Assessment of Voice Quality in Monozygotic Twins: Qualitative and Quantitative Measures

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Voice quality is the multidimensional vocal attribute, covering both laryngeal and supra laryngeal aspect. It is generally accepted that the physical characteristics of the laryngeal mechanism and vocal mechanism are genetically determined. It may be hypothesized that monozygotic (MZ) twins voice quality sound similar to certain degree. To measure the voice quality qualitative and the quantitative assessments can be used. The present study investigated MZ twins voice quality using Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) as qualitative and Dysphonia Severity Index (DSI) as a quantitative measure and compared both the voice quality measurements. Twenty pairs (6 M pair, 14 F pair) of MZ twins in the age range of 18 to 25 years were participated. Phonation of a, i, and u were recorded 3 times at comfortable pitch and loudness using Sony mini digital recorder. Five speech-language pathologists carried out qualitative assessment. CSL 4500 was used to measure the frequency and intensity parameters and jitter values. Correlation coefficient was significant (p< 0.01) for all the parameters except strain, loudness, low-Intensity and jitter, and paired't' test showed no significant difference between twins for any of the parameters. Gender difference was significant for maximum phonation time and high fundamental frequency. This difference was attributed to anatomy and physiological variation among gender. High negative Correlation coefficient (r = - 0.78) was found between qualitative and quantitative measurements. DSI also showed good coefficient value with roughness and breathiness of CAPE-V. In conclusion, voice quality of monozygotic twins was similar in many of the parameters of qualitative and quantitative measures. Further investigation with a large scale of sample and confirmed genetic analysis is warranted.

***Keywords**: CAPE-V, DSI, Correlation*

Voice quality is the term that subsumes a wide range of possible meanings, covering both laryngeal and supra laryngeal aspect. Vocal quality serves as a primary means by which speakers project their physical, psychological and social characteristics to the world. It is a multidimensional vocal attribute that is related to the distribution of acoustic energy in the vocal spectrum. Monozygotic twins resemble each other in many aspects like aptitude, habit, taste and style that constitute what we think of as human individuality (Gedda, Fiori & Bruno, 1960). It is generally accepted that the physical characteristics of the laryngeal mechanism, such as vocal fold length and structure, size and shape of the supraglottic vocal tract, and phenotypic similarities elsewhere in the vocal mechanism are genetically determined (Sataloff, 1997). It may be hypothesized that their voice also may sound similar at least to a certain degree. Several research groups have studied genetic similarities in monozygotic twins. Though voice is unique to individuals, studies involving listeners perception have showed the perceptive similarity in monozygotic twins (Decoster, Van Gysel, Vercammen & Debruyne, 2001). Also, several quantitative measures like fundamental frequency in phonation (Przbyla, Hori, & Crawford 1992; Decoster, Van Gysel, Vercammen, & Debruyne 2001; Kalaiselvi, Santhosh & Savithri 2005), speaking fundamental frequency (Debruyne, Decoster, Van Gysel, & Vercammen 2002), formants (Forrai, & Gordos 1983), Dysphonia Severity Index (Van Lierde, Vinck, De Ley, Clement, & Van Cauwenberge 2005) and glottal parameters (Jayakumar & savithri 2008) show similarity in monozygotic twins.

According to the European Laryngeal Society, an assessment of voice disorders should consist of laryngo-stroboscopy, perceptual voice assessment, acoustic analysis, aerodynamic measurement and subjective self-evaluation of voice. Two of the advice assessment tools, the perceptual assessment and the acoustic analysis address the voice quality. The perceptual assessment in its most simple form is a description of the sound of the voice. But it lacks precision and is hardly useful to compare results of individual or

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group participants. Besides, communication between clinician will be difficult, which is due to lack of agreement on definition and terminology. On top of that, each clinician has his own internal standard to compare the perceived voice quality (De Bodt, Wuyts, Van de Heyning, & Croux, 1997). To reduce these drawbacks different type of scale have been introduced to score specific aspect of voice quality. The GRBAS scale introduced by Hirano (1981), is widely used. The parameters of this scale are overall Grade, Roughness, Breathiness, Asthenia, and Strain. For each parameter, a four-point scale is used to indicate severity. The inter-rater reliability is moderate (Kreiman, Gerratt, 1998, De Bodt, Wuyts, Van de Heyning, Croux, 1997). Kreiman, Gerratt, Kempster, Erman and Berke (1993) further suggested that scaling system that replies primarily on ordinal or equal-appearing internal scales may have limited reliability potential. They suggested visual analog scaling procedure which could address several limitations of the other approaches. This perspective was incorporated into a new scaling tool produced by a group of clinical speech-language pathologists and voice scientists at Consensus conference for perceptual measure of voice quality by American speech-language hearing Association (ASHA, 2002). The tool was called CAPE-V (Consensus Auditory - Perceptual Evaluation of voice) and used a type of visual analog scaling supplemented by various other descriptors. In CAPE-V apart from Roughness, breathiness, strain, pitch and loudness the judges can introduce the parameters which they feel important for the particular voice ample. Secondly the judges can vary their rating from 0 to 100%. The Standard CAPE-V protocol includes sustained vowel /a/, and /i/, sentence repetition, and a brief sample of conversation.

On the other hand, instrument measurements frequently involve instrumentation to quantify voice quality. They are regarded as less subjective and hence are a more reliable method to document vocal dysfunction. It is therefore not surprising to find the extensive literature identifying which instrument measure can best predict perceptual assessment, with the intention of replacing perceptual evaluation to document voice quality. The results of these studies are inconclusive. (Heman-Ackah, Michael, Goding, 2002 / Heman-Ackah, Heuer, Michael, et al. 2003) Many researchers considered the multi dimensional nature of voice and advocated measure to predict perceptual voice quality (Piccirillo, Painter, Fuller, Haiduk, Fredrickson, 1998a / Piccirillo, Painter, Fuller, Fredrickson, 1998, Wuyts, De Bodt, Molenberghs, et al. 2000, Yu, Ouaknine, Revis, Giovanni, 2001). A disadvantage of some of these multi parametric methods is the need of specific equipment for some of the Lyapunov coefficient. The Dysphonia Severity Index (DSI) as proposed by Wuyts et. al. (2000) is also an objective multiparametric measurement. The DSI was derived from multivariate analysis of 387 subjects with the goal to describe the perceived voice quality, based on objective measurement it constructed so that perceptually normal voice corresponds with a DSI +5 and severely dysphonic voice corresponds with a DSI of -5, but scores beyond this range are also possible. An Advantage of this DSI is that the parameters can be obtained relatively quick and easily by speech pathologist in daily clinical practice.

Van Lierde et. al. (2005) assessed vocal quality in 45 monozygotic twins (19 males and 26 females). The authors hypothesized that the vocal characteristics and overall vocal quality will be identical in monozygotic twins. They used DSI to measure voice quality, in addition the effect of age and gender on voice quality was also determined. For quality assessment perceptual and objective measurement were made. In subjective assessment GRBAS scale was used. Maximum phonation duration (MPD), voice range, fundamental frequency, jitter, shimmer and DSI were measured for objective assessment. The results showed that the perceptual voice characteristics, the laryngeal, aerodynamic measurement, the vocal performance and the vocal quality by means of DSI were similar in monozygotic twins. But frequency and amplitude perturbation were dissimilar though in the normal range. Additionally results showed no effect of age and gender. But the perceptual voice characteristics were not compared with objective voice parameters. Santhosh & Savithri (2005) investigated acoustic and perceptual characteristics of the speech of five monozygotic twins. The results indicated no significant difference between twins for VOT and closure duration. However, significant differences between twins were noticed for vowel duration. Perceptual evaluation indicated significant difference between four twin pairs for all parameters, except articulation. Jayakumar & savithri (2008) investigated similarity of voice source in monozygotic twins using inverse filtering and the consistency of inverse filtered parameters. 6 monozygotic twins and matched unrelated pairs voice were investigated. Vag_physio module of VAGHMI software was used for inverse filtering. Results showed no significant difference between groups on voice source characteristics, specially the open quotient (OQ) and speed quotient (SQ) was more similar than unrelated pairs group. However further investigation on twin pairs selection based on perceptual similarity and confirmed genetic analysis was recommended by the researches.

Hakkesteegt, Brocaar, Wieringa, Feenstra, (2008) compared the GRBAS scale with DSI. The result showed that the range of DSI with in each G score was quite large, possibly due to differences in severity of dysphonia that was not reflected in the G score. They also reported DSI cut off 3.0 to differentiate between groups of individual with and without voice complaints. Hence, the limited insight necessitates further investigation on the voice characteristics of monozygotic twins. Also, comparison between Quantitative and Qualitative measure using limited range of equal-appearing interval scale (GRBAS) did not comprehensively reflect the consistency of the measurement, due to it is larger interval. To address these issues the present study aimed at investigating monozygotic twins' voice quality using CAPE-V as qualitative and DSI as a quantitative measure and comparing both the measurements.

Method

Participants: Twenty pairs (6 male pair, 14 female pairs) of monozygotic twins in the age range of 18 to 25 years (mean = 22.5 yrs) were participated in the study. Criteria for selecting monozygotic twins include (a) they should be same in gender, (b) Should have approximately similar height and weight. (c) Should have same blood group. None of the participant had any unstable voice, voice disorders, speech disorders, neuro-motor disorders, endocrinal disorders and/or hearing disorders.

Procedure and Measurements

Qualitative: The recording was made in quiet room. Participants phonated vowels |a|, |i|, & |u| three times for a minimum of five seconds at comfortable pitch and loudness. Sony mini digital recorder (MZ-R3, Sony Corporation, Japan) was used to record all the voice samples. CAPE-V scale was used as a qualitative scale for the voice assessment. In current study only vowel voice sample was used unlike standard vowel, sentences and brief conversation samples for CAPE-V scale. Five speech language pathologists (Master holders) were judged the MZ Twin voice samples.

Quantitative: A DSI measurement is a multi parameter approach to objectively measure the voice quality. DSI is based on the weighted combination of the following selected set of voice measurements: highest frequency (in hertz), lowest intensity (in decibels), maximum phonation duration (in sec), and jitter (in percent). It ranges from +5 to -5 respectively in healthy and severe dysphonic voice. It will be calculated as follows:

DSI= 0.13(MPT) + 0.0053 (high F0) – 0.02(low intensity) – 1.18(jitter %) + 12.4

Frequency and Intensity: The subjects were instructed to phonate vowel |a| as softly as possible at a comfortable pitch. After that they were asked to phonate vowel |a|, starting at a comfortable pitch going up to the highest and down to the lowest pitch. The clinician prompted and modelled the subject to achieve the highest possible pitch.

Maximum phonation time: The subjects were instructed to inhale deeply and sustain vowel |a| for as long as possible at a comfortable pitch and loudness. This was recorded three times the longest phonation time was used for further analysis.

Jitter: Subjects phonated vowel |a| 3 times at a comfortable pitch and loudness 5 seconds. The percentage jitter was calculated on a sample of 4 seconds, starting a half second after voice onset. To rule out technically invalid measurement due to correct marking of the voiced periods, the lowest of the three calculations was used.

Analyses: Monozygotic twins voice sample were judged by 5 speech-language pathologists who had one years of experience after the completion of master degree. Two samples were repeated once to check the test re-test reliability of the subjects, which showed 73% correlation. CSL 4500 was used to measure the frequency and intensity parameters and jitter values. MPT was calculated using stopwatch. To check the test re-test reliability 10% of the sample was re-analyzed using the same instrument, which showed 98% reliability.

Statistical analysis: SPSS 15 was used to make the statistical calculation. Paired t- test was used to find the difference between twins's pairs for qualitative and quantitative measures. Mann-Whitney 'U' test was performed to find the gender difference**.** Pearson product correlation was used to find the relation between the qualitative and quantitative measurements.

Results

Vocal characteristics in MZ Twins

Results of paired t test indicated no significant difference between twin pairs on any of the qualitative and quantitative parameters. The correlation between twin pairs was significantly high on breathiness, Roughness, Pitch, Overall severity (qualitative), and MPT, High-F0, and DSI (qualitative). Table 1 shows the mean, SD, r-value and p-value for all measures.

	Qualitative parameter (CAPE-V)					
	Roughness	Breathiness	Strain	pitch	Loudness	**Overall**
Mean (SD)	4.1(4.9)	6.5(6.7)	5.2(6.5)	5.8(5.6)	1.5(2.8)	**13.8(10.1)**
r-value(Pearsons)	0.56**	0.66**	0.39	0.59**	0.34	**0.83****
p-value (paired t)	0.48	0.13	0.37	0.05	0.06	**0.20**
	Quantitative parameter (DSI)					
	MPT	High-F0	Low Int	Jitter (%)	**DSI**	
Mean (SD)	14.6(2.9)	919(123)	55.3(2.8)	0.80(.43)	**3.82(1.1)**	
r-value(Pearsons)	0.74**	0.92**	0.29	0.40	**0.74****	
p-value (paired t)	0.23	0.12	0.74	0.36	**0.06**	

Table 1: Mean, SD, r-value, and p-value of all parameters.**(p<0.01)

Gender difference: Mann-Whitney 'U' test showed gender difference for MPT* (z = 0.042) and F0-high** (z=0.002) Value.

Comparison of Qualitative and Quantitative Evaluation

Over all DSI and CAPE-V values were negatively correlated (r = - 0.78, p<0.01). CAPE-V values increased with decrease on overall DSI values. Figure 1 shows the scatter plot of CAPE-V on X-axis and DSI on Y-axis.

DSI was correlated with two of the CAPE-V parameters. DSI was negatively correlated with roughness (r= -0.43, P<0.01), breathiness (r= -0.36, p<0.05). Figures 2 and 3 show the scatter plot of DSI with roughness and breathiness, respectively. Figure 2 & 3 shows scatter plot of DSI Vs Roughness and Breathiness.

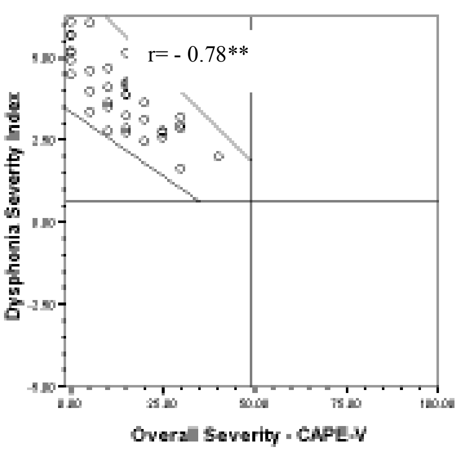

Figure 1: Scatter plate of DSI Vs CAPE-V scale.

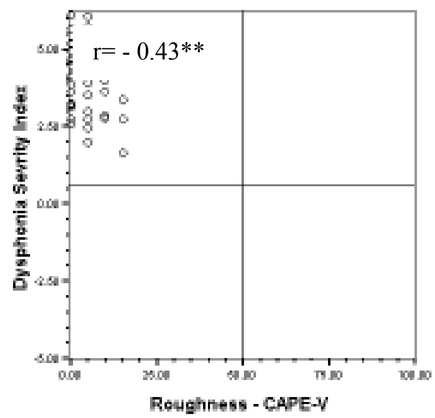

Figure 2: Scatter plate of DSI Vs Roughness

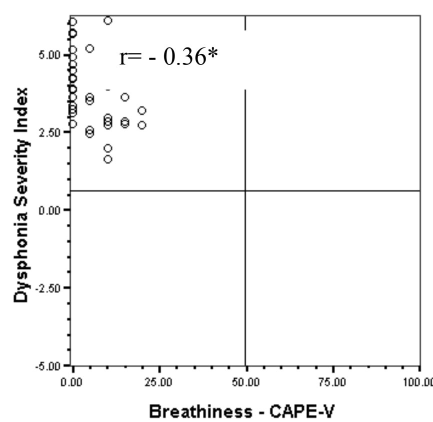

Figure 3: Scatter plate of DSI Vs Breathiness.

Also, jitter had positive correlation with overall severity, roughness, breathiness and strain on CAPE-V. Table 2 shows the r-value of jitter with each of the CAPE- V parameters.

r	Jitter
Overall severity	0.36*
Roughness	0.32*
Breathness	0.60**

Table 2: r – value of jitter, across CAPE-V.

Discussion

Few studies have investigated the vocal characteristics in monozygotic twins. The picture that emerges from the existing studies show similarities in fundamental frequency, voice onset time, voice quality, glottal parameters, and formant frequency. However, the results were inconsistent across the studies. Also there is inconsistent correlation between qualitative and quantitative measurements of voice monozygotic twins. The Current study investigated the voice quality in monozygotic twins using CAPE-V and DSI.

The objective of the study was to compare the qualitative and quantitative measurements of voice quality of monozygotic twins using CAPE-V and DSI. The results revealed several interesting points. First, there was no significant difference between twin pairs on any of the qualitative and quantitative measurements was observed. The results are in consonance with Van Lierde et al. (2005). They showed perceptual voice characteristics; the laryngeal, aerodynamic measurement, the vocal performance and the vocal quality by means of DSI were similar in monozygotic twins. But frequency and amplitude perturbation were dissimilar. Mann-Whitney 'U' test showed gender different for MPT and Fo-high among all the qualitative and quantitative assessment. These differences can be attributed to the anatomy and physiological difference in respiratory and phonatory difference among gender.

Secondly, DSI had high negative correlation between overall severity, and negative correlation between roughness and breathiness of CAPE-V. As the severity of voice increased DSI value decreased, which is an expected result. Hakkesteegt et al (2008) investigated 294 clients with voice compliant and 118 volunteers without voice complaint. The result showed that DSI significantly lower when the score on GRBAS grade was high. Also, DSI cut off 3.0 to differentiate between groups of individual with and without voice complaints. With a cut off 3.0, Maximum sensitivity (0.72) and specificity (0.75) were found. The current study also shows sensitivity value of 0.70 as DSI cut off being 3.0. High negative Correlation coefficient value($r = -0.78$) clearly reflects the relationship qualitative and quantitative assessment.

Third, jitter positively correlated with breathiness, roughness and overall severity. Breathiness, roughness and overall severity increased as the jitter percentage increases. Dejonckere, Remacle , Fresnel-Elba, Woisard, Crevier-Buchman, Millet (1996) investigated 943 voice patients and showed a good correlation between jitter and roughness on GRBAS scale.

In conclusion, voice quality of monozygotic twins was similar in many of the parameters of CAPE-V (qualitative) and DSI (quantitative). The correlation coefficient was significant between qualitative and quantitative parameters. Also DSI had good correlation with perceived roughness and breathiness of CAPE-V scale. DSI can be used as voice quality measurement to differentiate minimal changes like, comparing monozygotic twins voices and even to monitor the progress of voice therapy. Further investigation with a large scale of sample and confirmed genetic analysis is warranted.

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