# The Adaption to Online Synchronous Teaching and Voice Fatigue: Acoustic and Clinical Data

[*]Karina Evgrafova, PhD, [†]Natalia Sokolova, PhD, and [‡]Nikolay Shvalev, *†‡*Russia*

**Abstract:** At the onset of the COVID-19 pandemic in 2020, educators around the world suddenly shifted to online teaching.' In 2021, we presented research on the impact of this new professional reality on the vocal load of Saint Petersburg State University professors. The online synchronous teaching caused the significant increase in the vocal fatigue in university professors in comparison with the prepandemic studies. We continued our study during the postpandemic semester (winter-spring 2022). The goal of this study was to find out whether adaptation mechanisms during the pandemic period were developed to adjust to the different types of teaching modes. The acoustic and clinical data from the pre/post comparative study are now presented.

**Key Words:** Vocal fatigue−Teacher's voice−Voice load−Online synchronous teaching−COVID-19 pandemic.

## INTRODUCTION

Vocal fatigue in voice professionals has been studied intensely for decades,[6-8] especially regarding symptoms and risk factors. It is particularly self-reported by teachers as a sense of increased vocal effort and a sensation of laryngeal and pharyngeal constriction. The clinical analysis performed through laryngoscopy can detect symptoms associated with vocal disorders. Besides, vocal fatigue is also shown in tonal range, dynamic range, vocal quality, intensity and fundamental frequency changes. The acoustical aspect of the phenomenon allows its objective evaluating in terms of degree and dynamics.

We performed the acoustic, auditory, and clinical analysis of vocal fatigue symptoms in the professors of Saint Petersburg State university (pronunciation teachers and lecturers) in a number of previous studies in the COVID-19 prepandemic years.[3-5] Due to the COVID-19 pandemic, there was a dramatic change in the work mode of all voice professionals. In 2020, university professors around the world had to shift to online teaching.[1,9,10] In 2021 we presented the research on the impact of this new professional reality on the vocal load of Saint Petersburg University professors. The online synchronous teaching caused the significant increase in the vocal fatigue in university professors in comparison with the prepandemic studies.

We continued our study during the postpandemic semester (winter-spring 2022). During that period our participants either returned to classroom teaching or switched to hybrid mode of teaching (consisting of a mixture of distant and classroom activities). The goal of this study was to find out whether adaptation mechanisms during the pandemic period were developed to adjust to the different types of teaching mode.

Accepted for publication February 22, 2023.

From the *Phonetics Department, Saint Petersburg State University, Russia; †Department of English Philology and Cultural Linguistics, Saint Petersburg State University, Russia; and the ‡Saint Petersburg State Pediatric Medical University, Russia.

Address correspondence and reprint requests to Karina Evgrafova, Apt. 67, 11-2, Industrialny prospect, 195426, Saint Petersurg Russia. E-mail addresses: spbpmu@yandex.ru, evgrafova@phonetics.pu.ru

Journal of Voice, Vol. ■■, No. ■■, pp. ■■−■■
0892-1997



https://doi.org/10.1016/j.jvoice.2023.02.029

## METHODOLOGY

We followed the protocol used in our *pre-pandemic* and *pandemic* vocal fatigue studies[2,11] in terms of general experimental design, tasks and recording material. Although there were several unavoidable differences concerning the set of subjects and recording conditions.

In the prepandemic studies[11] 20 male and female subjects were recorded. We involved pronunciation teachers employed at the department of Phonetics (Saint Petersburg University) with average work experience of 7 years, professional speakers (broadcasters) and tour guides with the work experience not less than 5 years. The recordings were made in the recording studio at the Department of Phonetics, Saint-Petersburg State University. Multichannel recording system Motu Traveler, capacitomicrophone AKG and WaveLab program were used. The recordings had a sample rate of 44100 Hz and a bitrate of 16 bits.

By contrast, in pandemic and postpandemic studies 10 female teachers currently employed at the Department of Phonetics and the Department of English Philology and Cultural studies were engaged. They were involved in different types of teaching activities (i.e., lecturing on linguistics; English teachers running practical classes, and pronunciation coaches). The minimum workload a day was 3 hours while the maximum was 6 hours.

The absence of gender diversity among the subjects was caused by the fact that the teaching staff of the departments were predominantly female at the time of pandemic and postpandemic studies.

Due to Covid-19 restrictions, we could not arrange experimental recordings at the studio. The subjects recorded themselves *before* and *after* classroom/online synchronous teaching using their mobile phones. However, the reliability of acoustic voice parameters obtained using smart phone microphones is evaluated a number of relevant studies. It is shown than measures obtained from voice recordings using regular microphones in a sound-proof room and smartphone microphones have no statistically significant difference.[12] In order to obtain reliable acoustic data for subsequent acoustic analysis, the participants were provided with a set of recording guidelines. All the participants were instructed to hold their mobile phones 15−30 cm away from

the mouth during the recording. The recordings (before/after) had to be done in the *same* room using the *same* devices locating the phones at the *same* distance (15−30 cm) from the mouth without head-mounted microphones and top filters. All the devices in the room were to be turned to silent modes. The recommendations were aimed at preserving the acoustic accuracy of the data.

In all types of our studies (prepandemic/pandemic/postpandemic) participants did not report any chronic voice pathologies at the moment of the experiment. All of them had been previously undergoing regular laryngeal exams.

The tasks performed by the subjects did not differ across the studies either. The educators read a 4 minute phonetically representative text in Russian. They were asked to read at habitual loudness a 4 minute phonetically representative text in Russian before classes in the morning. After continuous classroom/online teaching during the working day they were asked to record the same text.

We used the *WAM* questionnaire to evaluate psychoemotional state of the teachers before and after their work. *WAM* (wellbeing, activity, mood) is used to assess the mental state of patients and healthy people, their psychoemotional response to loading.[13,14] The WAM questionnaire has the form of the scale with indices (3 2 1 0 1 2 3) and 30 pairs of words with opposite meaning (rested-tired, well-unwell, optimistic- pessimistic). The participants needed to circle one digit on the scale which best corresponded to their emotional state at that moment. The questionnaire was to be filled out twice on the day of the experiment: before and after teaching workload. Moreover, each participant wrote a detailed report describing self-perception of voice, mood, physical condition, type of voice activity, working conditions, and platforms used for on-line synchronous teaching. Each of the scales has an average score of four. When the score exceeds four points the state of well-being, activity, mood is defined as favorable. For normal state assessments, a range of 5.0−5.5 points is typical.

Besides, the participants had the laryngoscopy of vocal cords done regularly during the period of 2021−2022 (min. once a year).

## RESULTS

Thus, we obtained acoustic data (*objective evaluation*), self-reports (*subjective evaluation*), and laryngoscopy results (*clinical evaluation*) which showed the impact of different types of teaching mode on vocal fatigue.

### Results of acoustic analysis

We calculated a number of acoustic parameters which had been significant for detecting voice fatigue in our previous studies (mean F0, vowel duration and laryngealization) in nonfatigued (NF) and fatigued (F) speech samples. The values of the parameters in prepandemic, pandemic and postpandemic recordings are presented in Table 1, Table 2, and Table 3 below.

**TABLE 1.**
**F0 mean Values in Prepandemic Data**

| Prepandemic Data | | Mean F0 (Hz) |
|---|---|---|
| Female | Nonfatigued | 209 |
| | Fatigued | 212 |
| Male | Nonfatigued | 124 |
| | Fatigued | 130 |
| All subjects (average) | Nonfatigued | **185** |
| | Fatigued | **188** |

Nonfatigued voice vs. fatigued voice (male and female).

**TABLE 2.**
**F0 Mean Values in Pandemic Data**

| Pandemic Data | | Mean F0 (Hz) |
|---|---|---|
| All subjects Female (average) | Nonfatigued | **239** |
| | Fatigued | **251** |

Nonfatigued voice vs. fatigued voice (female).

F0 tends to be higher in the fatigued speech across all types of the recordings. However, the postpandemic values are closer to the prepandemic ones. The vowel duration increase in the fatigued speech is still noticeable, although it decreased in the postpandemic period. Laryngealization which is marked by significant decrease in pitch value and pitch breaks is associated with a creaky voice quality. The symptom was frequently reported by the teachers during the

**TABLE 3.**
**F0 Mean Values in Postpandemic Data**

| Postpandemic data | | Mean F0 (Hz) |
|---|---|---|
| Subject 1 | Nonfatigued | 201 |
| | Fatigued | 205 |
| Subject 2 | Nonfatigued | 216 |
| | Fatigued | 219 |
| Subject 3 | Nonfatigued | 198 |
| | Fatigued | 203 |
| Subject 4 | Nonfatigued | 224 |
| | Fatigued | 227 |
| Subject 5 | Nonfatigued | 197 |
| | Fatigued | 201 |
| Subject 6 | Nonfatigued | 234 |
| | Fatigued | 241 |
| Subject 7 | Nonfatigued | 258 |
| | Fatigued | 262 |
| Subject 8 | Nonfatigued | 231 |
| | Fatigued | 235 |
| Subject 9 | Nonfatigued | 224 |
| | Fatigued | 227 |
| Subject 10 | Nonfatigued | 193 |
| | Fatigued | 197 |
| All subjects (average) | Nonfatigued | **217** |
| | Fatigued | **222** |

Nonfatigued voice vs. fatigued voice (female).

self-assessment of voice quality. The mean duration of laryngealized speech segments is the longest during the pandemic and also reduced in the postpandemic period.

### Results of clinical analysis

The research subjects in their self-reports revealed the following complaints: muscular tension/discomfort in the neck, general tiredness, hoarse voice quality, creaky/fry voice, breathy voice, unsteady pitch, dry/scratchy throat, frequent throat clearing, sore throat, dry cough, psychological stress. We believe that vocal overload, inadequate posture and continuous talking while sitting, lack of auditory and visual feedback/ student interaction, technical problems, online connection failures lead to psychological stress and difficulties in voice production.

In such working conditions (online synchronous teaching) the clinical picture showed hypotonic dysphonia (decrease in the density of closure of the true vocal folds, linear, and oval fissure of glottis in all parts of the range, visibility of the ventricles of the larynx, absence of stroboscopic comfort). We believe that this condition was caused by excess voice use and the necessity to use remote microphones (Figure 1).

All these factors lead to forced manner of voice production (vocal fry/creaky voice). Stress, asthenia, and general decrease of physical activity (as the results of COVID-19 isolation) proved to be the triggering factors of the hypotonic dysphonia development. Fast vocal fatigue and overall lack of energy are often subjective manifestations of MTD.[15-19]

During the research we observed one severe case of overfatigue which resulted in the prenodule condition of vocal cords (Figure 2).

As a consequence of such vocal overloading, the educators often suffer from dysphonia and benign lesions such as nodules.[20-23] This condition without proper treatment and/or change in voice workload might potentially lead to the development of soft/hard nodules and subsequently require surgical treatment. The relief in voice fatigue came with both developing adaptation mechanisms and partly switching to in-class teaching in postpandemic.

### Results of subjective evaluation (WAM tests)

The WAM questionnaires showed that in all types of the studies *before* and *after* the workload *Wellbeing* scale exceeded 4 points, which indicated a favorable state of the subjects (Tables 5, 6, 7). However, on average, the *after* self-assessment showed decreased wellbeing index, but it did not fall out of the range of 4.0 points (whereas the maximum is seven). The results of the WAM questionnaire according to the *Activity* scale *before* and *after* the workload in all the types of studies also exceeded four points, which indicated a

**FIGURE 1.** Hypotonic dysphonia.

**FIGURE 2.** Prenodule condition of vocal cords.

**TABLE 4.**
**Vowel Duration Increase and the Percentage of Laryngealized Segments in Nonfatigued/Fatigued Voice (Prepandemic, Pandemic, and Postpandemic Data)**

| | Prepandemic | Pandemic | Postpandemic |
|---|---|---|---|
| | Vowel duration increase, ms | | |
| F | 4.3 | 7.2 | 5.2 |
| | Laryngealization, % | | |
| NF | 1.5 | 1.8 | 1.4 |
| F | 1.2 | 2.3 | 1.9 |

**TABLE 5.**
**The Mean Rates of WAM Test (Prepandemic Data)**

| Before | After |
|---|---|
| Wellbeing | |
| 5.9 (min. 5.3–max. 5.8) | 5.8 (min. 5.2–max .6.1) |
| Activity | |
| 4.8 (min. 4.1–max. 6.5) | 5.5 (min. 5.1–max. 6.2) |
| Mood | |
| 6.0 (min. 4.3–max. 6.7) | 6.3 (min. 5.9–max. 6.7) |

**TABLE 6.**
**The Mean Rates of WAM Test (Pandemic Data)**

| Before | After |
|---|---|
| Wellbeing | |
| 5.5 (min. 4.3–max. 5.8) | 4.3 (min. 4–max.5.1) |
| Activity | |
| 4.3 (min. 4.1–max. 5.5) | 5.4 (min. 4.1–max. 6.1) |
| Mood | |
| 5.0 (min. 4.3–max. 5.2) | 5.3 (min. 4.9–max. 6.3) |

**TABLE 7.**
**The Mean Rates of WAM Test (Postpandemic Data)**

| Before | After |
|---|---|
| Wellbeing | |
| 5.8 (min. 4.9–max. 6.7) | 5.5 (min. 5.0–max. 5.9) |
| Activity | |
| 4.7 (min. 4.2–max. 6.2) | 5.8 (min. 5.2–max. 6.5) |
| Mood | |
| 5.9 (min. 4.5–max. 6.2) | 6.1 (min. 4.9–max. 6.3) |

favorable state. The *Mood* rates increased *after* the workload. In total, the results of prepandemic and postpandemic tests look similar, whereas well-being, activity and mood rates are significantly lower in pandemic data (Table 4). These results are compliant with the complaints in the self-reports presented in the pandemic period.

## DISCUSSION AND CONCLUSION

Although the vocal quality improved as well as the clinical picture, neither the postpandemic voice nor the laryngoscopic data yet resemble the prepandemic data. The return to the regular working environment (with the absence of the necessity of the microphone use and visible audience follow-up and reaction) has had a positive effect on the vocal functions and reduced possible pathological changes in the larynx.

The results of the postpandemic data (hybrid mode of teaching) revealed that the educators managed to adapt specific voice strategies which resulted in voice fatigue reduction. The research subjects were able to avoid chronic vocal fatigue and strain reducing rate of speech, increasing vocal pauses in connected speech, and increasing the use of crisp diction, rather than increasing loudness.

We believe that the research results can contribute to the development of guidelines concerning new teacher's voice-use routine (hybrid mode of teaching) by voice pathologists and skilled speech-language clinicians. They may include special sets of vocal exercises and strategies to avoid voice overstraining by slowing the pace, making frequent pauses, putting an emphasis on diction and consonants rather on the loudness. The further studies in the field can suggest testing more subjects including males, identifying critical threshold of vocal fatigue based on acoustic analysis, investigating whether physiologic and/or neurologic fatigue (e.g, induced sleep deprivation, physical exercise, etc.) leads to the same effects on the acoustic signal, comparing acoustic manifestations of vocal and nonvocal fatigue.

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