DEVELOPING A SETUP FOR DETERMINING PROPULSION EFFECTS OF TURKISH VOWELS

Türkçe Ünlülerin İtki Etkilerinin Saptanmasına Yönelik Bir Düzenek Geliştirilmesi

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Öz: *Ünlülerinin sesletimiyle oluşan hava akımının basınç etkisini görünür/ölçülebilir kılan yeni bir yöntem geliştirmek için planlanan çalışmamızda; bir erkek denek, ultrasonik soğuk buhar makinası ve yeşil lazer işaretleyici ile hazırlanan deney ortamında Çağdaş Türkiye Türkçesi (ÇTT)'nin sekiz ünlüsünü (a, e, ı, i o, ö, u, ü) üretmiş ve lazer ışının ssoğuk su buharı ortamındaki hareketi cep telefonuyla kaydedilip itilme mesafesi, süresi, gecikmesi ve hızı incelenmiştir. Sonuçlar ünlüler arasındaki farkların tutarlığını göstermiş; /a/ ve /i/ en az (<10cm), /u/ ve /ü/ ise en fazla (15cm<) itilme oluşturmuştur. İtilme mesafesi; sesletim süresi, Jitter, Shimmer ve Harmonik Gürültü Oranı (HNR) ile ilişkili olup tek açıklayıcı değişkeni olarak HNR bulunmuştur. Bulgularımız, literatüre uyumlu olarak, alt ve üst dudağın öne uzatılmasıyla üretilen yuvarlak ünlülerin daha fazla hava akımı yarattığını göstermektedir. Deney dizaynının geliştirilmesi ile hem ÇTT'nin solunum yolu hastalıklarında parçacık yayma derecesine yönelik çalışmalar yapılabilecek hem de konuşmanın parça ve parçalarüstü özelliklerinin akustik tanımlanmasında yeni değişkenler elde edilmiş olacaktır.*

Anahtar Kelimeler: *Çağdaş Türkiye Türkçesi; konuşma; konuşma akustiği, ses, COVID-19, aerosoller*

Abstract: *In our study, it was aimed to develop a novel method that makes the pressure effect of the airflow created by the articulation of vowels visible/measurable. In order to determine the effect, a male subject produced eight vowels in Contemporary Turkey Turkish (CTT) (a, e, ı, i, o, ö, u, ü) into the combined setting of cool mist and green laser and the movement of the laser beam was recorded with a mobile phone to examine the propulsion distance, duration, delay and speed. The results revealed the consistency of differences between vowels; /a/ and /i/ produced the least (<10cm), /u/ and /ü/ produced the highest (15cm <) propulsion. Push distance; pronouncing duration is related to Jitter, Shimmer and HNR, and HNR was found as the only explanatory variable. The distance of propulsion is related to the duration of phonation, Jitter, Shimmer and Harmonic Noise Ratio (HNR), and HNR was found as the only explanatory variable. Our findings demonstrate that, following the literature, round vowels produced by elongating the lower and upper lip forward could create more airflow. With the development of this experimental design, it will be possible to work on the degree of particle emission in CTT respiratory tract diseases and to obtain new variables in the acoustic description of the segmental and suprasegmental features of speech.*

Keywords: *Contemporary Turkey Turkish; speech; speech acoustics, voice; COVID-19, aerosols*

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INTRODUCTION

Speech, a unique feature of human mind, is one of the fundamental characteristics of human civilization. It could be noted that speech is probably the most critical human ability playing a role in the socio-cultural development of human beings. It is produced as a very complex physiological process from the cortex of the brain to the tips of lips and carries very complex messages, including intentions,thoughts and feelings, that cause intense individual and socio-cultural effects. Therefore, speech is a common subject of all science disciplines, including physics, medicine and literature.

Technically, the generated speech signal coming out from the upper airway mostly through the mouth and partially through the nose is a very well organized and controlled pressure wave produced within the respiratory system of human beings, plus it is mostly an expiratory activity. Therefore, it carries not only sound signals but also the particles, droplets from both the upper and lower respiratory tract. This feature of the speech has been very popular due to the COVID-19 pandemic, which has been a significant issue throughout the world since the end of 2019. As it has been known that Sars-Cov-2 viruses are mainly transmitted by the respiratory droplets from the infected person to the others, using masks and keeping social distances, have emerged into our daily lives as major preventive issues (World Health Organization, WHO. 2020, Chen et al. Shereen et al. 2020, Sağlık Bakanlığı 2020, Anfinrud et al. 2020; Meselson et al. 2020, Rubin et al. 2020).

Respiratory droplets are produced not only during coughing or sneezing in the symptomatic patients but also breathing and talking of the asymptomatic cases running within the regular stream of life (Morawska et al. 2009, Johnson GR & Morawska et al. 2009, Chao et al. 2009, Johnson et al. 2011; Mubareka et al. 2019, Asadi et al. 2020a). It has been documented that droplets with an initial size larger than about 50 μm rapidly fall to the ground while smaller droplets shrink in size and remain airborne as aerosols for minutes (Asadi et al. 202a, Netz et al 2020). The studies demonstrated that speech is an important source for droplet emission because it produces droplets smaller than 1 μm, hanging in the air longer time depending on the background airstream, and further, smaller droplets easily escape from nasal filtration and go into the deeper parts of the respiratory system (Morawska et al 2009, Anfinrud et al. 2020, Chao et al. 2009, Johnson et al. 2011; Mubareka et al. 2019, Asadi et al. 2020a, Netz et al. 202, Inouye 2003, Inouye ve Sugihara 2015). Netz et al. (2020) revealed that physical analysis strongly supported the concept that speaking can be a major mechanism of SARS-Cov-2 transmission.

It has been shown that more droplets are generated via louder speech and speech sounds at a higher frequency (asadi et al. 2019). Furthermore, Asadi et al. (2020b) put forward vowels, nasals, and plosives, subsequently disperse more droplets than others, and fricatives were found to be the least responsible for expiratory droplet emission.

The previous researchers mainly presented the data about the amount and size of the droplets produced during various breathing modes, coughing, sneezing, and talking. However, the velocity of droplet spreading and its projection distance from the mouth and nose during the expiratory activities were less attracted the attention of the researchers. Geoghegan et al. (2017) reported peak air velocities for blowing (6 to 64 m/s), spitting (1 to 64 m/s), and coughing (1 to 47 m/s) by using a hot wire anemometry. They documented that droplets reached 500 mm far away from the mouth in the vertical line during coughing (maximum was 1100 mm). Chao et al. (2009), who applied the particle image velocimetry technique with a laser and CCD camera for measurement of the velocity of the particles, presented that the average velocities of the particles emitted during coughing and speech were 11,7 m/s and 3,9m/s, respectively. In the study of Inouye and Sugihara (2015), polypropylene funnel connected to a differential pressure transducer for measurement of the wind pressure during the speech, and wind pressure was directly measured as Pascal, and they calculated an index of “strong puff total". Inouye and Sugihara (2015) documented that wind pressure of the airflow near the mouth was weaker for the Japanese language compared to English and Chinese and suggested that it could be the reason for less spread of SARS in Japan.

No data about projection distance of the droplets or droplet spreading velocity were available for phonemes.

Very recently, just after the outbreak of COVID-19 pandemic, Anfinrud et al. (2020) presented an interesting simple experiment by using green laser light which was dispersed just in front of the mouth and the male speaker said “*stay healthy*” in the dark, and it was clearly seen that the droplets coming out from the mouth became visible as dispersing green flashes in the darkness It was apparent that when they repeated the phrase louder and stressed “*th*” at the end of the pattern, the amount of the green flashes increased. When the researcher wore a mask and repeated the same phrase, it was obviously revealed that the mask prevented the emission of the droplets.

As it is known, ultrasonic humidifiers vibrating at ultrasonic frequency range, create mist (cool fog) composed of water droplets. Particle size and particle concentration are related to the amount of dissolving solids within the water and the hardness of water (Sain et al. 2018). It is a fact that mist makes green laser beams visible (Craig et al. 2017). Hence we considered a simple research model to reveal the pressure effect produced by the air stream during articulation of the vowels. Through this experiment, it could be possible to present a method to demonstrate the amount of the distance in front of the mouth, which could be under the effect of pressure related to the airflow produced during the utterance of vowels.

Experimental Design and Test Method

All test items used in this study were bought by delivery service after ordering from the online shopping markets during COVID-19 pandemic while staying at home. The items needed in this study were as follows: A green laser (LaserScope brand, 532 nM, 300 W, made in China), protective glasses (Geo Fennel brand, red, made in Germany), a mini ultrasonic humidifier (Wollex Brand, made in China, size: 8x8x11,2 cm, volume 180 ml; 2W, 500 MA), a digital hygrometer-thermometer (Gomax brand, SGL 10 model, made in China), a digital TDSmeter (total dissolving solid meter; Knmaster brand, TS-300 model, made in Turkey), bottled drinking water (including natrium: 2,66 mg/l, aluminium < 2ugr/l, ammonium < 0,03 mg/l, ferrum <1 ugr/l, manganese < 1 ugr/l, sulphate: 3,69 mg/l; chlorine: 0,8 mg/lt; pH: 7,76; conductivity: 54,6 uS/cm), a smartphone (Samsung brand, Galaxy 8 model, Made in South Korea) for video recording (FHD, 1920 x 1280 res.), and 3 mm thick black cardboard.

For the experiment, a box was prepared by using black cardboards. One side was open for the speaker, and there was a window for the smart-phone camera on the right side of the speaker. Then, the green laser was fixed on a tripod and placed under the chin. The ultrasonic humidifier was set up just 2,5 cm in front of the subject. The left wall of the black cardboard was marked with 10 cm scales starting from the center position of the mist emitted from the ultrasonic humidifier. Total dissolving solids (TDS) content of water was measured within a cup before filling the humidifier, and the hygrometer was placed 10 cm above the humidifier to measure the humidity before starting the experiment (Figure 1).

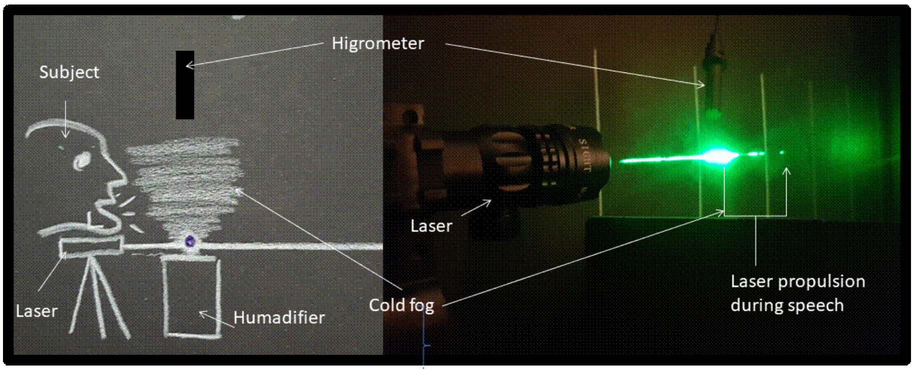

Figure 1*. The experimental setup.*

The male speaker (the first author of the study, 49 years of age; previously published vowel quadrangle of the subject was previously presented (Kemaloglu et al, 2020) uttered 8 vowels of the contemporary Turkey Turkish (CTT) in order of "a, e, ı, i, o, ö, u, ü" (with the phonetic symbols of International Phonetic Alphabet (IPA): /a, e, ɯ, i, o, œ, u, y/). The subject articulated all of the vowels three times in two separate sections during the nights of the subsequent two days. The experiments and recordings were performed after midnight within the most silent room at home, and the recordings were then stored in the hard disk of a personal computer.

All study procedures were approved by the clinical research ethics board in the University (2020/381) and were performed in accordance with the ethical standards of the institutional research committees and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

MEASUREMENTS

Ultimately, 6 video recordings, including subsequent utterances of 8 vowels, were taken to the analysis. First, by using a video edit program, recordings for each vowel were evaluated to find out the maximum movement of green laser light during each utterance. The frame in which the farthest point (p) of the laser beam from the center (c) of the beam just over the column of the mist (Figure 2) was detected for each utterance was print-screened and saved in jpeg format.

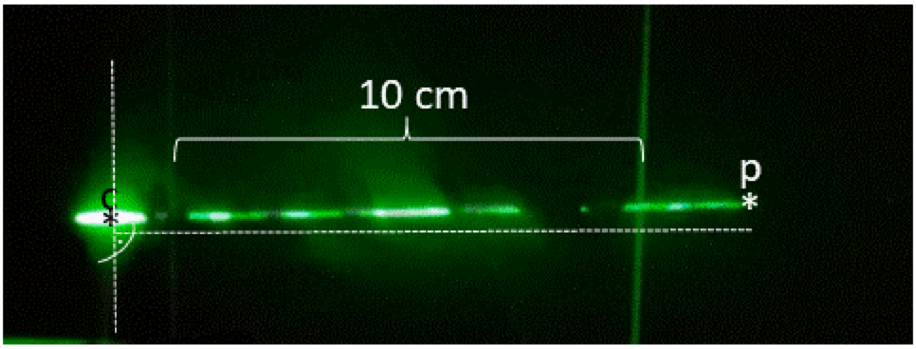

***Figure 2**. Propulsion distance (p-c) (c: center of the air fog; p: the farthest point of of the laser beam during the utterance of the vowel).*

The duration of this frame was noted as D3. Subsequently, the first frame in which the utterance started was labeled as D1, and the first frame in which propulsion of the green laser beam started after utterance was noted as D2. The propulsion duration was calculated as D3-D2, and the latency duration of the propulsion was calculated as D2-D1.

By using ImageJ (1.53a, Wayne Rasband, National Institute of Health, USA, http://imagej.nih.gov/ij) the 48 jpeg files of the captured frames were analyzed to measure propulsion distance ([c-p]). Before the measurement of [c-p] distance, first "analyze-set scale" function of the software was used to define scales between the first and second vertical lines as 10 cm. Furthermore, in addition to measurement of [c-p], the distance between the first and second vertical lines at their crossing points (z1 and z2) with the line through "c-p" were remeasured; then, by using these measurements, the following simple equation was run, and the real (corrected) [c-p] distance (propulsion distance) was calculated for each jpeg file: corrected [c-p] = 10 x [z1-z2] / measured [c-p].

The velocity of propulsion (m/s) was calculated by dividing propulsion distance ([c-p], meter) to propulsion duration (D3-D2; seconds).

Then, wav files of each recording were extracted from the video recordings and by using Praat (version 5.3.57) (Boersma ve Weenink 2013), the acoustic analysis was performed for the voice variables. First, the total duration of the utterance was found and then the intensity setting was adjusted to 70 - 100 dB, and the following measurements were performed on the selected frame of utterance above 70 dB: the utterance duration >70dB, amplitude, fundamental frequency (pitch), Jitter (local, %), Jitter (local-absolute, sec), Jitter (rap, %), Jitter (ppq5, %), Jitter (ddp, %); Shimmer (local, %), Shimmer (local, dB) and Harmonics to Noise Ratio (HNR, dB).

Furthermore, the amount of TDS (ppm) in water-filled in the ultrasonic humidifier was measured by the TDS meter, and amount of humidity (%) and temperature (^{o}C) were measured by the hygrometer just before the experiment.

By using SPSS (15.0 for Windows), descriptive data for each vowel was found, and vowels were classified according to the propulsion distance. Then, first, correlations of all variables related to the propulsion of the laser beam (propulsion distance, propulsion duration, propulsion latency duration, and propulsion velocity) with the acoustic variables were analyzed. Secondly, linear stepwise regression analyses were separately run for all of the parameters related to the propulsion of the laser beam (dependent variable) by entering the correlated acoustic variables as independent variables.

RESULTS

The experiments were completed as planned in two sections (the first section: recordings 1,2, 3, and the second section: recordings 4, 5, 6) without any unhandled exception. During the sections, the amount of TDS and temperature of the water used and the amount of humidity were 0,36 ppm, 28,0 ^{o}C, and 64%, respectively.

Totally 48 frames were analyzed for the measurement of propulsion distance ([c-p], cm) by ImageJ, and 48 wav files were evaluated for voice variables by Praat. Further, propulsion duration (msec) and propulsion latency (msec) were measured according to the number of frames detected with the help of video editing software.

It was observed that propulsion of the green laser beam started after a latency period (mean propulsion latency: 281,08 +/- 125,09 msec). Means of propulsion distance and propulsion duration were 11,27 +/- 5,22 cm and 596,0 +/- 216,34 msec, respectively. Mean of propulsion velocity was found to be 0,19 +/- 0,07 m/sec. Propulsion distance, propulsion latency, propulsion duration, and propulsion velocity demonstrated great variability according to the vowels (Table 1).

***Table** 1. Meand frame based data presenting propolsuion of the laser beam during utterance of the vowels and mean acoustic data of the articulated vowels.*

	Variables	Vowels in Contemporary Turkey Turkish letter, /phonetic transcription/							
		a /a/	**e /e/**	**ı / ɯ/**	**i /i/**	**o /o/**	**ö / œ/**	**u /u/**	**ü /y/**
Frame-based	**Propulsion distance (c-p)** (cm)	6,09	11,66	11,66	4,03	13,14	13,33	16,88	18,08
		+/- 1,21	+/- 3,27	+/- 1,22	+/- 1,4	+/- 0,96	+/- 2,31	+/- 1,5	+/- 3,4
	Propulsion duration (msec)	450,667	388	605,333	315,333	863,333	694,667	712,667	738
		+/- 95,26	+/- 38,78	+/- 170,43	+/- 121,387	+/- 143,14	+/- 140,32	+/- 106,96	+/- 154,87
	Propulsion latency duration (msec)	332,667	445,333	378	308	206,667	232	170,667	175,333
		+/- 85,84	+/- 37,24	+/- 100,1	+/- 99,73	+/- 97,25	+/- 44,9	+/- 100,36	+/- 107,31
	Propulsion velocity (m/sec)	0,143	0,184	0,201	0,161	0,156	0,199	0,242	0,253
		+/- 0,05	+/- 0,1	+/- 0,04	+/- 0,12	+/- 0,03	+/- 0,06	+/- 0,04	+/- 0,06
Acoustic by Praat	**Total utterance duration** (msec)	0,382	0,441	0,441	0,442	0,474	0,462	0,491	0,501
		+/- 0,03	+/- 0,05	+/- 0,05	+/- 0,04	+/- 0,04	+/- 0,03	+/- 0,05	+/- 0,05
	Utterance duration > 70 dB (msec)	0,252	0,302	0,302	0,294	0,313	0,307	0,334	0,347
		+/- 0,04	+/- 0,03	+/- 0,04	+/- 0,04	+/- 0,02	+/- 0,02	+/- 0,05	+/- 0,07
	Amplitude (dB) (> 70 dB)	78,71	77,618	77,618	77,1	79,4	79,9	77,981	77,79
		+/- 1,17	+/- 1,09	+/- ,0,73	+/- 1,09	+/- 0,69	+/-0,58	+/- 1,11	+/- 1,01
	F0 (Hz) (> 70 dB)	116,16	118,94	118,942	125,07	118,35	122,5	122,687	123,052
		+/- 4,5	+/- 3,0	+/- 2,89	+/- 5,96	+/- 3,35	+/- 3,44	+/- 7,61	+/- 5,47
	Jitter (local) (> 70 dB)	1,879	1,506	1,506	1,717	1,394	1,379	1,496	1,392
		+/- 0,36	+/- 0,2	+/- 0,15	+/- 0,33	+/- 0,2	+/- 0,11	+/- 0,2	+/- 0,26

	Jitter (local,abs) (> 70 dB)	0,162	0,127	0,127	0,137	0,118	0,113	0,122	14,803
		+/- 0,03	+/- 0,02	+/- 0,01	+/- 0,03	+/-0,02	+/- 0,01	+/-0,02	+/- 35,97
	Jitter (rap) (> 70 dB)	0,511	0,21	0,21	0,494	0,24	0,278	0,364	0,38
		+/- 0,23	+/- 0,04	+/- 0,04	+/- 0,21	+/-0,06	+/- 0,06	+/- 0,13	+/- 0,15
	Jitter (ppq5) (> 70 dB)	0,616	0,299	0,299	0,688	0,32	0,37	0,45	0,478
		+/- 0,22	+/- 0,04	+/- 0,05	+/- 0,35	+/- 0,07	+/- 0,07	+/- 0,16	+/- 0,15
	Jitter (ddp) (> 70 dB)	1,533	0,629	0,629	1,482	0,72	0,835	1,093	1,14
		+/- ,68	+/- 0,13	+/- 0,63	+/- 0,62	+/- 0,19	+/-0,17	+/- 0,38	+/- 0,44
	Shimmer (local) (> 70 dB)	15,889	7,647	7,647	9,834	8,472	9,2	9,894	8,543
		+/- 2,13	+/- 1,63	+/- 7,65	+/- 0,88	+/-1,31	+/- 2,18	+/- 1,72	+/- 1,77
	Shimmer (dB, local) (> 70 dB)	1,459	0,706	0,706	0,93	0,826	0,907	0,902	0,743
		+/- 0,19	+/-,14	+/- 0,71	+/- 0,08	+/- 0,1	+/- 0,2	+/- 0,14	+/-0,13
	HNR (dB) (> 70 dB)	5,923	9,773	9,774	7,407	10,539	9,028	14,071	10,635
		+/-1,05	+/- 1,56	+/- 9,77	+/- 1,05	+/- 1,21	+/- 1,4	+/- 1,0	+/-1,5

** According to International Phonetic Association (IPA);*
c-p: the distance between the center (c) of the green laser beam over the mist to farthest point of the laser spread.
F0: Fundemental frequency; HNR: Harmonic-noise ratio;

as seen in Table 2, there was consistency among the utterances for each phoneme regarding amount of propulsion distance. Since only 6 samples were taken for each phoneme, group differences were not tested. However, all utterances of "i" and "a" were within the first 10 cm, while the propulsion distances of all "ı" and "o" utterances were between 10 and 15 cm. It was seen that 9 of 10 utterances longer than 15 cm were "u" or "ü".

Table 2. *Distrubution of the vowels according to propulsion distance.*

	< 10 cm	10-15 cm	15 cm<	Total
a	6	0	0	6
e	5	1	0	6
ı	0	6	0	6
i	6	0	0	6
o	0	6	0	6
ö	1	4	1	6
u	0	2	4	6
ü	0	1	5	6
Total	18	20	10	48

The orders of the vowels in relation to propulsion distance, propulsion rate, propulsion duration and propulsion latency were seen in Figure 3.

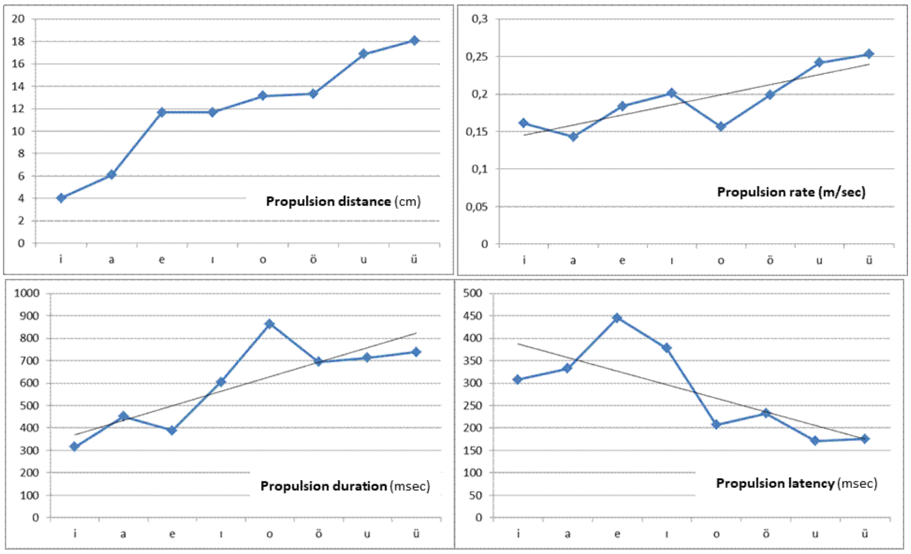

Figure 3. *Orders of the vowels in relation to propulsion distance, propulsion rate, propulsion duration and propulsion latency.*

The orders of the vowels in relation to acoustic variables were seen in Figure 4.

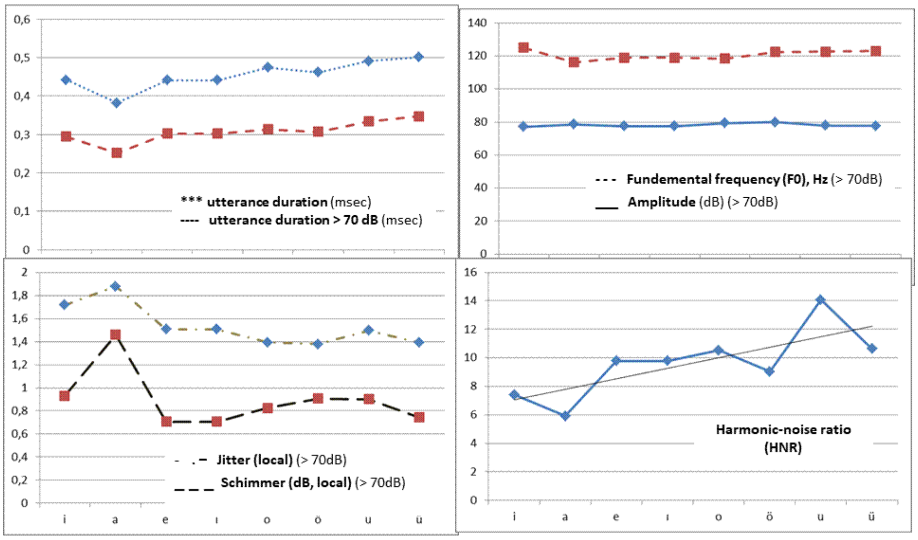

Figure 4*. Orders of the vowels in relation to utterance durations, fundamental frequency, amplitude Jitter, Schimemr and HNR values.*

In accordance with the data presented above, Spearman correlation analysis also revealed a high correlation of the propulsion distance with vowel type in the following order: i, a, e, ı, o, ö, u, ü (rho: 0,91, p < 0,0000001). The correlations of the propulsion distance, propulsion duration, propulsion latency duration, and propulsion velocity were summarized in Table 3.

Table 3*. Spearmann correlation anlaysis of the variables.*

	Propulsion distance [c-p]	**Propulsion duration (msec)**	**propulsion latance duration (msec)**	**propulsion velocity (m/sec)**
Propulsion duration (msec)	r: 0,71 p= 0,000001			
Propulsion latance duration (msec)	r: -0,61 p< 0,0000001	r: -0,73 p= 0,000001		
Propulsion velocity (m/sec)	0,67086409 p= 0,000001	ns	ns	
Total utterance duration (msec)	r: 0,53 p < 0,0002	0,57 p< 0,0000001	r: -0,4 p< 0,005	ns
Utterance duration > 70 dB (msec)	r: 0,49 p< 0,0005	r: 0,62 p< 0,0000001	r: -0,46 p< 0,002	ns
Jitter (local) (> 70 dB)	-0,42 p< 0,003	-0,53 p< 0,0002	ns	ns
Jitter (local,abs) (> 70 dB)	-0,346938776 p< 0,02	-0,41 p< 0,004	ns	ns
Jitter (rap) (> 70 dB)	ns	-0,29	ns	ns

		p< 0,05		
Jitter (ddp) (> 70 dB)	ns	-0,29	ns	ns
		p< 0,05		
Shimmer (local) (> 70 dB)	-0,32	ns	ns	ns
	p< 0,03			
Shimmer (dB, local) (> 70 dB)	-0,37	-0,3	ns	ns
	p< 0,01	p< 0,05		
HNR (dB) (> 70 dB)	0,76	0,71	-0,57	0,31
	0,000001	0,000001	p< 0,0000001	p< 0,05

c-p: the distance between the center (c) of the green laser beam over the mist to farthest point (p) of the laser spread.
F0: Fundemental frequency; HNR: Harmonic-noise ratio.

As seen, the propulsion latency duration was negatively correlated with the propulsion distance and propulsion duration. The propulsion distance was correlated with total utterance duration, utterance duration >70dB, Jitter (local, %), Jitter (local-absolute, sec), Shimmer (local, %), Shimmer (local, dB) and HNR. HNR emerged as the only variable which was correlated with all parameters related to the propulsion of the laser beam (propulsion distance, propulsion duration, propulsion latency duration, and propulsion velocity). An increase in HNR appeared to be related to increases in the propulsion distance, propulsion duration, and propulsion velocity and a decrease in the propulsion latency duration.

Stepwise regression analysis for the propulsion distance (dependent variable) with total utterance duration, Jitter (local, %), Shimmer (local, dB) and HNR (independent variables) disclosed that only HNR was extracted as the explanatory variable for the propulsion distance (R^2: 0,544; B: 1,395; p < 0,000001).When stepwise regression analysis was run for the propulsion duration (dependent variable) with utterance duration >70 dB, Jitter (local, %), Shimmer (local, dB) and HNR (dB) (independent variables) HNR was found to be only explanatory variable (R^2: 0,419; B: 50,795; p < 0,000001) in the first set. The second set of the explanatory variables was composed of HNR (R^2: 0,419; B: 36,079; p = 0,002) and utterance duration>70 dB (R^2: 1374,06 ; B: 1,395; p = 0,04). Stepwise regression analysis performed for the propulsion velocity (dependent variable) with HNR (dB) (independent variable) HNR emerged as a weak explanatory variable (R^2: 0,083; B: 0,008; p = 0,047). Besides, HNR (dB) appeared as only explanatory variable (R^2: 0,305; B: -25.062; p < 0,000001) for the propulsion latency duration which was entered as dependent variable for the following independent variables: utterance duration >70 dB and HNR (dB).

DISCUSSION

Speech is an important expiratory activity in daily life, particularly among people using the languages composed of pulmonary phonemes as Turkish and many European and Asian languages. The previous researchers documented the evidence for language differences in droplet emission while speaking (Inouye 2003, Inouye ve Sugihara 2015, Asadi et al. 2020). In our study, we demonstrated a new method for measurement of the amount of distance affected by the pressure of the airflow during the emission of the vowels. Because we analyzed only vowels but not syllables or phrases, the propulsion velocity was lower than the previous data. Notably, there was a considerable difference between the data presented in two previous studies (Chao et al. 2009; Geoghegan et al. 2017), probably due to the study designs.

Our study clearly revealed that particularly "u ,ü" and "o, ö", which were all rounded vowels articulated by protrusion movement of upper and lower lips, propelled the mist farther than the other vowels. Geoghegan et al. (2017) pointed out that mouth shape was the key parameter, so that pursed-lip mouth shape could result in higher air velocity at the mouth, and hence ejected faster airflow. Furthermore, Inouye and Sugihara (2015) reported the importance of the puff strength regarding higher air velocity near the mouth and suggested that the strength of puffs which are generated during speaking in social life could be responsible for the spread of aerosol in different countries. Our findings are in accordance with the findings of Geoghegan et al. (2017) and support the data of Inouye and Sugihara (2015). Nevertheless, to generalize our findings based on the voice recorded from one linguist, the data of more subjects should be analyzed. It was documented that rounding comprised larger phonological units in Turkish compared to English because the vowel harmony caused roundness of even consonants between two rounded vowels (such as "ütü") in Turkish (Boyce, 1990). That is, Turkish does not show the 'trough'-pattern seen in English[24]. Therefore, researches focused on acoustic and aerodynamic characteristics of CTT is of major importance regarding the evaluation of its aerosol spreading capacity. Regarding aerosol spreading capacity of any expiratory event or any aerosol-generating procedure, not only the amount or size of the droplets produced but their spreading velocity is also important. For CTT, it is logical to hypothesize that vowel harmony rules of CTT could provide some extra advantages regarding the least effort theory in human language Yılmaz ve Demir 2011). However, since the lips stay protruded through the articulation of consonant(s) in a word starting with one of the protruded vowels in Turkish (such as "ürgüp", "üstün"), Turkish could produce higher airflow, which might propel the droplets far, or to put it in the words of Inouye and Sugihara (2015), Turkish people might produce more puffs during the speaking. Final stress in the Turkish words (Özsoy 2004, Duyar 2019, Duyar et al. 2019) could be another disadvantage regarding aerosol spreading since stress in speech is mostly related to an increase in amplitude and/or frequency (Duyar 2019).

The data obtained from a single subject who was a linguist and the first author of this study clearly demonstrated that the acoustic variables such as utterance duration, Jitter, Shimmer and particularly HNR are related to the parameters of the propulsion of the laser beam (propulsion distance, propulsion duration, propulsion latency duration, and propulsion velocity). Although these data suggest that longer speech containing less high-frequency noise propels the air in front of the mouth more, such kind of interpretation should be delayed till having the data of the larger study group.

In this study, by using limited options and opportunities which were available in the "stay at home" period during COVID-19 pandemic, we tried to demonstrate a new technique which needs to be developed regarding a better standardization and more practical setup for analyzing more subjects in a voice - speech research laboratory. This technique could be useful not only in future medical studies focusing on droplet spreading during respiratory diseases such as COVID-19 but also in speech and language researches as a new describing variable for segmental and suprasegmental features of speech.

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