Influence of the Body Position and Emission Number in the Results of the Maximum Phonation Times of Adults without Vocal Complaints

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Abstract: Objective. To analyze if there is an influence of the body position and emission number in the results of the maximum phonation times (MPT) of adults without vocal complaints.

Materials and methods. This is an observational, analytical and cross-sectional study. Sixty subjects participated: 30 men and 30 women without vocal complaints. Subjects were instructed to stay in orthostatic or sitting position, according to the collection's order that was selected. The first 30 subjects were evaluated in order number 1 (sitting and orthostatic) and the other 30 subjects were evaluated in order number 2 (orthostatic and sitting), with a 5-minute interval between the emissions in the two positions. The MPT of vowels /a/, /i/, /u/, fricatives /s/ and /z/, and numbers were collected. After this, the subjects were instructed to do the same emissions mentioned above, but in another position (orthostatic or sitting). The values of MPT were statistically analyzed with both the Analysis of Variance (ANOVA) paired measures test to three criteria and the Tukey Test ($P < 0.05$).

Results. There was no difference between the MPT obtained in both positions. Males had all MPT higher than females. Regarding the emission number, there were differences for both sexes in the MPT of the vowel /a/ and the number counting.

Conclusion. In general, it is concluded that there is no influence of body position in the results of voice temporal measures, but the sex and the number of the emissions influence the result of the MPT.

Key Words: Aerodynamic measurement−Evaluation−Maximum phonation times−Phonation−Voice.

INTRODUCTION

The maximum phonation time (MPT) is one of the most-used techniques for vocal evaluation in clinical practice due to practicality, speed and low cost, and it is considered to be an aerodynamic measurement.[1−6] Due to its various applications, it is commonly used as the basis for other qualitative and quantitative assessments.[1] In addition, MPT is a complementary analysis for purposes of diagnosis, follow-up, and therapeutic evolution.[3,4,6−9]

The purpose of the evaluation of MPT is to quantify the relationship between the muscular and mucoundulatory action of the vocal folds and lung airflow, reflecting physical and emotional conditions. The measurement of MPT is aimed at verifying the patient's ability to control the pulmonary aerodynamic forces and the larynx myoelastic forces.[5,10,11] Current studies report that the variability in MPT seems to be driven by variations in the volume of air used for the task and lies mainly in laryngeal efficiency, also suggesting an influence of the frequency and intensity of the voice in the emission.[2]

The MPT corresponds to the maximum interval of time that the individual is able to sustain a sound in a prolonged expiration.[2,3] This measure includes the vowels /a/, /i/ and /u/ and voiceless and voiced fricatives /s/ and /z/, in addition to the number counting task.[1,11] In order to collect MPT, it is necessary to ask the patient to take a deep inspiration and vocalize the requested sounds as long as he/she can in a single expiration.[1,2,4,11,12] For each sample, the emission time is quantified by means of a chronometer or audio recorder.[4,12]

The phonemes /s/ and /z/ have different sonority; one is voiceless and one is voiced. In phonemes such as /s/, there is resistance to air, but not to the point of opening vibratory cycles. Since there is no vocal fold vibration, voiceless emissions are used to analyze respiratory control. In phonemes such as /z/, the vocal fold is closed at the time of expiration and opens in vibratory cycles in phonation.[1,11,13,14] Due to the vibration of the vocal folds generated by this type of phoneme, the voiced emissions are used to verify the interaction between respiratory level and glottal efficiency. Thus, the extraction of /s/ and /z/ and its ratio has the objective of verifying if there is a glottic air leak or a glottic hyperconstriction during phonation.[1]

To obtain the s/z ratio, the division of the MPT of /s/ by the MPT of /z/ is performed. The results of the extraction of /s/ and /z/ have the objective of evaluating the glottic efficiency from the sustained emission of these phonemes in a single expiration.[1,14]

There are several variations found in the studies involving MPT, mainly regarding the methodology used to obtain this

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measure.[2,3] This means that the question of how to obtain a reliable MPT has not yet been fully elucidated.[2,8] Two common divergences in the studies refer to the emission number and the body position used in the collection.

Regarding the emission number, there are many variations in the recommendations found in the literature. Most studies suggest that three samples of each phoneme should be extracted,[1,5,15–17] but some have considered the highest MPT,[5,15–17] while others recommend that the average obtained between them be considered.[1] A study that tested 15 consecutive emissions corroborated this orientation when it was verified that from the third emission, the individuals reached the maximum duration of phonation.[18] Another study that proposed to analyze intrasubject reliability showed that the second sample seems to be up to 2 seconds longer than the first and third, but the analysis showed a strong correlation between the three samples, which made the authors suggest the use of several trials and not just a single attempt.[2] However, there are also controversies regarding the number of collections.

A study that tested the reliability of the measure inferred that there is good agreement between five consecutive trials, however, that the collection on three consecutive days improves agreement.[3] Research that tested ten emissions suggested stable data from the fourth issue.[19] However, several authors counteract the realization of many emissions due to the presence of fatigue that occurs in front of a large number of consecutive samples.[15,19]

Regarding the body position used during the extraction of the MPF in the studies found in the literature, it is possible to observe variability in the recommendations using the orthostatic[1,16,20] and sitting[2,4,5,13,17] positions. The lack of consensus about the procedure and the nonstandardization of the body position during the collection of MPT can generate variation in the result of this extraction and consequently lead to a misinterpretation of the result.

Considering the above, it is necessary to provide evidence to support vocal clinical practice regarding the different body positions as well as the emission number required to obtain a reliable MPT.

Thus, the clinical question that supported the development of the present study was: In adults without vocal complaints, is there a difference in the results of the MPT due to body position and emission number? The hypotheses of the present study were: H0—there is no difference in the results of the MPT of adults without vocal complaints according to body position and emission number, and H1—there is difference in the results of the MPT of adults without vocal complaints as a function of body position and emission number.

The objective of this study was to analyze the influence of body position and emission number on the results of MPT of adults without vocal complaints.

MATERIALS AND METHODS

This is an observational, analytical, cross-sectional and prospective study. The research was carried out after the approval of the Institutional Research Ethics Committee under report number 1.213.297.

The sample size was calculated based on a pilot study. For this, five subjects from each collection order were collected. The largest standard deviation of the difference between the means of all MPT, which was 3.37 seconds for the MPT of the vowel /a/, was considered as an estimate of variability. Adopting a significance level of 5% and the power test of 80% to detect a minimum difference between the collection orders equal to a standard deviation, the sample size required was ten participants in each collection order.

The study was carried out in a Clinic-School of Speech Therapy. Members of the local community were recruited to participate. For the selection of participants, inclusion and exclusion criteria were established. Inclusion criteria were: adult individuals (aged between 18 and 45 years), both sexes, without vocal complaints and with adherence to the informed consent form. Exclusion criteria were: reports of symptoms or vocal and laryngeal alterations, respiratory problems, smoking, neurological diseases or difficulty in understanding the tasks to be performed. In the assessment for eligibility, by applying the selection criteria of the sample, the participants responded to a questionnaire prepared by researchers that addressed the topics of identification, occupation, voice complaints, and health data. In the included participants, some questionnaire data were used to characterize the sample.

In this way, 60 subjects aged between 18 and 30 years participated in the study: 30 female (average age 22.03 $\pm$ 2.85 years) and 30 male (average age 22.56 $\pm$ 2.93 years).

The collection was performed in cross-over to avoid the possibility that the collection order of body positions generated methodological biases such as: a decrease in MPT in the second position performed due to vocal fatigue after some emissions or an increase of MPT in the second position performed due to vocal warm-up or learning. Because it was a diagnostic test and not a rehabilitation analysis, it was decided to carry out a 5-minute wash-out. A simple randomization was performed in blocks to form the collection orders, with each one composed of 30 participants.

Thus, the first 15 participants of each sex performed in collection order 1, and the next 15 of each sex performed in collection order 2. The order of positions used for the collection was: Collection Order 1 was 15 male subjects and 15 female (average age 22.4 $\pm$ 2.91 years) who performed the procedures in the sitting and orthostatic orders; Collection Order 2 was 15 male subjects and 15 female subjects (average age 22.2 $\pm$ 2.89 years) who performed the procedures in the orthostatic and sitting orders. There were no differences between the ages according to sex and the collection order of the participants ($P = 0.580$, $P = 0.910$, respectively—Student's t test).

MPT collection was performed individually and lasted about 30 minutes: the participants were instructed to vocalize, for the maximum time that they could sustain, the vowels /a/, /i/, /u/ and the fricatives /s/ and /z/ as well as number

TABLE 1.
Analysis of the Maximum Phonation Time of the Vowel /a/ in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P*-value	Tukey Test
Male	Sitting	16.31	5.09	17.05	6.61	17.83	6.70	17.06	5.86	Sex	<0.001	Male > Female
										BP	0.869	
	Orthostatic	18.16	7.40	17.12	6.15	16.32	5.55	17.17	5.85	BP x Sex	0.760	
										EN	0.779	
	Sitting	13.60	4.52	14.89	4.96	14.29	4.28	14.27	4.45	EN x Sex	0.378	
Female										EN x BP	<0.001	Third sitting emission > First sitting emission
	Orthostatic	13.74	3.77	13.74	4.35	14.00	4.13	13.83	3.90	EN x Sex x BP	0.013*	First orthostatic male emission > Third orthostatic male emission

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

counting in sequence. Each sample was collected three times, and the average of the three emissions was taken for analysis. Each individual performed the sequence twice, one in a sitting position and the other in orthostatic, according to the pre-established collection order in the randomization process.

The extractions were timed by means of a Casio HS-3V-1R digital stopwatch (Casio India Co., Pvt. Ltd, India). Times were obtained in seconds and milliseconds.

The subjects were instructed to start the emission when they wanted; the researcher pressed the stopwatch as soon as the emission began. The interruption of the time counting occurred only at the end of the emission, and the times continued to be marked even in the face of changes in vocal emission, such as decrease in loudness and use of reserve air.[1]

For the orthostatic position, the subject was instructed to stand, arms loose along the body, and chin parallel to the ground. For the sitting position, they were instructed to sit in a chair with their legs bent at a 90° angle, feet on the floor, and chin parallel to the floor.

The normality of the variables was analyzed using the Shapiro-Wilk Test. For data analysis, the ANOVA test of paired measures and the Tukey test were used. A significance level of 5% was considered for all tests. The software used for statistical analysis was the Statistica 17.0 (Stat Soft Inc., Tulsa, Oklahoma).

RESULTS

Table 1 shows that there was a statistically significant difference: as a function of sex; at the intersection between emission number and body position and at the intersection of emission number, body position, and sex in the analysis of the MPT of the vowel /a/. Males had higher MPT than females, regardless of body position and emission number. The third emission of the MPT of the vowel /a/ in the sitting position showed higher values to the first emission in the same position independently of the subject's sex. The first emission in the orthostatic position for males showed greater results than the third emission with the same body position and sex.

It was observed that for the MPT of the vowel /i/ (Table 2) and /u/ (Table 3), there were only sex differences. Male presented higher MPT than female for both vowels, regardless of body position and emission number.

It was possible to see in Table 4 that there was a statistically significant difference in the MPT of the fricative /s/ as a function of sex and at the intersection between the emission number and sex. Males presented higher MPT than females regardless of body position and emission number. The third male emission was significantly higher than both the first male emission and the average emissions for the female sex.

For fricative /z/ MPT, statistically significant results were observed only by sex (Table 5). Males presented higher MPT than females, regardless of body position and emission number.

Table 6 shows that there was a difference in the results as a function of the sex and the emission number in the MPT of the number counting. Males presented higher MPT than females, regardless of body position and emission number. The first issue showed results lower than the

TABLE 2.
Analysis of the Maximum Phonation Time of the Vowel /i/ in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P*-value	Tukey Test
Male	Sitting	19.11	5.94	18,48	5.92	18.68	7.03	18.72	6.05	Sex	0.004*	Male > Female
										BP	0.870	
	Orthostatic	19.49	7.98	20.26	7.92	19.25	8.11	19.67	7.68	BP x Sex	0.526	
										EN	0.987	
	Sitting	15.92	5.53	15.93	5.92	16.49	6.25	16.11	5.69	EN x Sex	0.161	
Female										EN x BP	0.526	
	Orthostatic	15.55	5.35	15.28	5.22	15.85	5.97	15.61	5.54	EN x Sex x BP	0.296	

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

TABLE 3.
Analysis of the Maximum Phonation Time of the Vowel /u/ in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P* value	Tukey Test
Male	Sitting	18.71	7.08	19.04	7.00	19.38	7.20	19.27	7.05	Sex	0.004*	Male > Female
										BP	0.998	
	Orthostatic	18.59	7.36	18.83	7.31	19.21	8.27	19.09	7.32	BP x Sex	0.887	
										EN	0.155	
	Sitting	15.73	5.72	15.02	4.98	15.85	5.28	15.53	5.07	EN x Sex	0.691	
Female										EN x BP	0.575	
	Orthostatic	15.05	5.52	15.20	5.36	15.65	5.64	16.88	5.22	EN x Sex x BP	0.540	

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

TABLE 4.
Analysis of the Maximum Phonation Time of the Fricative /s/ in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P* value	Tukey Test
Male	Sitting	19.76	9.10	20.14	8.47	20.97	9.22	20.28	8.59	Sex	0.005*	Male > Female
										BP	0.589	
	Orthostatic	19.75	9.34	19.63	9.99	20.58	10.95	19.98	9.83	BP x Sex	0.727	
										EN	0.795	
	Sitting	16.71	8.78	16.56	8.33	15.83	9.12	16.36	8.60	EN x Sex	0.011*	Third male emission > First and average female emissions
Female										EN x BP	0.976	
	Orthostatic	14.88	8.20	15.18	7.37	14.76	8.15	14.94	7.78	EN x Sex x BP	0.704	

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

TABLE 5.
Analysis of the Maximum Phonation Time of the Fricative /z/ in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P* value	Tukey Test
Male	Sitting	19.86	8.02	19.77	7.92	19.89	8.22	19.82	7.74	Sex	<0.002	Male > Female
										BP	0.697	
	Orthostatic	19.62	7.82	19.63	9.10	19.44	8.20	19.56	8.19	BP x Sex	0.857	
										EN	0.783	
	Sitting	16.16	7.35	16.51	6.40	15.57	6.21	16.08	6.43	EN x Sex	0.901	
Female										EN x BP	0.768	
	Orthostatic	15.55	6.55	15.04	5.85	15.34	6.11	15.41	5.95	EN x Sex x BP	0.431	

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

second, third and average emissions, regardless of sex and body position.

As for Table 7, it was observed that there was no difference in the s/z ratio values as a function of body position, emission number, and sex.

DISCUSSION

Regarding sex, the males presented higher results than the females for all samples of MPT collected. Such data were expected due to anatomical and physiological differences between the sexes, in addition to greater respiratory support in males.[1,6]

As for the normality patterns of this acoustic measure for native speakers of Brazilian Portuguese, there are several proposals, but the most used in clinical practice standardizes minimum values of 14 seconds for adult females and 20 seconds for adult males.[1] If the MPT is less than 10 seconds in adults, pneumophonoarticulation and/or air leakage may be suspected due to lack of neuromuscular control.[1] Likewise, if values are higher than expected for sex, they may reflect the use of reserve air, hyperadduction or glottal obstruction during phonation.[1]

In the present study for females only a few vowel /a/ MPT emissions did not reach the recommendation of 14 seconds.[1] If the highest value of MPT among the three emissions is considered, women achieve the expected values for all MPT analyzed in both body positions. If the normality parameter is the average, for the MPT of the vowel /a/ in the orthostatic position, the average value of the participants in the present study was lower than the recommended value, although it was close.

For males, several emissions did not reach what is recommended in the literature, which is 20 seconds.[1] If we considered the highest emission among the three collections, for the vowels /a/ and /u/, the fricative /z/ in both positions and vowel /i/ in the sitting position, the values were lower than normal. Considering the average between

TABLE 6.
Analysis of the Maximum Phonation Time of the Number Counting in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P* value	Tukey Test
Male	Sitting	19.90	7.92	20.93	7.49	21.35	8.51	20.86	7.66	Sex	0.006*	Male > Female
										BP	0.568	
	Orthostatic	19.67	6.97	20.67	7.61	20.74	6.38	20.38	6.76	BP x Sex	0.819	
										EN	<0.001*	First emission < Second, third and average emissions
	Sitting	17.40	5.41	17.94	5.43	18.12	6.39	17.93	5.51	EN x Sex	0.702	
Female										EN x BP	0.910	
	Orthostatic	16.43	4.76	17.22	5.42	17.11	5.36	16.92	4.87	EN x Sex x BP	0.986	

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

TABLE 7.
Analysis of the s/z Ratio in Adults without Vocal Complaints, According to Body Position, Emission Number and Sex

		EN										
		First		Second		Third		Mean emissions				
Sex	BP	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Effect	*P* value	Tukey Test
Male	Sitting	1.01	0.27	1.04	0.25	1.05	0.21	1.02	0.19	Sex	0.384	
										BP	0.506	
	Orthostatic	1.02	0.29	1.03	0.31	1.04	0.27	1.02	0.24	BP x Sex	0.584	
										EN	0.880	
	Sitting	1.06	0.33	1.00	0.27	1.01	0.32	1.01	0.26	EN x Sex	0.335	
Female										EN x BP	0.859	
	Orthostatic	0.98	0.31	1.00	0.20	0.95	0.22	0.96	0.19	EN x Sex x BP	0.650	

Abbreviations: BP, body position; EN, emission number; SD, standard deviation.
*$P < 0.05$—ANOVA of paired measures to three criteria and Tukey Test.

the emissions, for the vowels /a/, /i/ and /u/ e for the fricative /z/ in both positions in addition to the fricative /s/ in the orthostatic position, males also did not reach the recommended values.

Regarding the emissions number, it was observed that there were differences for both sexes in the MPT of the vowel /a/ and the numbers counting. The third emission of the MPT of the vowel /a/ in the sitting position showed higher values than the first emission in the same position, independent of sex. For the same emission, only in males, there was a difference in the orthostatic position in that the first emission showed results superior to the third. Already, for number counting, the first emission had MPT higher than the second, third and average emissions, regardless of sex and body position.

This data shows the importance of collecting three emissions, as guided by some authors.[1,2,5,15,18] However, there was no difference between the MPT of the highest emission and the average emissions. Thus, it is inferred that the collection of the three emissions is important, but the form of analysis by the highest MPT or by the average of the three emissions seems to show similar data.

Thus, the results of the studies whose authors suggest that three samples of each phoneme should be extracted and that the largest MPT[5,15,17] should be considered and of other studies whose authors argue that the average obtained between them[15,21] should be considered seems to be comparable. However, the extraction of the measure on several consecutive days,[3] besides representing a clinical difficulty, seems not necessary.

Nevertheless, if the descriptive analysis of the normal values is resumed, it is observed that when the highest MPT between the three emissions is used, there is more chance of obtaining a value within normality. However, in spite of having a lower frequency of obtaining values within the range recommended by the literature, the average value was also very close and without statistical relevance.

It is believed that the main reasons that may have influenced the results and different inferences among the studies about the quantity of emissions are related to heterogeneity in the methodological characteristics. Among them, we can mention: the sample size, most of the time without sample size calculation; some characteristics of the selected population for the study as age, trained or untrained voices, normal or dysphonic voice, as well as the presence or absence and type of laryngeal pathology, since they can influence both the time of vocal fatigue and the improvement of performance either through learning or vocal warm up with the increase in the number of performances; methodological characteristics of data collection such as the fact that the participant knows the task previously, receive a model or instructions before execution, can also influence the results obtained.[18] However, the most heterogeneous factor among the studies refers to the form of data analysis. There were studies that analyzed the data by correlation, concordance/reliability and by comparison. Corroborating this inference, a study that analyzed the correlation and the comparison between the duration of MPT showed a good correlation calculated by the interclass correlation coefficient, but the duration was variable when calculated by repeated measures ANOVA.[2] Several are the tests that can be used to analyze paired measures and calculate if there were changes, as well as to measure the extent of change in the scores of these measures. Moreover, the guideline for interpreting the results adopted by the authors can also influence the inferences.[22] Authors mention that the only analysis that seems to be inadequate is by correlation, since it is possible to obtain low agreement even in the presence of correlation.[22] The heterogeneity in the cited characteristics can lead the authors to obtain different results, and makes it difficult to compare the results.

Regarding body position, the results of the present study indicate that, in general, there was no difference between the MPT results for the samples collected in the sitting and orthostatic positions. Thus, there seems to be no interference of the body position in the result of the extraction of the MPT.

According to the literature, in some studies, the subjects were advised to remain sitting in a comfortable

position,[2,4,5,13,17] and others oriented the subjects to stay in an orthostatic position.[1,16,20] According to the data obtained in the present research, there seems to be, from a clinical point of view, no single position which allows the measurement to be properly extracted.

Authors who previously analyzed the body position reported differences as a function of it but did not report the specific positions or make recommendations at the time of data collection,[3] which made it impossible to compare their findings to those of the present study. They were not found other studies that have analyzed this variable. The results of the present study indicate that there is no problem in requesting the subject's preference position. It is possible that this is a good alternative, that is, being in the most comfortable position can help in the execution of the task without influencing the results obtained. However, it is believed that the position chosen by the subject must be standardized for all the extractions performed (pre- and post-therapeutic process, pre- and postexecution of a certain technique and in scientific research).

There was no difference in the function of any analysis criterion for the s/z ratio alone. Regarding the descriptive analysis, the literature recommends that the result of the s/z ratio obtain an approximate value of 1.0 regardless of sex, which indicates a match between the voiceless and voiced phoneme.[1,13,14] Values below 0.8 are indicative of cases of laryngeal hyperconstriction, and values equal to or greater than 1.2 may suggest a lack of glottal coaptation to phonation, a lack of laryngeal control over the air passage or vocal pathology.[21] In the present study, for both sexes, in both positions and in all the samples obtained, the values were within the recommended one.

The present study presented limitations on the absence of laryngological exams in patients, due to the nonrecommendation of the Institutional Research Ethics Committee to perform invasive procedures in subjects without vocal complaints. Further studies are suggested to verify if there is influence on vocal use and the position that the subject evaluates as being the most comfortable for the extraction of the MPT.

CONCLUSION

From the results obtained, it was possible to conclude that, in general, there was no influence of body position on the results of the temporal measures of the voice, with similar values obtained both in the orthostatic and sitting positions. However, collecting three emissions of each phoneme seemed to be important so that one can consider the highest value or the average among the three values obtained.

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