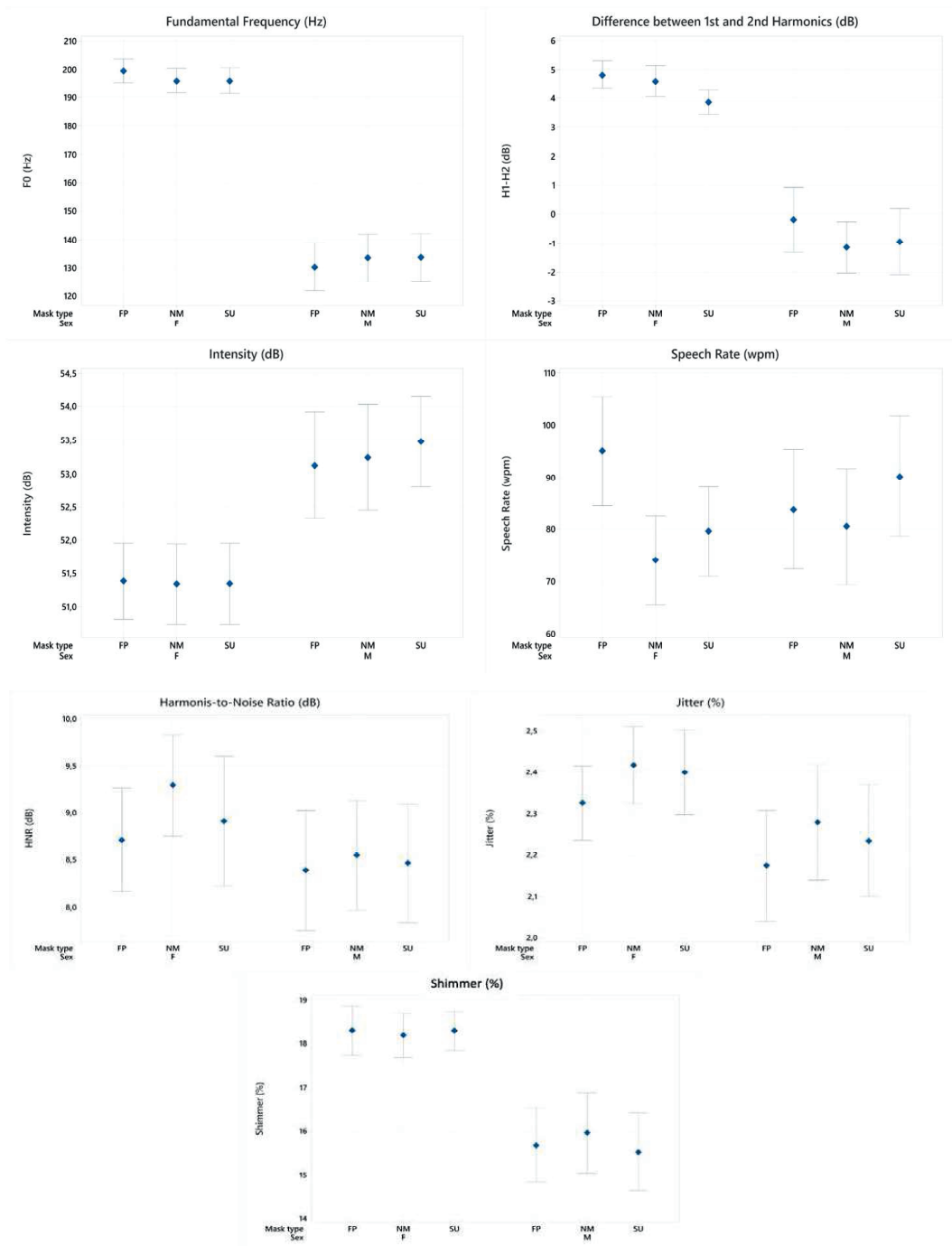


Figure 1. Average and standard error values of F_0 , H_1-H_2 , intensity, and speech rate without a mask (NM), wearing a surgical mask (SU), and wearing a FFP2 type mask (FP), by sex.

Table 2 summarizes the results of the linear mixed effects model on the acoustic parameters, by sex and mask type.

Table 2.

Results of the mixed effect models on the acoustic parameters obtained from the samples collected with no mask (NM) vs. surgical mask (SU) and no mask (NM) vs. FFP2 type mask as independent variables. The asterisks indicate the level of statistical significance:

*** $p < 0,05$; ** $p < 0.01$; *** $p < 0.001$.**

| | | Linear mixed-effect models results on the acoustic parameters | | | | | | | |
|---------------|-----|---|----------------|--------------------------------|-----------|-------------|------|--------|---------|
| Language | Sex | Mask type | F ₀ | H ₁ -H ₂ | Intensity | Speech rate | HNR | Jitter | Shimmer |
| AM - Armenian | F | NM vs SU | 0.00 | 3.34 | 0.00 | 0.23 | 0.26 | 0.04 | 0.08 |
| | | NM vs FP | 2.07 | 0.23 | 0.08 | 2.40 | 0.74 | 1.16 | 0.07 |
| | M | NM vs SU | 0.05 | 0.13 | 1.33 | 0.38 | 0.06 | 0.48 | 2.40 |
| | | NM vs FP | 4.11 | 2.13 | 0.14 | 0.04 | 0.10 | 0.94 | 0.52 |

Discussion and conclusions

This study aims to investigate the impact of two types of protection masks on seven acoustic parameters used in the acoustic-phonetic approach for forensic speaker recognition by sex in the Arminian language.

The results did not reveal any effect of protective masks on all the acoustic parameters evaluated, contrary to the results previously obtained for most other languages [1]. Therefore, more samples in the Armenian language must be collected to better assess the impact of protective masks on acoustic parameters.

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ВЛИЯНИЕ ЗАЩИТНЫХ МАСОК НА АКУСТИЧЕСКИЕ ПАРАМЕТРЫ СУДЕБНОЙ ИДЕНТИФИКАЦИИ ГОВОРЯЩЕГО НА АРМЯНСКОМ ЯЗЫКЕ

Сарайва А., Фейеш А., Девенсон Ж., Кочарян В.

В статье анализируется влияние медицинских защитных масок на ключевые акустические параметры, используемые в практике судебной идентификации говорящего на армянском языке. Исследование сосредоточено на сравнительном оценивании двух распространённых типов защитных масок и их воздействии на семь акустических параметров, традиционно применяемых в акустико-фонетическом подходе к идентификации личности по голосу.

Работа представляет собой логическое продолжение серии ранее выполненных исследований, посвящённых изучению аналогичного явления в отношении нескольких языков стран Европейского союза. Используемый речевой материал является частью Многоязычной Судебной Голосовой Базы Данных (Forensic Multilingual Voices Database, FMVD), созданной в рамках проекта «Компетенции, Образование, Исследования, Тестирование, Аккредитация и Инновации в Судебно-экспертной Науке» (CERTAIN-FORS), финансируемого Европейским Союзом и координируемого Европейской Сетью Институтов Судебной Экспертизы (ENFSI).

Предварительный анализ полученных данных показал отсутствие статистически значимого влияния защитных масок на исследуемые акустические параметры армянской речи, что контрастирует с ранее опубликованными результатами по другим языкам, демонстрирующими различимые изменения акустической структуры речи при ношении масок. Этот факт подчёркивает необходимость дальнейшего расширения выборки носителей армянского языка и углубления эмпирической базы для более четкого определения возможных масочных эффектов.

Ключевые слова: *судебная идентификация говорящего, защитная маска, акустико-фонетический анализ, судебная фонетика.*

**ՊԱՇՏՊԱՆԻՉ ԴԻՄԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ՁԱՅՆԱՅԻՆ
ԱԿՈՒՍՏԻԿ ՊԱՐԱՄԵՏՐԵՐԻ ՎՐԱ՝
ՀԱՅԵՐԵՆ ԼԵԶՎՈՎ ԽՈՍՈՂԻ ԴԱՏԱԿԱՆ ՆՈՒՅՆԱԿԱՆԱՑՄԱՆ
ԳՈՐԾԸՆԹԱՑՈՒՄ**

Սարայվա Ա., Ֆեդես Ա., Դևենսոն Ջ., Քոչարյան Վ.

Հոդվածում վերլուծվում է բժշկական պաշտպանիչ դիմակների ազդեցությունը հայերեն լեզվով խոսողի դատական նույնականացման գործընթացում կիրառվող հիմնական ակուստիկ պարամետրերի վրա: Հետազոտությունը կենտրոնացած է պաշտպանիչ դիմակների երկու տարածված տեսակների համեմատական գնահատման և դրանց յոթ ակուստիկ պարամետրերի հանդեպ փոխազդեցության վրա, որոնք ավանդաբար կիրառվում են անձի ծայնով նույնականացման ակուստիկ-ֆոնետիկական մոտեցման շրջանակներում:

Աշխատանքը տրամաբանական շարունակությունն է նախորդ հետազոտությունների շարքի, որոնք նվիրված էին Եվրոպական միության մի շարք լեզուների դեպքում նույնատիպ երևույթի ուսումնասիրմանը: Օգտագործվող խոսքային նյութը Բազմալեզու Դատական Ձայնային Տվյալների Հավաքածուի (Forensic Multilingual Voices Database, FMVD) մաս է, որը ստեղծվել է «Հմտությունները, կրթությունը, հետազոտությունը, թեստավորումը, հավաքարմագրումը և նորարարությունները դատափորձագիտության մեջ» (CERTAIN-FORS) նախագծի շրջանակներում, այն ֆինանսավորվում է Եվրոպական միության կողմից և համակարգվում Եվրոպական Դատափորձագիտական Ինստիտուտների Ցանցի (ENFSI) կողմից:

Ստացված տվյալների նախնական վերլուծությունը ցույց է տվել, որ պաշտպանիչ դիմակները վիճակագրորեն նշանակալի ազդեցություն չունեն հայերեն խոսքի ուսումնասիրված ակուստիկ պարամետրերի վրա: Սա հակադրվում է այլ լեզուների վերաբերյալ նախկինում հրապարակված արդյունքներին, որոնք ցույց էին տվել դիմակների կրելու դեպքում խոսքի ակուստիկ կառուցվածքի տարբերելի փոփոխություններ: Նշված հանգամանքն ընդգծում է հայերեն լեզվի կրողների ընտրանքի հետագա ընդլայնման և էմպիրիկ բազայի խորացման անհրաժեշտությունը՝ պաշտպանիչ դիմակների հնարավոր փոխազդեցությունների ավելի ճշգրիտ որոշման համար:

Բանալի բառեր. խոսողի դատական նույնականացում, պաշտպանիչ դիմակ, ակուստիկ-ֆոնետիկական վերլուծություն, FMVD, դատական ֆոնետիկա, CERTAIN-FORS:

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