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Author(s)	Tam, Ka-chun, Bryan; 譚家駿
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Effects of straw phonation on vocal attack time in Cantonese speakers

Tam Ka Chun Bryan

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Abstract

The present study aimed to achieve three objectives. The first objective was to investigate the effects of straw phonation on vocal attack time (VAT). The second objective was to find out whether VAT values vary with straws of different inner diameters. The third objective was to determine if VAT varies as a function of different tones during straw phonations. Ten males and 10 females participated in the study. VAT values were obtained from their phonation during an open-mouth condition and during phonation into straws of different inner diameters. Results revealed that straw phonations yielded significantly longer VAT than open-mouth phonations. However, the VAT values obtained from straw phonation of different inner diameters were similar. Tone-by-gender interactive effects also existed. Contour tones yielded significantly longer VAT than level tones in female but similar tone effect did not exist in male. The results provided empirical data to support the use of straw phonation in voice therapy.

Effects of straw phonations on vocal attack time in Cantonese speakers

Semi-Occluded Vocal Tract

Phonation with a semi-occluded vocal tract is an umbrella term for various vocal training techniques employing certain degrees of occlusion in the vocal tract or artificially lengthened vocal tract (Bele, 2005). Semi-occluded vocal tract can be achieved by the use of voiced fricatives /*β*/ (Laukkanen, Lindholm, Vilkman, Haataja & Alku, 1996), "y-buzz" (Lessac, 1967), and phonations into tubes or straws (Costa, Costa, Oliveira & Behlau, 2011; Laukkanen, 1992; Laukkanen, Lindholm & Vilkman, 1995; Laukkanen, Titze, Hoffman & Finnegan, 2008; Laukkanen, Horácek, Krupa & Svec, 2012; Titze, Finnegan, Laukkanen & Jaiswal, 2002; Vampola, Laukkanen, Horácek & Svec, 2011). All these types of vocal techniques involve changes in acoustic impedance relative to open-mouth phonations (Story, Laukkanen & Titze, 2000). According to Story et al. (2000), acoustic impedance refers to the acoustic energy transfer in achieving wave motion in air and it consists of two components, resistance (removal of energy) and reactance (storage of energy). Based on the study results of Story et al. (2000), acoustic reactance of the vocal tract was found to increase during tube phonations and result in reduced phonation threshold pressure, which refers to the least amount of subglottal pressure needed to establish vocal fold vibration for sustaining phonation (Titze, 2009).

The literature has documented physiological and acoustical studies on phonation using semi-occluded vocal tract. Laukkanen et al. (1996) evaluated the use of voiced bilabial fricative /*β*/ as vocal exercise in laryngeal muscle activities during sustained vowel prolongation. They found a decrease in muscular activity during vowel production immediately after the exercise, suggesting an improvement in vocal economy. Other studies investigated the use of phonation into straws or tubes (Laukkanen, 1992; Laukkanen et al., 2012; Titze et al., 2002; Vampola et al., 2011). It was commonly found

that there was an increase in sound pressure level after tube phonation without increased phonatory effort, again suggesting an improvement in vocal economy (Laukkanen, 1992; Laukkanen et al., 2012; Titze et al., 2002; Vampola et al., 2011). Titze (2006) used computer simulations to study physiological changes during phonation with a semi-occluded vocal tract. Titze (2006) found that semi-occlusion near to the mouth led to an increase in intraglottal pressure, which refers to the pressures acting over the medial surface of the vocal folds (Titze, 2000). An increase in intraglottal pressure could facilitate vocal fold abduction and therefore, could act as a cushion to reduce the tissue collisions between vocal folds (Titze, 2006).

Vocal Attack Time

Baken and Orlikoff (1998) developed a simple and non-invasive method to measure the duration of vocal onset through obtaining sound pressure (SP) and electroglottographic (EGG) signals. The measurement is based on the fact that vocal folds are driven to vibrate with small-amplitudes even before adduction is established (Titze, 1988). The small vibration of the vocal folds creates a minimal SP signal and on the other hand, EGG signal, which indicates the magnitude of vocal fold contact area, shows a rapid growth as vocal fold adduction is accomplished. The time lead of onset of SP signal to the actual contact of vocal fold at vocal startup is defined as vocal attack time (VAT) (Baken & Orlikoff, 1998). In a validation study of VAT carried out by Orlikoff and his colleagues (2009), a negative VAT value (SP signal leads EGG signal) was found to suggest hard glottal attack while a relatively large VAT value (EGG signal leads SP signal) was found to suggest breathy voice with soft onset.

Straw phonation and VAT

Although numerous studies were done to investigate the effects brought by tube and straw phonations, most interpretations were mainly based on separate measurements of SP

and EGG signals. The physiological change during vocal onset was not investigated. Measurement of VAT values could be more representative in evaluating the effects of straw phonations as VAT reflects the mechanism of vocal folds behavior during vocal startup clearly. Drinking straws were used in this study because they are easily accessible in daily life.

One hypothesis is that when compared to open-mouth phonations, straw phonations may yield a longer VAT due to easier phonation initiation and avoidance of abrupt vocal folds approximation. Laukkanen et al. (2007) found out that during tube phonations, the vocal folds were more relaxed and hence lowered the phonation threshold pressure. With a lower phonation threshold pressure during straw phonations, vibration of vocal folds may be established earlier when the subglottal pressure is below the usual level that is required to be built up to in open-mouth phonatons. The onset of sound pressure signals may be advanced and therefore, the VAT values may become larger. Besides, Laukkanen et al. (2007) and Titze et al. (2002) found out that during tube phonations, the heightened supraglottic pressures acted as back pressures on the vocal folds. Subsequently, the intraglottal pressures were raised and the vocal folds were abducted (Laukkanen et al., 2007; Titze et al., 2002). Under such conditions, vocal folds approximation may be resisted and therefore delayed. As a result, VAT values may become larger.

Another hypothesis is that VAT may increase with decreasing straw inner diameters. For straws of smaller inner diameters, the occlusion (i.e. the acoustic impedance) of vocal tract increases and the straw effect proposed above is expected to increase. VAT may increase as a result. Therefore, in the present study, straws with different inner diameters were used to investigate the influence of varying acoustic impedance on VAT.

Tones, Gender and VAT

Ma, Baken, Roark and Li (2012) found that in Cantonese speakers, contour tones

(tone 2, 4 and 5) yielded larger VAT values than level tones (tone 1, 3 and 6). The authors proposed that the results were probably due to the underlying differences in physiological mechanism of productions of the two types of tones. Because a more complex pre-phonatory adjustment was required for productions of contour tones, it took more time for the vocal folds to adduct for phonations, leading to a longer VAT (Ma et al., 2012). Ma et al. (2012) and Roark, Watson, Baken, Brown & Thomas (2012) also highlighted that VATs of males were significantly longer than those of females, probably due to the anatomical differences in vocal folds of males and females. As vocal folds of males were thicken and heavier, it took more time for vocal folds to approximate and hence a longer VAT (Ma et al., 2012; Roark et al., 2012).

It was hypothesized that the patterns of difference in VAT between contour and level tones and between the two gender groups revealed by Ma et al. (2012) would maintain during straw phonations. Straws phonations should impose equal effects on production mechanism of all the six Cantonese tones and the two gender groups. Any interactions between straw phonations and tones may identify tones that yield the longest VAT in straw phonations. Hence, it could suggest the use of those tones as preferred stimuli for straw exercise. Also, any interaction between straw phonations and gender may identify if straw exercise are more suitable for a specific gender group.

Objectives and research hypotheses

The present study aimed to achieve three objectives. The first objective was to investigate the effects of straw phonation on vocal attack time (VAT). It was hypothesized that the VAT values obtained during straw phonation would be greater than that obtained during open-mouth phonation. The second objective was to find out whether VAT values vary with straws of different inner diameters. It was hypothesized that the VAT values obtained with straws of smaller inner diameter would be greater than those obtained with

straws of larger inner diameters. The third objective was to determine whether VAT values vary as a function of lexical tones during straw phonations. It was hypothesized that the same effect of tone would maintain in different phonation conditions. Results from this study would contribute to a better understanding of the physiological change of vocal folds during straw phonation. The results could also provide some empirical data to support whether straw phonation is useful for voice therapy.

Method

Participants

Twenty participants, including 10 males (mean age = 22.1 years; SD = 1.10; age range from 21 to 25 years) and 10 females (mean age = 22.1 years; SD = 0.32; age range from 22 to 23 years), participated in this study. They were all native Cantonese speakers who did not have history of dysphonia, speech, language and hearing impairments. They claimed to be healthy during data collection.

Instrumentation and Materials

Speech (sound pressure) signals were captured using an M-Audio Fast-Track interface with a Radio Shack 33-3012 headset positioned 5cm from the participant's mouth corner. Electroglottographic (EGG) signals were captured using electroglottograph (model 6103; KayPENTAX, New Jersey, U.S.). Both signals were recorded using software Audacity (version 1.2.6), at 44.1 kHz sampling rate and 32 bits resolution.

Drinking straws with three different inner diameters (4mm, 5mm and 10 mm) were used. The straws were all 10cm in length with a mark at the 2cm-position from one end. Participants were instructed to achieve lip seal at the mark. This was to ensure a standard length of 8cm from the lips to the end of the straw. The straws with inner diameters 4mm and 5mm were made of polypropylene while the composition of the straws with inner

diameter 10mm was not specified by the manufacturer.

Stimuli

A list of disyllabic words consisting of the target syllable /wu/ was constructed. Among the six lexical tones in Cantonese, there was no Cantonese real word with the syllable /wu/ presented in Tone 5. For this tone, participants were instructed to say the Cantonese word 會 (/wui_5/) as in disyllabic word "不會". The syllable /wui_5/ was chosen because it was a real word and had the closest transcription with target syllable /wu_5/.

As participants were told to produce vowels, such as /i/ and /a/, instead of /wu/ in a number of studies of tube phonation (Gaskill & Quinney, 2012; Laukkanen et al., 2012; Story et al., 2000), a pilot study was conducted before the actual experimental recording to evaluate the practicability and validity of using the above set of stimuli. Five participants (three males and two females; mean age = 22.4 years; SD = 0.55; age range from 22 to 24 years) participated in the pilot study. They were required to produce syllable /wu/ at the six Cantonese lexical tones with an open-mouth and into a straw. They were also required to read the word list developed by Ma et al. (2012). The stimuli consisted of six pairs of homophones with the syllable /a/ in the word-initial positions in a disyllabic word context (i.e. a total of 12 disyllabic words) and each of the pairs represented each of the six Cantonese tones.

Results showed that of the 150 data of open-mouth phonations of /wu/ (6 tones x 5 trials x 5 participants), 43 data (28. 7%) could not meet the Figure of Merit (FOM) $\geqq$ 0.75 acceptability criterion (Roark et al., 2012). Of the 300 data of open-mouth phonations of /a/ in disyllabic word context (6 tones x 5 trials x 2 two homophones for each tone x 5 participants), only 13 data (4.3%) failed to meet the FOM criterion. Of the 450 data of straw phonations (6 tones x 5 trials x 3 straws x 5 participants), only 11 data (2.2%) failed to meet the same criterion. Table 1 lists the mean VAT values as a function of tone and

phonations conditions.

Table 1. *Summary of mean VAT (and standard deviation) in milliseconds (pilot study).*

Tone	Open-mouth				Straw with inner diameter					
	/wu/		/a/		10 mm		5 mm		4 mm	
1	-12.24	(21.72)	-1.34	(3.33)	-3.12	(10.70)	2.80	(5.13)	1.19	(3.28)
2	-42.15	(31.84)	4.73	(2.79)	3.95	(3.79)	4.18	(4.15)	4.15	(3.68)
3	-17.44	(25.99)	-1.27	(4.56)	-0.29	(6.72)	2.82	(5.72)	2.02	(4.68)
4	-40.80	(35.90)	3.02	(3.03)	7.07	(9.51)	6.29	(10.72)	2.10	(4.77)
5	-29.01	(30.29)	0.72	(6.48)	4.00	(6.22)	2.51	(10.33)	4.68	(3.25)
6	-47.21	(35.05)	-1.69	(7.46)	-1.01	(11.41)	-1.44	(7.92)	2.60	(5.13)

The mean VAT values of /wu/ in open-mouth phonations fell far outside from the "comfortable" onsets range (-1.4 to 9.6 ms) reported in Orlikoff et al. (2009), while those of straw phonations and /a/ in open-mouth phonations fell mostly within the range. In light of the extreme VAT values and the relatively high percentage of data failing to meet the acceptability criteria (28.7%) for /wu/ in open-mouth phonations, the stimuli used in Ma et al. (2012) were employed for open-mouth phonations. The set of stimuli being constructed with the syllable /wu/ was used only for the three straw conditions.

Procedure

Recordings were made in a sound booth at the Voice Research Lab, the University of Hong Kong. A pair of surface electroglottographic (EGG) electrodes was placed over both sides of the participant's thyroid lamina. The participants were told to a prolonged vowel /a/ and position of the EGG electrodes were then adjusted to ensure adequate signals, which were monitored and indicated by an oscilloscope, could be obtained. The microphone-to-mouth corner distance was maintained at 5 cm.

The participants were first briefed the two lists of stimuli. In particular, for tone 5 in

the stimuli set of /wu/, the participants were instructed to produce /wu/ using the tone of "會(/wui$_5$/)". Participants were told to use their habitual voice and rate in reading the words and take a pause before moving on to the next words. They were asked to read out the stimuli set of /wu/ using one of the three straws. This procedure was then repeated five times. In every trial, the sequence of the words was randomized and different. The order of the recording with straws of different inner diameters was randomized for each participant. The participants were then asked to read out the stimuli set of the 12 disyllabic words in open-mouth conditions. This task was again repeated five times.

Results

For each straw condition, each participant produced six Cantonese tones for five times. Therefore, for each participant there were 90 data points (6 tones x 5 trials x 3 straw diameters). For open-mouth condition, the VAT value of each tone was calculated by averaging the 10 trials (5 trials x 2 two homophones for that tone). A total number of 3000 data points ([90 data points with straw + 60 data points without straw] x 20 participants) were obtained. Based on the Figure of Merit (FOM) $\geqq$ 0.75 acceptability criterion (Roark et al., 2012) and boxplot graph, 97 (3.3%) data and 278 (9.3%) outliers were excluded respectively. The statistical calculation was therefore based on the remaining 2625 data points. A repeated measures analysis of variance (ANOVA) was carried out. The dependent variable was the mean VAT values. The between-subject variable was gender of participants (male versus female). The within-subject variables included tone (six lexical tones) and phonation conditions (open-mouth and three straws of different inner diameters). Kolmogorov–Smirnov test and Levene's test confirmed the normal distribution and the homogeneity of variance of the data respectively. Table 2 lists the descriptive statistics of VAT values under different conditions.

Table 2. *Summary of mean VAT (and standard deviation) in milliseconds.*

Tone	Open-mouth	Straw with inner diameter			Overall
		10 mm	5 mm	4 mm	
Male					
Level tones					
1	-1.08* (6.21)	0.41 (7.92)	1.80 (3.02)	0.65 (3.03)	0.44 (3.66)
3	0.82* (3.28)	2.36 (3.39)	2.49 (2.16)	2.32 (4.31)	2.00 (2.67)
6	1.75* (4.67)	2.77 (3.57)	2.96 (2.21)	2.82 (3.39)	2.57 (2.71)
Contour tones					
2	5.13* (13.83)	7.54 (8.08)	7.89 (16.04)	2.76 (2.10)	5.83 (9.30)
4	2.77* (3.27)	6.21 (12.64)	2.64 (3.02)	2.48 (5.31)	3.52 (4.55)
5	1.59* (3.10)	3.89 (3.94)	3.32 (2.05)	3.17 (2.35)	2.99 (2.22)
Female					
Level tones					
1	-0.22* (3.50)	3.59 (3.80)	4.72 (5.49)	3.51 (4.50)	2.90# (3.22)
3	0.30* (4.34)	4.32 (3.63)	7.55 (6.82)	5.08 (2.40)	4.31# (2.91)
6	2.48* (4.83)	5.13 (3.35)	6.36 (3.33)	5.58 (2.39)	4.89# (2.19)
Contour tones					
2	5.14* (3.41)	7.41 (3.72)	8.35 (3.08)	7.58 (3.25)	7.12 (2.57)
4	4.85* (4.13)	6.28 (4.45)	7.87 (4.37)	7.31 (3.66)	6.58 (2.25)
5	4.53* (3.80)	7.42 (4.30)	10.20 (4.54)	8.50 (3.14)	7.66 (2.52)

* Significantly smaller than those of the three straw conditions.

Significantly smaller than those of the three contour tones.

Main effect of Phonation condition

The results of Mauchly's test of sphericiy revealed that the within-subject factor "phonation conditions" met the assumption of compound symmetry was met (p = .53). Results showed that the main effect of straw conditions were significant [F (3, 42.38) = 5.21, p < .05, partial eta-squared = .23]. Post hoc pairwise comparisons were performed and revealed that phonations into all the three straws yielded significantly larger VAT values than open-mouth phonations. There were no significant differences between

phonations into straws with inner diameters of 4 mm, 5mm and 10mm. Figure 1 shows the differences in VAT values between the four different phonation conditions.

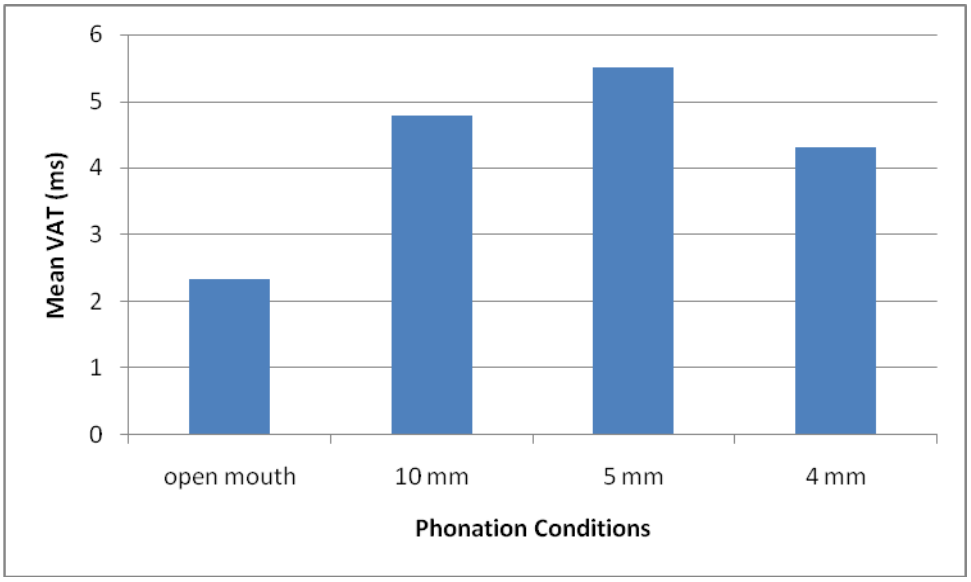

Figure 1. *Mean VAT in milliseconds (ms) of different straw conditions.*

Effect of tone and gender

Results showed a significant interaction between tone and gender [F (5, 14) = 3.97, $p < .05$, partial eta-squared = .59]. Independent samples t-test was conducted to further investigate the simple main effects of gender. Significant difference was only noted for tone 5 with VAT values of female being significantly larger than those of female [T (18) = 4.39, $p < .05$]. Repeated measures ANOVA were carried out separately for each gender group to further study the simple main effects of tone. For males, no significant differences were noted across the six tones. For females, all the contour tones (tone 2, 4, 5) yielded significantly larger VAT values than all the three level tones (tone 1, 3, 6) ($p < .05$). In addition, results revealed that tone 1 and tone 4 yielded significantly smaller VAT values than tone 6 ($p < .05$) and tone 5 ($p < .05$) respectively. Figure 2 demonstrates the relationship between tones and gender.

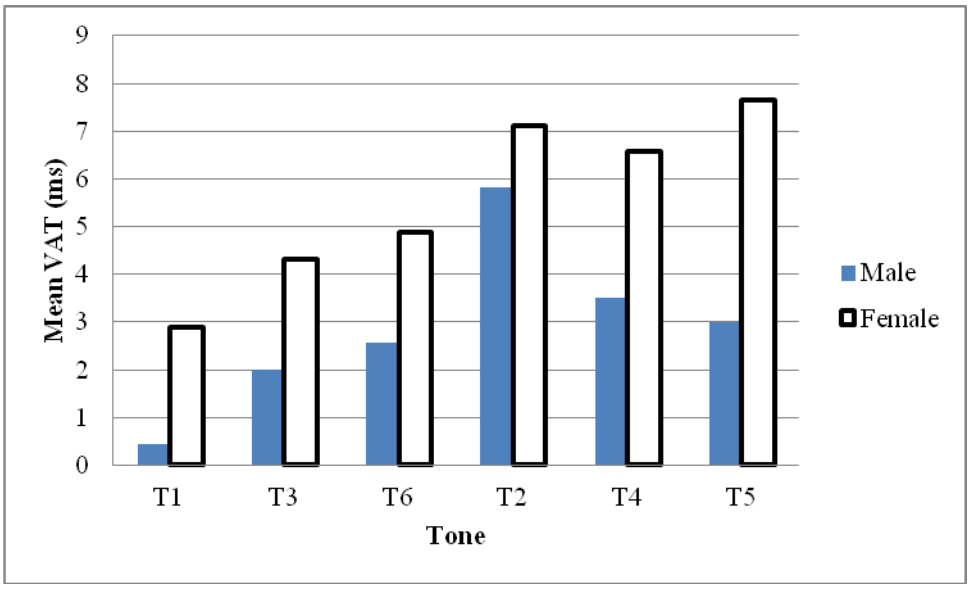

Figure 2. *Mean VAT in milliseconds (ms) as a function of tone for both gender groups.*

Discussion

Vocal attack time (VAT) is defined as the time lead of the onset of sound pressure signal to the actual contact of vocal folds at vocal onset (Baken & Orlikoff, 1998). The present study aimed to achieve three objectives. The first objective was to investigate the effects of straw phonation on vocal attack time (VAT). The second objective was to find out whether VAT values vary with straws of different inner diameters. The third objective was to determine if VAT varies as a function of different tones during straw phonations.

Effects of straw phonations

It was hypothesized that straw phonations could yield a longer VAT than open-mouth phonations. The present results found that the VAT values of straw phonations were significantly larger than that obtained from open-mouth phonation. The hypothesis was confirmed. The results suggested that during straw phonations, the time difference between the establishment of sound pressure signal and that of physical contact of vocal folds at vocal onset were longer than that in open-mouth phonation. According to Orlikoff et al. (2009), a longer VAT indicated a more comfortable voice onset and implied a

reduction of vocal fold collision. Two possible reasons might explain the results. The first reason was that during straw phonation, abrupt vocal fold contact was avoided. An increase in intraglottal pressure (that is, the pressure acting on medial surface of vocal folds) might have occurred during straw phonation (Laukkanen et al., 2007; Titze et al., 2002). As a result, vocal fold approximation might be resisted and delayed. Therefore, VAT might be longer during straw phonation. Another possible reason was that initiation of vocal fold vibration was easier during straw phonations. A reduction of phonation threshold pressure might have occurred during straw phonations (Laukkanen et al., 2007; Titze, 2009). As a result, vocal folds might be set to vibration more easily and quickly. VAT might therefore be longer during straw phonations. Future studies are warranted to testify the hypothesis

Effect of straw inner diameters

It was hypothesized that VAT might increase with decreasing straw diameters. However, results revealed neither a significant difference in VAT values between straws of different inner diameters nor a systematic trend of change of VAT values with varying straw diameters. The VAT values of phonation into straw with different inner diameters were similar. The results did not confirm the hypothesis. The results might suggest that straw inner diameters might not be a significant factor for change of VAT values in straw phonations.

One possible reason might be that in spite of the difference in inner diameters, the overall resistance of the three straws might be similar. Therefore, their effects on VAT were similar.

Another possible reason might be that instead of straw inner diameters, there might be other significant contributing factors to the change of VAT values. Laukkanen et al. (2007) and Titze et al. (2002) found out that the effects of straw/ tube phonations increased

with length and overall resistance of straw/ tube respectively. Therefore, it is likely that the length and overall resistance of the straws could have more influential effects on VAT than straw inner diameters. This hypothesis should be pursued in future with appropriately-designed studies.

Effects of Tones and Gender

The hypothesis for tone effect was that VAT of contour tones should be longer than those of level tones regardless of the phonation conditions. Results revealed that in females, VAT values of contour tones (tones 2, 4, 5) were significantly larger than those of level tones (tones 1, 3, 6). In males, results revealed no significant differences in VAT values across the six Cantonese tones. The hypothesis was confirmed in females but not in males.

For females, the findings were consistent with the results obtained by Ma et al. (2012). As suggested by Ma et al. (2012), the significant differences between contour and level tones were a result of the physiological difference in productions of the two types of tones. Because rapid changes of F_0 were necessary for productions of contour tones and thus, more complex and continuing pre-phonatory adjustments of vocal folds had to be carried out by the extrinsic and intrinsic muscles, resulting in a slower vocal folds adduction and hence a larger VAT.

The greater viscosity (i.e., greater resistance) of vocal folds in males than in females, as suggested by Chan and Titze (1999), might account for the results in males. Due to such anatomical differences of vocal folds, changes in vocal folds configurations were more difficult to be accomplished in males (Chan and Titze, 1999). As a consequence, the pre-phonatory adjustments of vocal folds in males might not be as much as in females for producing contour tones and therefore, as reflected by the results, there were no significant differences in VAT values across the six tones in males.

The hypothesis for gender effect was that VAT of males should be longer than those of females. The results revealed a gender difference for tone 5 only and surprisingly, it was the VAT values of females being larger than those of males. The hypothesis was not confirmed by the results. The results were not consistent with findings of the normative study of VAT values of 112 English speakers and 59 Cantonese speakers conducted by Roark et al. (2012) and Ma et al. (2012) respectively. It was expected that due to the anatomical difference of vocal folds between males and females (vocal folds are heavier and thicker in males than in females), the VAT values of males should be longer than those of females (Ma et al., 2012; Roark et al., 2012). One possible account for the results of the present study might be that the sample size (20 participants) of this study was relatively small when compared to that of the previous normative studies. Future studies with larger sample size are warranted for more representative VAT data between gender.

Clinical implications

The significantly larger VAT values of straw phonations indicated that a softer and more comfortable onset of voice could be produced in straw phonations (Orlikoff et al. 2009). Besides, several studies revealed that effects of tube (straw) phonations remained immediately after it (Costa et al., 2011; Laukkanen, 1992; Laukkanen et al., 2012; Laukkanen et al., 2008; Laukkanen at al., 1995; Vampola et al., 2011). It is therefore very likely that, the increase in VAT values during straw phonations will remain after it. According to Titze (2006), during straw phonations, semi-occluded vocal tract was achieved with an increased supraglottal (oral) pressure behind the lips, one would experience a sensation of strong vibration in the facial tissue. After straw phonation, one could try to achieve the same sensation by narrowing the epilaryngeal tract (Titze, 2006). The reason why narrowing the epilaryngeal tract could yield that sensation might be that when constricted epilaryngeal tract could result in reduced phonation threshold pressure

(Titze & Story, 1997), as in the case in straw phonations. Consequently, effects similar to those observed during straw phonations, including vibration of facial tissues, easier onset of phonation and larger VAT, could be achieved. It seemed possible that with such a strong tactile feedback in facial tissues, one could achieve the effects of straws even in open-mouth productions after having adequate experience and training of straw phonations.

Limitations and directions for research in the future

The first limitation was that due to time limitation, the sample size was relatively small in the present study as only 20 participants were recruited. This might be a possible contributor to the insignificant gender difference in VAT, which in several other studies, were found to be significant.

Secondly, due to that most of the straws available in the public were packed with the making materials being unspecified, one of the three types of straws used in this study were unknown. Fair comparisons could not be made to investigate accurately the effects of straw diameters. Therefore, straws with a continuum of inner diameters and each being made of the same material should be employed in future studies to systematically evaluate the change of VAT values across straws of different inner diameters. However, it was also possible that straw inner diameters itself might actually cause little or no effect on VAT. Alternatively, effects of straws with different lengths (Laukkanen et al., 2007) or different overall resistances (Titze et al, 2002) on VAT could be investigated.

Last but not least, as significant difference in VAT values between straw phonations and open-mouth productions were revealed by this study and persistence of straw effects was found present in various studies (Costa et al., 2011; Laukkanen, 1992; Laukkanen et al., 1995; Laukkanen et al., 2008; Laukkanen et al., 2012; Vampola et al., 2011), the notion that straw exercises could be used in voice treatment is well-supported. However, only

very few studies, including the one done by Costa et al. (2011), evaluated the treatment effects of straw exercise for patients with voice problem. More studies examining the treatment efficacy of straw exercises are essential in providing evidence for using straw exercise as voice treatment method.

Conclusion

This study was the first study to investigate the effects of straw phonations using vocal attack time (VAT). Results revealed that straw phonations yielded significantly longer VAT than open-mouth phonations. However, the VAT values obtained from straw phonation of different inner diameters were similar. Tone-gender interactive effects also existed. Contour tones yielded longer VAT than level tones in female but tone effect did not exist in male.

The results suggested that straw phonations could have positive effects on voice production as it promoted more gradual onset of voice. Such results supported the use of straw phonation in voice therapy. However, more studies investigating the treatment efficacy of straw exercise are essential to provide evidence for its effectiveness as a voice therapy approach.

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References

Baken, R.J., & Orlikoff, R.F. (1998). Vocal fold adduction time estimated from glottographic signals. Presented at: *the 25th Mid-Winter Meeting of the Association for Research in Otolaryngology.* St. Petersburg, FL.

Bele, I.V. (2005). Artificially lengthened and constricted vocal tract in vocal training methods. *Logopedics Phoniatrics Vocology, 30*, 34-40.

Chan, R.W., & Titze, I.R. (1999). Viscoelastic shear properties of human vocal fold mucosa: measurement methodology and empirical results. *Journal of the Acoustic Society of America, 106*, 2008-2021.

Costa, C.B., Costa, L.H., Oliveira, G., & Behlau, M. (2011). Immediate effects of the phonation into a straw exercise. *Brazilian Journal of Otorhinolaryngology, 77*, 461-465.

Gaskill, C.S., & Quinney, D.M. (2012). The effect of resonance tubes on glottal contact quotient with and without task instruction: a comparison of trained and untrained voices. *Journal of Voice, 26*, 79-93.

Laukkanen, A.M. (1992). About the so called "resonance tubes" used in Finnish voice training practice: An electroglottographic and acoustic investigation on the effects of this method on the voice quality of subjects with normal voice. *Scandinavian Journal of Logopedics and Phoniatrics, 17*, 151-161.

Laukkanen, A.M., Lindholm, P., & Vilkman, E. (1995). Phonation into a tube as a voice training method: Acoustic and physiologic observations. *Folia Phoniatrica et Logopaedica, 47,* 331-338.

Laukkanen, A.M., Lindholm, P., Vilkman, E., Haataja, K., & Alku, P.A. (1996). A physiological and acoustic study on voiced bilabial fricative /β/ as a vocal exercise. *Journal of Voice, 10*, 67-77.

Laukkanen, A.M., Pulakka, H., Alku, P., Vilkman, E., Hertegård, S., Lindestad, P.A., Larsson, H., & Granqvist. S. (2007). High-speed registration of phonation-related glottal area variation during artificial lengthening of the vocal tract. *Logopedics Phoniatrics Vocology, 32,* 157-164.

Laukkanen, A.M, Titze, I.R, Hoffman, H., & Finnegan, E. (2008). Effects of a semioccluded vocal tract on laryngeal muscle activity and glottal adduction in a single female subject. *Folia Phoniatrica et Logopaedica, 60,* 298-311.

Laukkanen, A.M., Horácek, J., Krupa, P., & Svec, J.G. (2012). The effect of phonation into a straw on the vocal tract adjustments and formant frequencies. A preliminary MRI study on a single subject completed with acoustic results. *Biomedical Signal Processing and Control, 7,* 50-57.

Lessac, A. (1967). *The use and training of the human voice* (2nd ed.). Mountain View, CA: Mayfield.

Ma, E. P.-M., Baken, R. J., Roark, R. M., & Li, P.-M. (2012). Effect of tones on vocal attack time in Cantonese speakers. *Journal of Voice, 26,* 670. e1-6.

Orlikoff, R.F., Deliyski, D.D., Baken, R.J., & Watson, B.C. (2009). Validation of a glottographic measure of vocal attack. *Journal of Voice, 23,* 164-168.

Roark, R.M., Watson, B.C., Baken, R.J., Brown, D.J., & Thomas, J.M. (2012). Measures of Vocal Attach Time for Healthy Young Adults. *Journal of Voice, 26,* 12-17.

Story, B.H., Laukkanen, A.M., & Titze, I.R. (2000). Acoustic impedance of an artificially lengthened and constricted vocal tract. *Journal of Voice, 14,* 455-469.

Titze, I.R. (1988). The physics of small-amplitude oscillation of the vocal folds. *Journal of the Acoustic Society of America, 83,* 1536-1552.

Titze, I.R., & Story, B.H. (1997). Acoustic interactions of the voice source with the lower vocal tract. *Journal of the Acoustic Society of America, 101,* 2234-2243.

Titze, I.R. (2000). *Principle of voice production*. Salt Lake City: National Center for Voice and Speech.

Titze, I.R., Finnegan, E., Laukkanen, A.M., & Jaiswal, S. (2002). Raising lung pressure and pitch in vocal warm-ups: The use of flow-resistant straws. *Journal of Singing, 58,* 329-338.

Titze, I.R. (2006). Voice training and therapy with semi-occluded vocal tracts: Rationale and scientific underpinnings. *Journal of Speech, Language, and Hearing Research, 49,* 448-459.

Titze, I.R. (2009). Phonation threshold pressure measurement with a semi-occluded vocal tract. *Journal of Speech, Language, and Hearing Research, 52,* 1062-1072.

Vampola, T., Laukkanen, A.M., Horácek, J., Svec, J.G. Vocal tract changes caused by phonation into a tube: a case study using computer tomography and finite-element modeling. *Journal of the Acoustic Society of America, 129,* 310-315.

Appendix A

Consent Form

香港大學
言語及聽覺科學系 BSc (Speech and Hearing Sciences)
四年級畢業論文
[飲管發聲練習與發聲原理之關係]

參與同意書

這是一項關於飲管發聲練習與發聲原理之關係的學術研究。旨在更深入了解飲管發聲練習對發聲原理的影響及它對聲線障礙的治療效用。

此項研究會於香港大學言語及聽覺科學部的隔音房間內進行，研究員會首先與閣下進行一項健康問卷調查，索取有關閣下的聲線健康、言語及聽覺能力的資料。問卷調查大約需時五至十分鐘。如閣下有任何聲線、言語及聽覺問題，便不會適合進行此項研究。參與者須根據研究員的指示在無飲管的情況下讀出不同聲調的元音及詞語，以及在含著飲管的情況下發出類似元音的聲音。本項研究，是利用電腦儀器分析飲管發聲練習與發聲原理的關係。在過程中，研究員會將兩塊鐵片貼於你的頸部兩旁的位置，並在口部附近設置麥克風，以用作錄音用途，整個過程將不會有任何不適的感覺。整個過程將會維持約二十分鐘。閣下於研究中進行的錄音及健康問卷調查資料將會儲存於言語及聽覺科學部的電腦內，並受到檔案加密及電腦密碼的保護，防上資料外泄。資料將會保存到直至研究完成，大約2013年4月30日，然後會被刪除。

是次研究並不為閣下提供個人利益，但所搜集數據將對研究聲線問題提供寶貴的資料。是次研究並不涉及任何風險及不會對參與者的身心理造成任何危險的後果。閣下可隨時提出終止，有關決定將不會引致任何不良後果。參與純屬自願性質，個人資料將絕對保密。閣下有權利隨時要求檢閱或刪除閣下於研究中進行的部份或全部錄音。如你對是項研究有任何問題，請現在提出。

如日後你對是項研究有任何查詢，請與研究員譚家駿先生聯絡(電話: 91633829/電郵: ab1020@hku.hk)。是項研究由香港大學言語及聽覺科學系助理教授馬珮雯博士負責監督。如你對是項研究有任何查詢，亦可與馬珮雯博士聯絡 (電話: 28590594/電郵: estella.ma@hku.hk)。

如你想知道更多有關研究參與者的權益，請聯絡香港大學非臨床研究操守委員會 (2241-5267)。

如你明白以上內容，並願意參與是項研究，請在下方簽署。

參與者姓名: _____ 參與者簽署:_____

研究員姓名: _____ 研究員簽署:_____

參與研究日期: _____

Appendix B

Health Questionnaire

香港大學
言語及聽覺科學
四年級畢業論文-[聲線學術研究]
健康問卷調查

請回答以下有關你的健康狀況的問題:

1. 請問你現在/ 曾經有沒有患過聲線上的問題?
   ☐ 有　如有, 請詳細列明情況:_____
   ☐ 沒有

2. 你現在/ 曾經有否患過言語及/或 咬字不清的問題?
   ☐ 有　如有, 請詳細列明情況:_____
   ☐ 沒有

3. 請問你有沒有任何聽覺問題?
   ☐ 有　　☐ 沒有

4. 請問你在過去兩星期曾否有過以下病症? (可選擇多於一項)

☐ 喉嚨發炎　☐ 傷風　☐ 流行性感冒
☐ 竇炎　☐ 鼻炎　☐ 過敏性鼻炎(鼻敏感)
☐ 氣喘(病),哮喘　☐ 甲狀腺機能亢進　☐ 甲狀腺機能減退
☐ 扁桃腺炎
☐ 不適用, 我沒有任何以上病症

5. 請問一個月前到現在, 你有否服食任何藥物?
   ☐ 有　如有, 請詳細列明情況:_____
   ☐ 沒有

6. 你從前或現在有沒有患過哮喘或其他相關的呼吸系統疾病?

☐ 有 ☐ 沒有

7. 請問你的喉嚨或附近位置曾否受過任何損傷?
☐ 有 ☐ 沒有

8. 請問你有沒有胃酸倒流的情況?
☐ 有 ☐ 沒有

9. 請問你今天/近幾天有沒有上呼吸道受感染的情況?
☐ 有 ☐ 沒有

10. 請問你有否吸煙? ☐
有 ☐ 沒有
如有, 吸煙的次數及數量是:_____

11. 你是否在嘈雜的環境下工作?
☐是 ☐不是

12. 平日工作或消閒時, 你是否須要大聲說話?
☐是 ☐不是

13. 廣東話是否你的母語?
☐是 ☐不是

個人資料:

姓名: _____ 性別:_____
聯絡電話:_____
出生日期:_____ 年齡:_____

Appendix C

Word Lists of Stimuli

Word Stimuli for Open-mouth Phonations

Tone					
1	2	3	4	5	6
丫 (丫叉)	啞 (啞巴)	亞 (亞洲)	芽 (芽菜)	瓦 (瓦片)	硬 (硬幣)
鴉 (鴉片)	啞 (啞鈴)	亞 (亞軍)	牙 (牙齒)	雅 (雅典)	挜 (挜拃)

Word Stimuli for Straw Phonations

Tone					
1	2	3	4	5	6
烏 (烏鴉)	糊 (糊仔)	惡 (厭惡)	湖 (湖水)	會 (不會)	護 (護士)