THE UNIVERSITY OF HONG KONG

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Laidlaw Undergraduate Research and Leadership Programme
Report Form

Please complete and return this form, together with a research attachment report, to the Horizons Office (laidlaw@hku.hk).
The report must be endorsed by your HKU supervisor.

Name:	Lee Tung Julianne
Curriculum:	Bachelor of Science in Speech and Hearing Sciences
Year of Study:	4
Research Attachment Details:	
Institution:	Voice Research Lab, The University of Hong Kong
HKU Supervisor:	Dr MA, Estella P. M.
Research Topic:	Visualizing voice disorder: real-time ultrasonographic evaluation of vocal functions
Attachment Period:	06/2022-09/2022

Report

Please provide two narrative reports of **1000 to 3,000 words or two videos of 3-5 minutes (with sub-titles)** describing the research activities undertaken during your Laidlaw Scholarship and your leadership development journey, which may include but need not be limited to the following:

FIRST REPORT (due by September 30, 2022)
Research
- Brief description summarizing the purpose of the project, hypothesis, methodology, procedures, principal results, and conclusions
- Difficulties encountered and how they were resolved
- Improvements that could be made if the project were to be repeated
- Impacts of the research beyond the classroom
- Suggestions and extensions for further study

SECOND REPORT (due by August 30, 2023)
Leadership Development
- What was done to build leadership capability
- Action taken and experience gained to practice leadership
- Critical skills identified and developed for success in your future career
- Further experiences and development approaches that will best position you for your career

Overall Experience

- Reasons for undertaking the Laidlaw programme at the start
- What did you gain from the overall programme? The research experience, leadership training, networking and any other aspect you wish to comment on.
- Will the programme help you in the future and if so in what ways?
- Are there aspects of the programme that you think can be improved? And if so, how?
- Are you prepared to "give back" to the programme in the future by being an active alumnus?

Signature: Date:26/9/2022

Visualizing voice disorder:
real-time ultrasonographic evaluation of vocal functions

Introduction

Dysphonia in the paediatric population

Voice disorder has a high prevalence of 11.6% among school-aged children, characterized by altered voice quality, pitch and loudness (Carding et al., 2006). Chronic dysphonia in children is most commonly due to the presence of vocal fold nodules, which are associated with phonotrauma (Gambalonga et al., 2020). With impaired communication, the child's quality of life is adversely impacted in terms of self-esteem and formation of social relationships (Connor et al., 2008; World Health Organization, 2013). Additionally, listeners tend to associate abnormal voice qualities with negative stereotypes and false estimates of personality traits (Ma & Yu, 2013). Therefore, early identification and intervention of voice disorder in children is of utmost importance.

Flexible Nasolaryngoscopy vs. Laryngeal Ultrasonography

To diagnose voice disorder, flexible nasolaryngoscopy is the current gold standard to evaluate vocal fold functions; however, its operation is challenging on young children due to difficulty with cooperation (e.g., crying, extensive movements), low tolerance, secretions and obstructed supraglottic structures (Ongkasuwan et al., 2016). Given the non-invasive nature, laryngeal ultrasonography has been under investigation as an alternative for the paediatric population.

First introduced in the 1970s, laryngeal ultrasonography was primarily applied in investigating fetal human upper respiratory anatomy; little research has been conducted on assessing vocal fold lesions (Spadola Bisetti et al., 2009). In recent literature, laryngeal ultrasonography has been adopted to identify vocal fold movement impairment (VFMI) with 90%-100% diagnostic accuracy, also highly tolerated by the young patients and well-accepted by their caregivers (Ongkasuwan et al., 2016). Its application is feasible due to children's limited extent of thyroid cartilage calcification, thus allowing visualization of the vocal folds via ultrasound (Ongkasuwan et al., 2016). Additionally, in the current COVID-19 pandemic era, this technique is associated with less risk of infection as face masks can be worn during the examination.

Concerning limitations, laryngeal ultrasonography is not a substitute for a complete airway examination due to its limited ability to examine vocal fold margins and laryngeal closure patterns (Ongkasuwan et al., 2016). Calcification of thyroid cartilage in older adults also impairs visualization of laryngeal structures via ultrasound. Other challenging conditions include limited access to the anterior neck, such as difficulties with extending the neck or the presence of tracheostomy tubes that cannot be removed.

In the context of Hong Kong

The long waiting time for public speech therapy services and unaffordability of private clinics in Hong Kong resulted in delayed diagnosis and treatment for patients from low- or mid-income families. Moreover, the prevalence of paediatric voice disorders and its adverse impacts on quality of life have been overlooked in the local context, given the lack of research and a limited database of laryngeal ultrasonography. Noting that voice problems do not resolve spontaneously, the absence of early intervention may give rise to an unfavourable prognosis.

Purpose

The purpose of this research was to evaluate the use of ultrasound imaging in assessing vocal functions and structures in the paediatric population. The primary goal was to develop a normative database of laryngeal ultrasonographic images of children with and without voice disorders. This study also examines the reliability of using ultrasound in measuring vocal fold structures and functions.

Methodology

Participants

Ethics approval has been obtained from the Faculty Research Ethics Committee (FREC) of the Faculty of Education at the University of Hong Kong prior to participant recruitment. Participants aged 3 to 12 years old were targeted and recruited via HKU mass emails, recruitment letters to primary schools and online social media platforms (e.g., Voice Research Lab Instagram).

The inclusion and exclusion criteria are as follow: participants are not currently on medication that may affect voice; participants are not currently having upper respiratory infection, neurological conditions nor asthma.

Procedures

A bedside laryngeal ultrasonography was operated with a GE LOGIQ e ultrasound machine with a GE 12L-RS Linear Probe by the principal investigators of this project. Participants were examined in the supine position with the anterior neck well-extended using a shoulder roll; the probe was angled superiorly from the child's hyoid level to the cricoid cartilage (Wang et al., 2011). All ultrasound images were recorded.

Data analysis

All laryngeal ultrasound images were individually reviewed and evaluated by two examiners.

For qualitative analysis, the symmetry of vocal fold movement was evaluated. The mobility of right and left vocal folds individually was categorized into no, partial, and full mobility (Ongkasuwan et al., 2016). Beside, the suspected presence of vocal pathologies such as vocal fold nodules was noted.

For quantitative analysis of vocal fold functions, the vocal fold-arytenoid angle (VAA), maximum glottic angle (MGA), vocal fold length and subglottic airway diameter were measured in a quiet breathing task during maximum vocal fold abduction; the vocal fold-arytenoid angle (VAA) was re-measured in a sustained vowel prolongation task during maximum vocal fold adduction (Wang et al., 2011).

Table 1. Parameters obtained from ultrasound images

Vocal fold movement	Task	Parameter (unit)
1. Vocal fold abduction	1. Quiet breathing	1. Vocal fold-arytenoid angle (VAA) (°)
		2. Maximum glottic angle (MGA) (°)
		3. Vocal fold length (VFL) (mm)
		4. Subglottic airway diameter (SAD) (mm)
2. Vocal fold adduction	2. Sustained vowel prolongation of /i/	5. Vocal fold-arytenoid angle (VAA) (°)

For inter-rater reliability and intra-rater reliability, independent-samples t-tests were performed to determine the statistical differences of all parameters. Pearson's correlation coefficients were also calculated to determine the linear relationship of all parameters.

Results and Discussion

Demographics of participants

Seven participants ranged from 4 to 8 years old were recruited. All participants received no formal diagnosis of voice disorder by otorhinolaryngologists. For auditory-perceptual evaluation of voice, roughness and breathiness of voice were present in subject 02 and 05.

Table 2. Demographics of participants

Subject	01	02	03	04	05	06	07
Age/sex	4;2/M	8;0/M	6;0/M	6;3/M	4;7/M	8;9/M	5;2/M
Previous/ ongoing speech therapy	Yes	No	No	No	Yes	No	No

Ultrasound measurements

Raw data collected by independent investigators has been attached in table III (Appendix). For qualitative analysis, full mobility of left and right vocal fold and the symmetry of vocal fold movement were observed. Vocal fold nodules were suspected to be present in two participants (S02 and S05).

For quantitative analysis, an increasing trend of right and left vocal fold lengths across age were observed. However, there was no apparent trend reflected in the data of subglottic airway diameter across age groups. Laryngeal ultrasonography was also able to exhibit that the left and right vocal-fold arytenoid angles were significantly larger during abduction compared to adduction.

Inter-rater reliability

Regarding the interpretation of ultrasound measurements, Pearson correlation was performed to measure the association of data by independent raters.

Table 3. Pearson correlation for inter-rater reliability

parameters	VAA_AB_L	VAA_AB_R	VAA_AD_L	VAA_AD_R	MGA	VFL_L	VFL_R	SAD
pearson correlation	0.107	0.429	-0.107	0.393	-0.071	0.5	0.179	0.371
sig. (2-tailed)	0.819	0.337	0.819	0.383	0.879	0.253	0.702	0.468

Across all parameters, there was no significant correlation between data by independent raters.

An independent-samples t-test was performed to calculate the statistical difference between independent raters.

Table 4. independent-samples t-test for inter-rater reliability

Parameters	VAA_ AB_L	VAA_ AB_R	VAA_ AD_L	VAA_ AD_R	MGA	VFL_L	VFL_R	SAD
t	-0.65	0.151	0.843	1.8	0.495	-1.185	-0.807	-0.461
df	12	12	12	12	12	12	12	11
sig. (2-tailed)	0.528	0.882	0.416	0.097	0.629	0.259	0.435	0.654

The significance level of all parameters was p>0.05, thus concluding the statistical difference between independent raters is not significant.

The low inter-rater reliability can be explained by the small sample size of n=7. It also suggests the necessity of measures to be adopted in order to enhance agreement between examiners (e.g., training for ultrasound measurement, developing an artificial intelligence-empowered laryngeal ultrasonography).

Intra-rater reliability

The data analysis procedure was repeatedly administered by the same rater. Raw data collected from repeated administrations has been attached in table XI (Appendix).

An independent-samples t-test was performed to calculate the statistical difference between trials performed by the rater.

Table 5. Independent-samples t-test for intra-rater reliability

parameters	VAA_ AB_L	VAA_ AB_R	VAA_ AD_L	VAA_ AD_R	MGA	VFL_L	VFL_R	SAD
t	-0.054	0.092	-0.85	0.745	0.224	-0.094	0.009	-0.082
df	12	12	12	12	12	12	12	12
sig. (2-tailed)	0.958	0.929	0.412	0.471	0.827	0.927	0.993	0.936

The significance level of all parameters was p>0.05, thus concluding the statistical difference between trials is not significant.

Pearson's correlation coefficient was used to evaluate the association of data between trials by the same rater.

Table 6. Pearson correlation for intra-rater reliability

parameters	VAA_ AB_L	VAA_ AB_R	VAA_ AD_L	VAA_ AD_R	MGA	VFL_L	VFL_R	SAD
pearson correlation	0.941	0.739	0.522	0.187	0.655	0.599	0.651	0.924
sig. (2-tailed)	0.002	0.058	0.229	0.687	0.11	0.156	0.114	0.003

Across all parameters, there was no significant correlation between trials except for the left vocal fold-arytenoid angle during abduction and subglottic airway diameter. The insubstantial correlation can be explained by the small sample size of n=7.

Conclusion

The present research developed preliminary normative data of vocal fold structures of children aged from 4 to 8 years using laryngeal ultrasonography. Inter-rater reliability was low, potentially due to the small sample size. It is aspired to develop a database with larger sample size in future studies.

Reflection

<u>Difficulties encountered and resolutions</u>

Involving young children as research participants was challenging. Some children exhibited uncooperative behaviours during data collection, such as reluctance to lie supine for neck extension, potentially due to discomfort with the shoulder roll. To resolve the challenge, the investigators applied principles of behavioral management, taking reference from our pediatric clinical experience as speech therapists under training at Speech, Language and Hearing Clinic, HKU last year. Positive reinforcement was provided once the desired behaviour was observed, providing tangible (e.g., snacks and drinks) and intangible rewards (e.g., verbal compliments, the opportunity to view their own vocal folds in ultrasound and explore with the ultrasound probe). As a result, participants' compliance and adherence to the procedures increased.

Other young participants may be unfamiliar with the operation of laryngeal ultrasonography, thus acting cautious about applying the probe on their anterior neck regions. As a solution, the investigators demonstrated the procedures on themselves and on hand puppies, also fostering children's understanding of the implementation and rationale of the research with child-friendly terminologies, allowing the participant to be familiarized and at ease with the procedures. Consequently, they were more willing to attempt the laryngeal examination.

<u>Improvements that could be made if the project were to be repeated</u>

During data collection, ultrasound gel was applied on the participants' anterior neck as a transducer to allow clearer imaging via ultrasound. However, difficulties with operation were noted. The gel prevented the probe from being in position, thus easily sliding away from the view of vocal folds, given that children had smaller anterior neck regions. As a result, the relocation of the probe on the participants' neck was time-consuming and might cause discomfort to the child. It is suggested that an ultrasound gel pad can be developed adapted to parameters of children's anterior neck (i.e., diameter, curvation), allowing smoother operation when scanning superficial structures. It can also act as a cushion to ease the pressure on the participants' neck, eliminating potential discomfort.

During data analysis, the measurements (i.e., vocal fold-arytenoid angle (VAA), maximum glottic angle (MGA), vocal fold length (VFL) and subglottic airway diameter (SAD) were manually plotted on the laryngeal ultrasound images by the investigators. However, there may be deviations of the plotting by hand, leading to discrepancy of quantitative data between raters, thus unable to achieve substantial inter-rater agreement. It is suggested to develop a program with artificial intelligence and big data, such that deep learning allows automatic plotting of parameters on the ultrasound images, ensuring reliability between individual raters.

<u>Impacts of the research beyond the classroom</u>

Prior to this project, there was limited research investigating the use of laryngeal ultrasonography in assessing pediatric voice by speech therapists in Hong Kong. By collecting normative data ranging from four- to eight-year-old participants, this project expands the local library of laryngeal ultrasound images of vocally healthy and unhealthy children, in hope of developing an extensive database with larger sample size to represent the general population.

In addition to exploring the use of laryngeal ultrasonography, this project advocates early identification and intervention of voice disorder in children. The majority of caregivers expressed primary concerns with their child's vocal conditions, as well as uncertainty with further actions to be done (i.e., assessment and treatment), reflecting inaccessibility to speech therapy services and limited voice-related information available to the public. Therefore, this project hopes to raise public awareness concerning dysphonia and encourage early identification.

Suggestions and extensions for further study

A database of laryngeal ultrasonographic images of children with and without voice disorders with a larger sample size can be developed in Hong Kong to represent the general population, thus establishing a solid foundation to further investigate its accuracy and possibility as a formal assessment tool for laryngeal disorders in near future. Normative data obtained from this project can also be applied in cross-cultural comparison, given that voice problems exist globally regardless of language differences.

The long-term goal of this research is to incorporate artificial intelligence into voice disorder diagnosis. Utilizing deep learning and big data, computers will automatically plot parameters in laryngeal ultrasound images, thus making plausible predictions and achieving inter-rater reliability. Additionally, as voice problems frequently occur in the school-age population, it is aspired that the examination can be widely adopted by school-based speech therapists for screening purposes in near future once the technique becomes more well-developed, thus encouraging early identification and intervention.

Acknowledgement

I would like to express my sincerest gratitude to Dr. Estella Ma for her guidance and supervision in making this project possible. My sincere thanks also goes to Dr. Alice Siu for her kind advice on implementation of ultrasonography and outcome measurements. I would also like to thank Wei Yi and research assistants at the Voice Research Lab, HKU for their kind support. Last but not least, I would like to thank my fellow principal investigator, Natalie, for our pleasant collaboration.

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Appendix

Appendix 1. Raw data of ultrasound measurements by rater 1 and 2

RATER	SUBJECT	AGE/SEX	VAA_AB_L	VAA_AB_R	VAA_AD_L	VAA_AD_R	MGA	VFL_L	VFL_R	SAD
1	1	4;2/M	133.137	149.406	112.415	121.925	49.478	6.799	7.456	8.22
	2	8;0/M	134.488	127.991	116	107.708	48.261	8.65	8.769	8.226
	3	6;0/M	115.942	112.166	96.144	99.909	47.563	5.346	5.88	9.431
	4	6;3/M	142.337	147.207	103.708	103.033	52.086	7.545	8.862	10.328
	5	4;7/M	101.432	105.952	105.86	96.402	26.463	5.672	5.427	8.293
	6	8;9/M	137.246	137.259	89.755	103.977	82.809	9.759	9.339	8.689
	7	5;2/M	134.725	136.374	92.306	110.814	47.777	5.318	5.248	7.999
2	1	4;2/M	135.176	147.908	95.721	102.712	53.333	6.224	6.573	8.468
	2	8;0/M	144.66	127.809	87.411	95.467	53.808	9.177	8.676	/
	3	6;0/M	136.797	155.056	72.985	78.775	55.153	5.968	6.132	8.549
	4	6;3/M	135.959	141.323	115.069	103.287	54.43	8.621	8.038	10.323
	5	4;7/M	121.117	95.32	105.244	100.068	40.364	10.749	11.593	6.936
	6	8;9/M	125.001	130.449	94.514	102.425	38.104	9.289	8.636	10.685
	7	5;2/M	129.027	107.606	106.952	102.873	34.536	6.888	6.796	9.2

Appendix 2. Raw data of ultrasound measurements of repeated administrations by rater 1

RATER	SUBJECT	AGE/SEX	VAA_AB_L	VAA_AB_R	VAA_AD_L	VAA_AD_R	MGA	VFL_L	VFL_R	SAD
1	1	4;2/M	133.137	149.406	112.415	121.925	49.478	6.799	7.456	8.22
	2	8;0/M	134.488	127.991	116	107.708	48.261	8.65	8.769	8.226
	3	6;0/M	115.942	112.166	96.144	99.909	47.563	5.346	5.88	9.431
	4	6;3/M	142.337	147.207	103.708	103.033	52.086	7.545	8.862	10.328
	5	4;7/M	101.432	105.952	105.86	96.402	26.463	5.672	5.427	8.293
	6	8;9/M	137.246	137.259	89.755	103.977	82.809	9.759	9.339	8.689
	7	5;2/M	134.725	136.374	92.306	110.814	47.777	5.318	5.248	7.999
2	1	4;2/M	133.317	133.909	114.169	108.943	44.135	6.992	7.537	8.618
	2	8;0/M	131.735	141.62	104.58	105.743	48.95	8.436	8.711	8.02
	3	6;0/M	125.647	117.911	92.383	92.84	56.246	5.435	5.438	9.837
	4	6;3/M	147.315	152.575	117.761	96.97	55.328	7.63	8.341	9.919
	5	4;7/M	97.441	112.738	113.199	115.454	27.312	6.051	5.868	8.226
	6	8;9/M	132.775	124.408	101.841	97.546	54.921	7.362	7.334	8.537
	7	5;2/M	134.1	127.958	102.324	103.671	55.918	7.684	7.7	8.279

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LAIDLAW SCHOLARS

TO BE COMPLETED BY HKU SUPERVISOR

I have examined the research report and rate the student's performance as satisfactory / ~~unsatisfactory~~ (*Please circle whichever is applicable*)

Comments:

Julianne is a very bright and conscientious student.

Being her supervisor, I have the opportunity to observe Julianne's ability in planning a research study and in handling challenges effectively. She learned how to perform ultrasound scanning quickly and demonstrated her competence in engaging children participants skillfully to undergo ultrasound scanning. This is not an easy task even though for experienced clinicians.

Julianne has proven herself to be an invaluable team member. She is always proactive in making suggestions to the project, and has made significant contributions to the study with her original ideas. Such level of leadership and critical thinking skills is outstanding for an undergraduate, and attests to Julianne's quality.

It has been a great pleasure working with Julianne on the project. I look forward to working on further voice projects with her.

Name: Dr Estella Ma Signature: ____________ Date: 29 Sept 2022