

1. Portfolio

Introduction and Rationale

In my practice, as a freelance vocal coach, I have the pleasure of teaching two young women with Down Syndrome ("DS"), in addition to 26 other singers without DS, every week.

During this Module, I will investigate relevant physical and physiological differences between singers with DS and singers without DS, and will consider the impact of these differences, together with any associated conditions and disorders, upon their singing voices. I will then consider ways in which I might help my DS students to strengthen and improve their singing voices, whilst enhancing their learning experience in my teaching studio.

My study will traverse several disciplines, drawing on research and intelligence published by practitioners and researchers across several fields, including medicine, speech therapy, physiotherapy, occupational therapy and psychology, to supplement literature published by vocal pedagogues and voice scientists. I hope that a multi-discipline literature review will enable me to obtain a sufficiently comprehensive picture and understanding of my chosen enquiry, such that I can use my findings to improve my teaching methods for my DS students.

The rationale for this study is my desire to research and understand the challenges faced by singers with Down Syndrome, with the aim of taking any steps possible to improve their singing experience. If I can acquire a detailed knowledge of the physiological differences and challenges faced by a singer with DS and the impact of these on their vocal mechanism and voice production, I may be able to devise ways of better navigating any challenges and work more knowledgeably and sympathetically with my DS students to improve their voices, their experiences in my studio, and their self-confidence and enjoyment of singing.

I am approaching my research from the perspective that every individual who wants to learn to sing should be supported, and shown how best to maximise their potential and to navigate their vocal challenges. Every voice is unique (Johar, 2016) and I wish to explore whether at least some of the issues commonly encountered by DS singers might be ameliorated with a different teaching approach.

One of my motivations in embarking upon this research is my personal knowledge, via my personal observations and information communicated to me from my DS students, of the importance which they attach to music and specifically their voice lessons, and the

enrichment that singing adds to their lives, not only for the enjoyment of creating music, but also for the way learning to sing enhances their linguistic skills, their social interactions and feelings of inclusion, their creativity and self-expression, their feelings of self-worth and self-confidence, and their mental health.

The information and self-perceived benefits shared with me by my DS students, are in line with the conclusions of studies conducted with participants from the general population, confirming the benefits of singing to physical and mental health and well-being. These benefits include improved breathing, voice quality and posture (Clift and Hancox, 2001), feelings of happiness and positivity (Bush & Gick, 2012; Livesay et al., 2012) a reduction in stress levels (Judd and Pooley, 2013; Linemann et al., 2017), increased feelings of comfort, relaxation and energy (Livesay et al., 2012; Mellor, 2013); cognitive stimulation (Livesay et al., 2012), social and musical connection with others (Stewart and Lonsdale, 2016; Vaillancourt et al., 2018) , and feelings of self-confidence, self-esteem and accomplishment (Busch and Gick, 2012, Livesay et al., 2012; Vaillancourt et al., 2018). What's more, it has been shown that listening to music engages a network of neurological functions, as it processes certain perceptual abilities such as pitch identification, auditory memory and selective attention (Peretz and Zatorre, 2005; Zatorre et al., 2007) and also engages the working memory mechanisms and auditory cognitive systems (Bella et al., 2003; Peretz and Zatorre, 2005). Participation in musical activity has a powerful emotional impact, in a manner which is highly rewarding (Geethanjali et al., 2018; de Manzano et al., 2010; Nakahara et al., 2011) and creating music with others increases social communication, cooperation and empathy (Koelsch, 2010; Koelsch et al., 2006). I hope that by conducting this research, I will obtain a better understanding of the challenges faced by DS voice students and then be able to adopt a more expert teaching approach, so as to facilitate my DS singers sharing in, to the fullest extent possible, all the benefits of singing that other singers enjoy.

I believe it is arguable from the obvious lack of literature regarding the singing voices and potential of individuals with DS, that this sector of the singing population does not receive sufficient consideration, and that there is perhaps a common perception that DS singers cannot be taught to sing well. However, in my view, we in the field should not underestimate the importance of music to DS individuals, nor their musical capabilities or their need and desire for a musical education, of which singing is foundational (Bonis et al., 1974). Charles Hoffer, a renowned music educator and researcher, stressed the importance of self-expression facilitated by music and the other art forms, and went so far as to say that the enrichment arising out of participation in the arts is the difference between merely existing in

life and of truly living (Hoffer, 2017). John Dewey, believed that every person is capable of being an artist and living an artful life of social interaction (Goldblatt, 2006). The renowned Hungarian composer and music education philosopher, Zoltan Kodaly, believed that every person has musical ability and that singing should be the foundation of all music education (Bonis et al., 1974). I hope that my research will help me to be more useful as a vocal tutor to my DS students and perhaps provide me with sufficient knowledge to be a resource for other vocal tutors in Hong Kong, encouraging them to treat individuals with DS as singers with potential, just as they would any other student. I also hope that, by sharing what I learn from this research, I can inspire more local vocal tutors to work with DS students.

Planned Programme of Study - Aims and Objectives:

Aims of the Project:

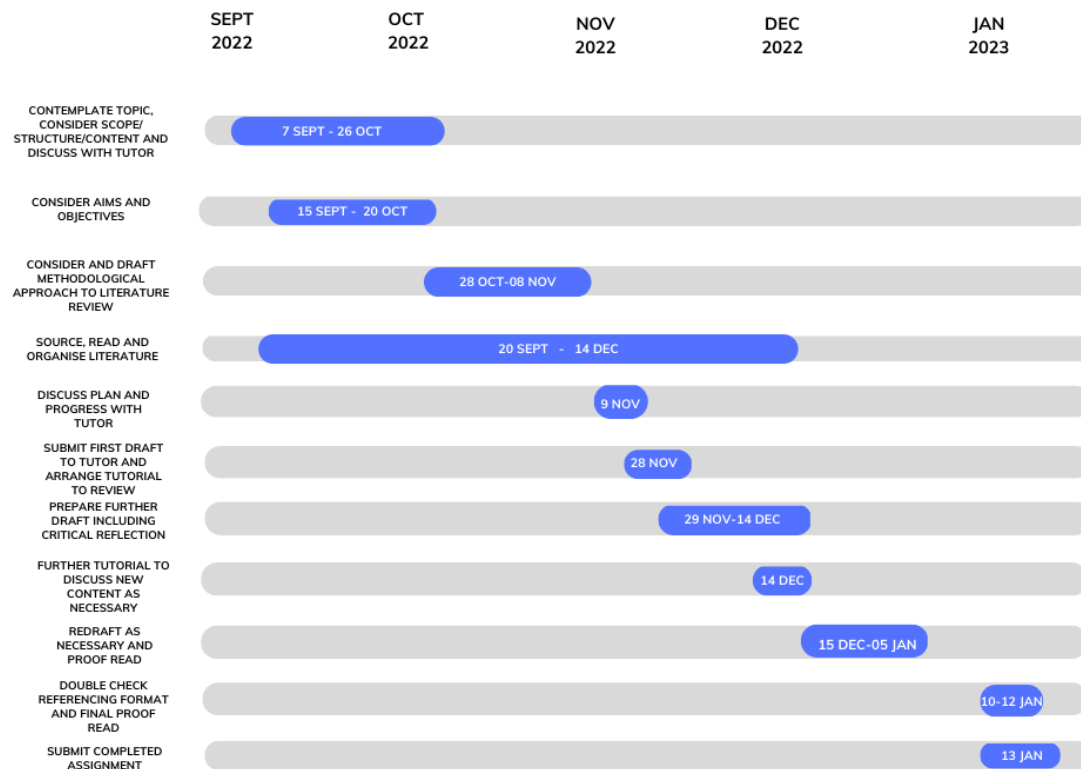
- To widen my knowledge and understanding of the challenges faced by singers with DS, and the anatomical features that create those challenges, so that I can better support them as students, ensuring that they sing safely and maximise their potential;
- To identify and consider as much relevant research as possible, across multiple disciplines, to give me the best information and most detailed understanding I can obtain from the literature, so that I can be a more effective tutor of DS students of singing;
- To secure a detailed understanding of the limitations of voice production in a singer with DS and the reasons for those limitations;
- To seek to alleviate some of the vocal challenges faced by my DS students, by exploring and applying information obtained from directly relevant or analogously relevant studies;
- To critically review my current approach to teaching Down Syndrome singers on the basis of the information obtained during my research, and to consider how I might develop a more sympathetic and effective tutoring programme for my DS students;

- To draw together and create a digital catalogue of all the relevant research I can find, which can be supplemented as further studies are published.
- To make available the information I compile, with other locally based vocal tutors, to encourage wider support of tuition for DS singers in Hong Kong;
- To broaden my knowledge of methodologies for executing a literature review so that I can achieve more efficient research skills and organisation.

Objectives of the Project

- To identify the significant researchers and contributors on my chosen field of enquiry, via a comprehensive search, across several disciplines, of relevant books, journals, research reports, dissertations, articles and any other sources of credible information available
- To critically analyse and compare information and data obtained from the literature, by conducting a comprehensive literature review;
- To consider how to incorporate information obtained from the literature into my practise;
- To consider whether, upon the basis of the knowledge acquired from my research, I can create teaching tools to assist and improve the learning experience of my DS students and, if appropriate, to progress this initiative in a further module of this course of study.
- To consider how I might share and disseminate important information obtained from my research with other voice teachers working with DS students.

The timeline below shows the timescales for implementing each stage of this Assignment:



Literature Review Process

As I reviewed relevant literature to research my enquiry and support my conclusions, I was mindful of the need to follow a methodology which would enable me to provide a reliable and trustworthy review for the reader (Snyder, 2019) and to create a foundation for advancing knowledge (Webster and Watson, 2002).

Whilst acknowledging the benefits of the very rigorous, structured and focussed methodology of the systematic review, I decided to adopt a narrative methodology to review the literature for this assignment, as I considered this to be more appropriate for the reasons stated below.

A systematic review is not necessarily superior to a narrative review, rather it is one characterised by tight focus, exhaustive searches, a high rejection-to-inclusion ratio and an emphasis on technical rather than interpretive synthesis methods to answer a narrow

question or enquiry (Greenhalgh et al., 2018). A narrative review has been described as a scholarly summary along with interpretation and critique (MacLure, 2005) and its main goal is to advance understanding and facilitate development (Dixon-Woods et al., 2006). The narrative approach represents my goals as regards my research of this topic, and although not a so-called systematic review, my research has nevertheless been conducted in a careful and systematic way, as described below.

In part, I chose the narrative methodology because my preliminary reading revealed a striking lack of data and information on my specific enquiry. The enormous amount of medically based literature which became apparent early on in my preliminary reading, did not contain data or information specific to my narrow enquiry as to the effects of Down Syndrome on the voice and upon the DS singer. Therefore, although this medical literature provided a useful education as to the main and potentially relevant features and challenges of Down Syndrome, it did not otherwise help me answer my specific enquiry. The lack of literature from vocal pedagogues necessitated a review of literature created across multiple other professional disciplines, such as Medicine, Speech Therapy, Occupational therapy, Physiotherapy, Psychology, to help me find some of the answers I needed to progress my research and think about how I could improve my tutoring of my DS students. The necessity of reviewing literature across multiple disciplines and the broad nature of my enquiry would have made a systematic review implausible in the context of this assignment.

I have therefore adopted a more descriptive review, which, in part, provides my subjective perspective on my topic, namely how, on the basis of what I have learnt through my research, I can help my DS students navigate the challenges they face when singing, and improve their learning experience in my studio. I acknowledge that my narrative review, although in part evidence based, does not contribute any scientific evidence to my line of enquiry. However I hope to use my research to provide convincing arguments and opinions, based on the published primary evidence that I have read, and to authentically represent in my assignment, both the underpinning evidence and how this evidence has been drawn upon and drawn together to support my conclusions (Greenhalgh et al., 2018).

Regardless of the methodology chosen, a literature search should be a systematic and well organised search of published data, to identify a breadth of credible references on a specific topic (Rau, 2004). I commenced my literature search on a broad basis and then filtered my approach to identify themes and specific lines of enquiry; this type of process which progresses from the general to the particular has been described as analytical reading (Hart, 2014, p.53).

I conducted a literature review process for the following purposes:

- To gain an understanding of the current status of research on my chosen topic and identify the most prominent themes and conflicts
- To identify gaps in relevant research which would justify my chosen enquiry
- To inform my methodological choices for this and any further research on my chosen topic

My chosen topic required me to review literature across several academic disciplines, including disciplines of which I had no knowledge or experience. This was a lengthy and challenging process, as I was unfamiliar with much of the terminology used in other disciplines, particularly medical terminology, from which I drew much of the information I used to research my topic, but as Hart says, 'if you cannot understand the vocabulary of a subject then you cannot analyse and evaluate the relevance of that research to your work' (2014, pg.113)

My preliminary reading suggested that I needed to bridge significant gaps in the literature pertaining to challenges faced by DS individuals, by using analogously relevant studies, for example, studies where groups of participants without Down Syndrome nevertheless shared common disorders which affected their singing voices.

My review of the literature was conducted using multiple electronic databases: Pubmed, Google Scholar, UWTSD Database, Voice Study Centre Database, Researchgate, Mendelay, MyBib and the Journal of Voice Database.

An initial search strategy was developed to highlight two main concepts: (1) features of Down Syndrome and (2) Down Syndrome singing.

In order to identify the number of features which might impact upon the voice, I began my research by focussing on medical literature and inputting very broad search terms, including "Down Syndrome", "features of Down Syndrome", "physical features of Down Syndrome", "characteristics of Down Syndrome", "children with Down Syndrome", adults with Down Syndrome", "impact of Down Syndrome", "effects of Down Syndrome" and "symptoms of Down Syndrome". This initial literature search ensured that I was aware of and could

therefore consider all aspects of Down Syndrome which could potentially affect the singing voice.

After identifying a list of physical features, symptoms and disorders associated with Down Syndrome, I was able to combine terms describing each feature with terms associated with the singing voice, to identify literature more specifically relevant to my chosen topic. So for example, I combined typical Down Syndrome features and disorders such as “hypotonia”, “macroglossia”, “respiratory disorder”, “pulmonary disorder”, “hoarseness”, “dysphonia”, “dyspnea” with typical vocal terms such as “voice”, “singing”, “singer”, “vocal tract”, “voice training”, “vocal folds”, “vocal cords”, “larynx”, “laryngeal”, “laryngeal muscles”, “tongue”, “pitch”, “resonance”, and “voice quality”, to attempt to find any literature exploring the links between these features or disorders associated with Down Syndrome, and the singing voice.

As I did not conduct a formal systematic review, I did not produce a rigid list of inclusion and exclusion criteria. I reviewed and included any relevant literature I could find and did not exclude any literature on the basis of its date of publication, although this was in any event self-limiting, since literature concerning the traits of Down Syndrome only started being published after identification of the genetic basis of Down Syndrome (Windsperger and Hoehl, 2021). I even included some literature regarding studies where participants did not have Down Syndrome, since it became apparent to me early on that I could learn more about the impact and potential improvement of challenges faced by Down Syndrome singers, by including certain studies where the participants did not have Down Syndrome, but nevertheless shared common traits and disorders, affecting their vocal production and sound in similar ways and for similar reasons. I excluded studies which dealt only with aspects of Down Syndrome affecting pre-natal, neo natal or children, too young in my view (even without Down Syndrome), to be taught to sing in any purposeful or trained way. I did not specifically exclude non-primary literature from my review, but found little that I attached any weight to when considering my conclusions and how best to adjust my teaching approach for my DS students. I very much favoured primary literature, as I intended the information obtained from this research to be used to devise appropriate exercises, and I wanted the exercises I created for my DS students to be inspired by credible, published work. As there was so little literature specifically dealing with my enquiry, I did not exclude studies with small numbers of participants, however where I was able to find more than one study investigating a matter that was relevant or analogously relevant to my enquiry, I relied more on those where a larger number of participants were involved (Moura et al., 2008; Pryce, 1994; Purely et al., 2008; Salgueirinho et al., 2016; Galambos et al., 2006).

In the early stages of my literature review, I deliberately excluded the terms “phonation” and “speech”, to avoid becoming overwhelmed with literature relating only to speech deficiencies associated with Down Syndrome, although in the latter stages of my research, I did undertake some specific searches on the impact of Down Syndrome on speech, to include a section on issues faced by Down Syndrome singers relating to enunciation, vowel formation and placement, and tongue control. As I read and learned more about the impact of Down Syndrome, not just upon the voice itself, but also upon the singing process and experience, I expanded my search terms to identify further literature relevant to the broader picture, for example the impact of compromised auditory function and eyesight upon Down Syndrome singers.

My initial list of electronic database resources was expanded, as I explored further references which I found included in the bibliographies of articles and studies which I had reviewed, leading me to a number of relevant text books (some of which I was able to borrow from my local public library and the library of City University of Hong Kong), as well as to websites, a number of medical and speech therapy online resources and other grey literature in the form of unpublished theses and videos which I reviewed more for interest than reliance.

Critical Reflection

I adopted Transformative Learning as my Reflective model; this best aligned with my initial intent, as well as the impact that my research study had upon my understanding of my chosen study and my intention to enhance and improve my teaching approach for my DS students.

The Transformative Learning model was first developed in 1981 by Meizrow. This theory results in changes to viewpoints, expectations, and assumptions after a transformative experience or situation. A transformative experience for me in relation to this research project has been the education provided by my extensive review of the literature broadly identified above, which has persuaded me to revise several of my prior perceptions, assumptions and expectations of my students with DS. Furthermore, my research has been transformative in that it has inspired my decision to adapt my teaching practice, in accordance with the information and knowledge I have now accumulated, and has additionally strengthened my commitment to my role as a vocal tutor, thereby leading to personal development.

The theory delivered by Meizrow in 1981 has been developed over the last four decades and now contains many further theories (Hoggan, 2015). As Hoggan (2015, p.71) describes, transformative learning refers broadly to “processes that result in significant and irreversible changes in the way a person experiences, conceptualizes, and interacts with the world”. I believe that my research study has been a process which has fundamentally altered my treatment and understanding of my topic of study, and moreover, that my research has shown me, inter alia, how important it is not to interact with others based on assumptions, rather than truths. In the case of my DS students, I've been making assumptions as to their vocal ability and potential, and I intend to use my research to see if any of my assumptions are incorrect, and if so, to devise a better way of teaching my DS students.

As I started investigating the literature in relation to the challenges faced by singers with DS, I quickly became aware of the lack of studies undertaken in the field of vocal pedagogy. Moreover, the studies that I did uncover, focussed more on confirming perceptions of the DS voice, rather than investigating any link between the presenting features of DS and the impact that these might have upon the vocal mechanism and voice production. I therefore found myself unable to take my research very far by consulting the literature available in the field of vocal pedagogy, and so embarked upon a much wider exploration of studies and information published by medical practitioners, medical researchers, speech therapists, occupational therapists, educational therapists and psychologists.

My first task was to educate myself as to the major relevant physical and physiological differences between persons with DS and those without this condition. I sought to identify features of DS that would specifically impact upon the entire system of voice production and delivery, dealing with each stage of the process, namely respiration, vibration and pitch, resonance and articulation. I initially cast my net wide by inputting very broad terms and strings of words, such as “Down Syndrome”; “Trisomy 21”; “features of Down Syndrome”; “Down syndrome Voices”. This very broad search criteria produced a vast number of articles and studies conducted with the field of medicine and I then read as many articles as was necessary to identify the major features of Down Syndrome. I then considered which of these features might impact upon vocal production and/or upon vocal experience and enjoyment and analysed the information obtained and considered how I could apply this to my teaching. After obtaining a broad base of information, from which I followed many trails initiated in the body of articles I read or within their bibliographies, I input more specific search terms such as “the impact of Down Syndrome on singing voice”; “Down Syndrome and respiration”; “Down Syndrome and the vocal tract” and obtained further information,

mostly from the fields of medicine and speech therapy.

As I began to digest and understand more about the true extent and nature of the challenges faced by DS singers, I realised that I needed to adopt a much more targeted approach to supporting my DS students and that there was potential to improve their experience in my teaching studio and perhaps also the quality of their vocal sound. I found it helpful to examine the possibilities from a non-emotional perspective (as this reflective model encourages), realising that with greater knowledge and understanding, I could employ a better teaching strategy than simply supporting my DS students with patience and encouragement. I formed the view, from reading about methods used to improve voices compromised by other disorders, most noticeably Parkinsons Disease, that certain exercises might improve aspects of voice production and quality, and I devised some exercises for my DS students, as attached at Appendix 1. My intention is to supplement these exercises, once I have tried these initial ones with my DS students and am able to observe and obtain feedback from the students as to which work best, are easiest for them to perform, and which are most fun and therefore most likely to be practised in between their lessons.

During the course of my research, the vast amount of literature, across multiple disciplines, was helpful in constructing both a “big picture” understanding and a more detailed appreciation of how Down Syndrome affects the singing voice.

Although researching the literature has been an extensive and difficult task across multiple disciplines, gathering as much information as possible, before distilling the same to retrieve the information most relevant to my enquiry, I believe that this was the correct approach to obtaining the significantly enhanced understanding that I now have of the challenges faced by singers with DS.

The referenced information I have obtained from the literature as to the positive impact and well-being that singing has upon individuals with DS, has, of itself, caused me to reflect upon the experiences I am trying to create for my wider student population and reminded me of the significance and responsibility of my role as their tutor. The challenge of researching detailed data in disciplines, previously foreign to me, has been both stimulating and personally satisfying and I feel that my work in this regard has resulted in a deeper level of self-understanding, as envisaged by this reflective theory.

2. Written Assignment

I intend to explore the challenges faced by a singer with DS in 3 parts:

- (i) I will examine the complex system of breathing, vibration, resonance and articulation that enables voice production and delivery in every singer, and then identify any common physical and physiological features caused by DS, which may alter or detrimentally impact any aspect of this system.
- (ii) I will research how these features, of themselves, may impact voice production and will also consider any link between these features and laryngeal problems or other disorders commonly suffered by singers with DS.
- (iii) Finally, I will consider how any typical or common DS features which are external to the vocal tract, such as nasal bone structure, poor muscle tone, restricted vision, hearing and memory retention, typically impact upon the singing experience of vocalists with DS.

Voice Production System

Within this section I will examine the voice production system, so as to facilitate a comparison between that of a singer without DS and that of a singer with DS. I will consider each of the essential components of voice production, and identify any impact on all or any of these processes caused by the physical and physiological differences found in a singer with DS.

The human voice produces and shapes sound using 4 basic parts. The activator (the breath) creates the initial energy required to activate the vibrator (the vocal folds) which then creates sound waves which are amplified by the resonator (chest, mouth, nose, head). Once produced, the sound is shaped by articulators (lips, tongue, jaw).

“From a phonatory point of view, voice is produced when the expiratory airflow from the lungs sets the closed vocal folds of the larynx into vibration, converting aerodynamic power generated by the thoracic and abdominal muscles (subglottal component) into the basic sound wave (acoustic power). This sound wave is further filtered and amplified by oral articulators, such as pharynx, tongue, palate, lips, and jaw (supraglottal component), and is

emitted from the mouth and nose as sound of voice”
(Simonyan and Horwitz, 2011, p.198)

Respiratory System

The breathing system adopted by the singer requires a high level of respiratory and abdominal muscle strength, coordination and control, particularly as regards the exhalation phase:

“While the expiratory forces are pressing air out of the lungs, the thoracic muscles are resisting the collapse of the lungs to control the expiratory pressure. The tonicity of the abdominal wall also participates in maintaining ribcage expansion and in controlling ascension of the diaphragm” (Desjardins and Bonilha, 2019).

Singers with DS have reduced pulmonary function and control. In a study conducted in 2015 (Salgueirinho, C. et al., 2016), several medical professionals compared, inter alia, the pulmonary function of adults with DS to that of adults not suffering from the condition. Thirty four adults, all under the age of 40, half of whom had DS, participated in the study, and were selected according to various inclusion and exclusion criteria, such that any variances between the two participant groups were confined to pulmonary function and activity. The participants undertook various lung function tests, namely forced expiratory volume in one second, forced vital capacity and the fraction of expiration in one second, and peak expiratory flow. As regards pulmonary function, the participants with DS showed significantly lower values for each test, confirming reduced pulmonary function within that group.

Factors contributing to reduced pulmonary function include;

- pulmonary hypertension
- pulmonary hypoplasia
- hypotonia and decreased respiratory muscle strength
- obesity

and these are all common features of individuals with DS. Within this next section, I will explore the research relating to each of these conditions and their effect on pulmonary

function, together with the implications for the singing voice of DS students.

Pulmonary Hypertension

Pulmonary hypertension is frequently diagnosed in individuals with DS (Bush and Ivy, 2022) and is believed to be caused by the disruption to formation of new blood vessels, leading to impairment of arterial and alveolar development in the lungs (pulmonary hypoplasia), in utero and continuing post-natal (Galambos et al., 2016). Pulmonary hypertension is the result of pressure in the blood vessels leading from the heart to the lungs being too high, causing thickening of the arterial walls, resulting in a number of serious symptoms, including shortness of breath (Dumitrescu et al., 2017; Naeije, 2014; Yorke and Armstrong, 2013; Laveneziana et al., 2012). Pulmonary tension can result in compression of the left recurrent laryngeal nerve, causing left vocal cord paralysis and hoarseness of voice (Albarqy et al., 2016). Further, the impairment of lung function caused by pulmonary hypertension results in dyspnoea, even at rest (Dumitrescu et al., 2017; Bush et al., 2017) and this naturally impacts upon the ability of the DS singer to produce sufficient and effective breath support for their voice, which compromises their singing. As Richard Miller writes, "Breath management is the essential foundation for all skilful vocalism" (Miller, 2000 p.32). In a similar vein, Richard Alderson writes that "breath is the foundation on which singing is established and good breathing is the basis for all good singing," (Alderson, 1979 p.28), and William Vennard states that "if his breathing can be improved his singing can also" (Vennard, 2012 p.18).

In a study carried out in 2021 (Mohamed et al., 2021), it was shown that both proprioceptive neuromuscular facilitation (PNF) of respiratory muscles (a stretching technique which improves muscle elasticity) and inspiratory muscle training, were effective in improving respiratory muscle strength, chest expansion, spirometry and functional capacity in a group of 45 children with Down Syndrome aged between 10-13 years. PNF has long been used to stretch respiratory muscles to improve pulmonary function and dyspnea (Ries et al., 1988). Whilst I am not qualified to administer PNF therapy, the significant body of studies indicating that this is beneficial for improving pulmonary activity in compromised individuals is useful knowledge, as I am aware that both my students with DS regularly attend physiotherapy sessions and adding PNF to their physiotherapy programmes may be something which I could suggest and encourage, to improve their dyspnea and assist their singing. There are also studies (Seo et al., 2015; Jun et al., 2016; Yong et al., 2017; Bhatnagar and Sharma, 2022) which suggest that breathing exercises also produce a significant improvement on pulmonary function and chest expansion. In these studies, feedback breathing exercises

with breath training devices were utilised, with positive effects (Jun et al., 2016;Yong et al., 2017) and in the Jun study (Jun et al., 2016) simple balloon blowing exercises were proven to improve the pulmonary function of elderly smokers. I have therefore added some fun exercises using balloons to my exercises in Appendix 1, to undertake with my DS students and will observe whether, over a period of time, these appear to have a positive impact on their breathing capacity and control when singing. If I perceive an improvement in pulmonary function with simple balloon exercises and these are tolerated without discomfort, I will discuss the use of adding exercise with the assistance of a breath training devices with each of my DS student's therapists, and if appropriate carry out this additional exercise during lessons, under my careful supervision.

Hypoplasia

Pulmonary hypoplasia, namely incomplete lung development is a typical feature of DS (Bush et al., 2017; Cooney and Thurlbeck,1982; Colvin and Yeager, 2017). Incomplete lung development commonly causes dyspnoea, frequent infections of the lower respiratory tract and recurrent bronchitis, all of which compromise the quality of respiration (Steiroopoulos et al., 2013).

I believe it is reasonable to hypothesise that compromised lung function and capacity resulting from incomplete lung development and abnormal lung structure, would negatively impact the breath support and control of a singer with DS. As pointed out by Espir, "Phonation is the production of vocal sounds resulting from the passage of currents of air through the larynx. The strength, tone, pitch and resonance of the voice area likewise dependent on the structure and neuro-muscular control of the laryngeal and respiratory systems" (Espir and Rose,1983, p.82).

Hypotonia and Decreased Respiratory strength

In addition to hypotonia of the skeletal muscles, individuals with DS commonly experience decreased respiratory muscle strength, affecting lung function (Costa et al., 2017). Studies have shown that individuals with DS have low respiratory pressure values, with maximum expiratory pressure values tending to be below 50% and maximal inspiratory pressure values tending to be below 60% of those expected of individuals without DS (Biasoli and Machado, 2006). Several articles written for medical journals have claimed that individuals with DS would benefit from muscle training to minimise future respiratory complications

(Furlan et al., 2015; Castoldi et al., 2012; Silva and Valadares, 2015).

In a study carried out to evaluate respiratory muscle force and expiratory flow, and to investigate the impact of posture on the respiratory performance of children with DS, it was concluded that children with DS, commonly exhibited postural challenges, together with diminished thoracic and lower respiratory muscle strength, and that these combined to decrease pulmonary ventilation, resulting in dyspnoea (shortness of breath) (Siqueira de Oliveira et al., 2014).

According to a study by Herrero et al. (Herrero et al., 2010), the inability to maintain quality of posture and movements affects the torso and alters the harmony of breathing mechanics, modifying thoracic and abdominal pressures. The authors concluded that assisted motor development balances the thorax and abdomen, maintaining a balance point between these two cavities, and thus adjusting lung capacity and volumes.

Although this study was conducted in relation to patients with cerebral palsy, it is reasonable to hypothesize that the similar hypotonia and compromised posture and movement amongst individuals with DS might respond to the improvement methods promoted in the study.

Accordingly, it might be useful to consider resources already familiar to singing tutors, such as the Alexander Technique, to assist DS singers to achieve better posture and movement, and better balance between the thorax and abdomen, which Herrero et al. (Herrero et al., 2010) claim will impact positively upon lung capacity and volume. In considering this, I am mindful, however, of other studies carried out, where any benefit of Alexander Technique to respiratory function and musical performance of musicians without DS, was reported as inconclusive (Klein et al., 2014).

Obesity

In 2019, a study was undertaken which provided one of the largest and most comprehensive evaluations of obesity in children with DS in the United States. (Pierce et al., 2019). The study found 20% higher rates of obesity in the 412 participants, who all had Down Syndrome and were aged between 2 and 23 years, when compared against the national rates of obesity.

Obesity in individuals with Down Syndrome affects both children (Stefanowicz-Bielska et al., 2020; Bertapelli et al., 2013; Bertapelli et al., 2016) and adults (Prasher, 1995; Merrick et al.,

2000;Havercamp et al., 2017; Tërshnjaku,2020). Studies have shown that compared to adults without disabilities, adults with DS are twice as likely to be overweight and that extreme obesity ($BMI \geq 40$) is four times higher in adults with DS (Rimmer and Wang, 2005). One study found that adolescents with Down syndrome are two to three times more likely to be obese than adolescents in the general population (Rimmer et al., 2010).

There is extensive literature and evidence that obesity negatively impacts pulmonary function, regardless of the cause of obesity (Sue, 1997; Li, 2003; Malfort et al., 2016; Dwivedi,2016; Johnson, 2019). The mechanical properties of the lungs and chest wall are altered significantly in obesity and these alterations reduce the compliance of the lungs, chest wall and entire respiratory system. The reduction in respiratory system compliance also alters the breathing pattern due to an increase in intra-abdominal and pleural pressures, caused by fat accumulating in the thoracic and abdominal cavities. This alteration of the breathing pattern results in a significant reduction in both the expiratory reserve volume and the resting volume of the lung, known as the functional residual capacity (Dixon et al., 2018; Jones et al., 2006; Pelosi et al.,1998; Steier et al.; Watson et al., 2005; Dwivedi, 2016). Put succinctly, “obesity significantly interferes with respiratory function by decreasing lung volume, particularly the expiratory reserve volume and functional residual capacity” (Mafort et al., 2016).

It is clear that individuals with Down Syndrome are likely to face challenges when breathing for singing, since they are typically overweight and in some cases obese, and their pulmonary function is already compromised, as indicated above. As a vocal tutor, I can explain the benefits of exercise for singing to my DS students and, whilst I believe that addressing any weight issues they may have is beyond my role, I can certainly support and encourage their healthy diet and exercise, particularly in view of my long term and very positive relationships with my current DS students. In due course, I intend to supplement the exercises currently included in Appendix 1 to this assignment with some gentle aerobic exercises to be carried out during our vocal warm up at the beginning of each lesson. I will endeavour to devise exercises which are fun to do and easy to remember, in the hope that my DS students will perform these exercises regularly themselves, as well as under my supervision during their lessons.

Vibratory System and Pitch Control

The second step towards voice production is vibration. Air expelled towards the vocal folds

by the coordinated action of the diaphragm and abdominal muscles, opens first the bottom and then the top of the vocal folds, which then close sequentially due to the low pressure created behind the fast moving air column (the Bernoulli effect) creating a vibratory cycle. The rapid pulses of air created by repeating vibratory cycles produce voiced sound.

Vocal fold movements are controlled by intrinsic and extrinsic laryngeal muscles, which may be compromised by the hypotonia commonly experienced by individuals with DS. We know that hypotonia affects the muscles of children and young adolescents with DS (Dey et al., 2013; Frith & Frith, 1974), however hypotonia may persist into adulthood and is mentioned in several papers which discuss healthcare and management for adults with DS (Jensen and Davis, 2012; Smith, 2001; Van Allen et al., 1999). Pryce (Pryce, 1994) believes that the hypotonia which so commonly affects the skeletal muscles of individuals with DS, also affects the extrinsic laryngeal muscles which hold the larynx in situ, and the tonicity of the pharyngeal walls which affect resonance.

In a singer without DS, the intrinsic laryngeal muscles work together to;

(i) adduct the vocal folds and close the glottis (thyroarytenoid, lateral cricoarytenoid, inter-arytenoid muscle),

(ii), abduct the vocal folds and open the glottis (posterior cricoarytenoid muscle)

(iii) adjust the length and tension of the vocal folds (cricothyroid muscle)

The extrinsic muscles on the other hand, connect the larynx with surrounding structures, such as the hyoid bone, sternum and pharynx, and also adjust the position of the larynx within the neck relative to the spine, to modulate vocal fold length, fundamental frequency, oro-pharyngeal resonance frequencies and formant structure (Simonyan et al., 2011).

As one of the most common manifestations observed in patients with DS is hypotonia of the masticatory and oropharyngeal muscles (Szyszka-Sommerfeld et al., 2022), I agree with Pryce (Pryce, 1994), that it is reasonable to hypothesise that hypotonia found in individuals with DS could extend to muscles in the vocal tract. If this is accepted, it is also reasonable to conclude that hypotonia could compromise the efficient adduction and abduction of the vocal cords, leading to issues of breathiness and poor pitch control. Further, Pryce believes that the characteristically gruff voice of an individual with DS may be caused by hypotonia of the

pharyngeal walls, and the harmonics picked up by the vibrations of the muscular walls of the vocal tract (Pryce, 1994).

There is a scarcity of material produced by vocal pedagogues, relating to differences in the structure or physiology of the vocal folds of individuals with DS, and the manner and rate of vibration. I have therefore considered articles and data from studies across related disciplines, such as those carried out by medical practitioners and speech therapists, to inform my research and to support my conclusions. Although it is beyond my ability to carry out a study focussing on the impact of DS upon the muscles within the larynx which control pitch, I am persuaded by the studies and literature I have read about the impact of DS on muscle tone generally, and, more specifically, upon muscle function and structure within the mouth and throat, that fundamental frequency and pitch control of individuals with DS could be caused, at least in part, by hypotonia within the laryngeal muscle group. The thyroarytenoid muscle and cricothyroid muscle are the primary controllers of vocal pitch (Belyk et al., 2018) and if these muscles are affected by hypotonia in individuals with DS, then it is reasonable to hypothesize that the typical poor pitch of a singer with DS could be caused by inefficient or inadequate muscle strength in those muscles which control the vocal folds. There is evidence that laryngomalacia, the medical term for floppiness of the laryngeal tissues above the vocal cords, exists in individuals with DS and can affect the arytenoid cartilages (Prescott, 1991, Roger et al., 1995). Further, it is well documented that hypotonia in DS individuals does affect the tongue and lips, creating oral dysfunction when swallowing (Frazier and Friedman, 1996; Kaczorowska et al., 2019; Miller & Leddy, 1998; Stoel-Gammon, 1997). I believe it is reasonable therefore to hypothesize that laryngeal muscles as well as other muscles in the oral cavity and throat may be affected by hypotonia in individuals with DS.

Another factor which might affect smooth vibration and pitch, is the level of elasticity of the vocal folds. The elasticity of the vocal folds found in individuals without DS, makes the folds pliable such that vibration can be achieved smoothly and efficiently (Zhang 2016; Moore and Thibeault, 2012). When the vocal folds vibrate, the superficial elastic tissue of the vocal fold is displaced in such a way that it creates a “mucosal wave”. This mucosal wave is dependent upon vocal fold structure, and therefore any physical alterations in the soft tissue bulk of the vocal folds will cause mucosal wave abnormalities (Krausert et al., 2010). If the mucosal wave is abnormal, it is reasonable to hypothesise that this could result in compromised pitch and perhaps other issues, such as hoarseness and strained phonation, thereby detrimentally impacting the overall quality of the voice. Laryngeal hypertension may affect the vibratory cycle and has been attributed as one of the causes of the gruff and

hoarse voices acknowledged to be a common feature of individuals with DS (Groves and Gray, 1985; Hollien and Copeland, 1965; Novach, 1972; Moran, 1986).

The scarcity of literature and lack of data concerning the impact of DS upon laryngeal aerodynamics (the airflow and pressure changes produced within the larynx) was recognised in a study carried out in 2019 (Pebbili et al., 2019). That study performed perceptual and laryngeal aerodynamic evaluations and found significantly increased sub glottal pressure and laryngeal adductor reflex in the participants with DS, and the authors concluded that the laryngeal hyper function identified was a plausible cause for the strained and guttural quality of voices of the DS participants.

It has been claimed that neurological disorders can also produce vocal fold tension which affects vibration frequency.(Hirose et al., 1995). Whilst Down Syndrome is a genetic disorder, it manifests in many systems throughout the body and has neurological complications (Lev and Melamed, 2002); I believe therefore that a worthwhile study might be to investigate whether individuals with DS commonly exhibit the same lack of vocal fold tension found in individuals suffering from neurological disorders such as Parkinsons disease, so that they might benefit from any treatment options identified for improving the vocal quality of individuals with neurological disorders.

Despite the factors mentioned above, it is interesting to note the conclusions of a number of studies which measured and compared fundamental frequencies of participants, including participants with DS. Vocal fundamental frequency (“f₀”) is the central tendency of the frequency of vibration of the vocal folds during connected speech (Baken & Orlikoff, 1987). A number of studies carried out between 1964 and 2010, cumulatively involving approximately 600 DS participants and focussing mainly on vocal fundamental frequency, concluded that the larynxes of individuals with DS produce vibration comparable to individuals without DS. (Michel and Carney,1964;Weinberg and Zlatin,1970; Novak, 1972; Pentz & Gilbert, 1983; Moura et al., 2008; Rodger, 2009). Data collected was both qualitative and quantitative, and whilst findings across all the studies were not conclusive, the majority reported no discernible difference between individuals with DS and participants without DS, when fundamental frequencies between participants were measured and compared. Evaluations relied on both perceptual and acoustic measurement methods, and some discrepancy has been noted between the two (Rodger, 2009) which may be due to the perception of lower

pitch in DS individuals being influenced by factors other than the actual frequency of vocal fold vibration (Kent and Vorperian, 2013).

The suggestion from the literature cited above that there is no significant difference in the vibratory process of singers with DS and those without DS, caused me to question my belief that the unreliable pitch of my students with DS was the result of differences in the vibratory process of their vocal tract. I now acknowledge that my limited experience of teaching singers with DS cannot support my previous assumption that all DS voices are significantly lower in pitch than their similarly aged counterparts without DS, since this may in fact be my perception rather than the reality.

It is also interesting to note the results of a study undertaken via acoustic reflection technique, which concluded that the typically small oral cavity of individuals with DS does not appear to impact the pharyngeal length, pharyngeal volume and vocal tract length, which were all measured within normal limits (Xue et al., 2010).

Resonance and Articulation

Resonance refers to the amplification of sound waves produced by vibrating vocal folds, as they pass through the hollow spaces of the pharynx, mouth and nose. The quality of resonance is affected by the breath force, which, as previously discussed is typically compromised in individuals with DS.

One of the characteristics of the Down Syndrome voice is nasality, a resonance distortion that may be related to velopharyngeal dysfunction. Individuals with DS, commonly exhibit velopharyngeal insufficiency which occurs when the sphincter muscle between the oral and nasal cavities doesn't close completely, causing air to escape through the nose instead of the mouth resulting in a muffled or nasal voice. In a study undertaken in 1980 (Kline and Hutchison, 1980), a marked increase in perceptually judged nasality as well as acoustically determined nasality reported in individuals with DS.

The surgeon and vocal scientist, Thomas Fillebrown (Fillebrown, 1911), emphasises the carrying power of resonant tone and the need to distinguish between nasality and nasal resonance – the former to be avoided, the latter to be cultivated. He identifies several causes of nasal tone, including a raised or stiffened tongue, a sagging soft palate, and a stiffened jaw; these features prevent free tone emission and are commonly exhibited by

individuals with DS.

In a study undertaken in 2009 (Lee et al., 2009), different aspects of intonation and phonation in the voices of people with DS were acoustically analysed. The results indicated that adults with Down syndrome exhibited a reduction in organic and laryngeal tessitura, little melodic variation and reduced intonation patterns.

Resonance is closely linked and affected by articulation. The main articulators are the tongue, the lips, the upper teeth, the alveolar ridge, the uvula, hard and soft palates, the pharyngeal wall and the glottis. Problems with these articulators will result in dysphonia (Catani et al., 2022).

In a recent study (Farpour et al., 2021) the lip and tongue strength and endurance of a small group of children with DS and a larger group of children of similar age without DS, was measured with an Iowa Oral Performance Instrument. The results showed that anterior and posterior tongue strength and lip strength and endurance were all significantly lower in children with DS. The strength of the tongue is relevant to my exploration of the challenges experienced by DS singers, because the position and shape of the tongue are critical elements of optimal acoustical resonance, impacting both resonance and laryngeal efficiency. It has been said that:

“The tongue, with its connections to the entirety of the vocal mechanism, should be the first point of investigation when diagnosing many vocal problems.” (Le Fevre and McCoy, 2011).

It would seem reasonable to presume that a lack of strength in the tongue might result in the tongue lying too flat in the mouth, or an inability to arch the tongue sufficiently to form vowel sounds with accuracy, since the hump of the tongue determines which harmonics are accentuated and therefore the vowel that we hear. Indeed the evidence of significantly weaker tongue strength in DS individuals correlates with the poor vowel formation that I hear in the singing voices of my DS students, and so I have endeavoured to find studies, not necessarily relating to DS individuals, where effective exercises to strengthen the tongue were explored and proven.

In 2017, a study was carried out in Hong Kong, to explore the effects of oral-pharyngeal motor training on children suffering from obstructive sleep apnea (Cheng et al., 2017) . In this study, which was aimed at finding ways to improve the respiratory function of children

with sleep apnea, ten children aged between 6 and 18 years participated in a training programme consisting of 10 individual mobilisation exercises involving the oro-facial and pharyngeal area. These exercises aimed to strengthen and correct improper function of the tongue and facial muscles. One of the outcome parameters that was chosen to determine the impact of the motor training exercises, was tongue strength and this was measured using the Iowa Oral Pressure Instrument. The study determined that an 8 week regime of the exercises undertaken by the participants significantly improved tongue strength.

In another study undertaken in 2009 (Guimarães et al., 2009), researchers investigated the impact of oropharyngeal exercises in patients with obstructive sleep apnea syndrome (OSAS). I was interested in the methods and results of this study since the test group suffered from upper airway occlusion, which is also suffered by many individuals with Down Syndrome (Mitchell et al., 2003; Bertrand et al., 2003; Southall et al., 2008) and the exercises made a significant and positive difference to the sleep apnea suffered by participants in this study, as well as showing a significant reduction in the neck circumference of participants, leading to the conclusion that the exercises (undertaken over a period of 3 months) resulted in a positive remodelling of the upper airway tract. As individuals with OSAS typically have an elongated and floppy soft palate and uvula, enlarged tongue, and inferior displacement of the hyoid bone (Sforza et al., 2000; Arens and Marcus, 2004; Davidson, 2003) there are parallels that can be drawn with features of Down Syndrome, and so I considered that exercises improving airway flow of OSAS patients might also be beneficial to individuals with DS, particularly singers with DS, where breath support is crucial to singing effectively.

The impressive results of the above studies inspired me to produce my own set of facial and pharyngeal mobilisation exercises for my DS students. The exercises I suggest in Appendix 1 are devised by me but are based upon information obtained by reading the studies above (Cheng et al., 2017; Guimarães et al., 2009). The exercises I have devised are presented within a colourful, illustrated chart, to hopefully make the exercises easy to remember and understand, with bright colours and illustrations hopefully adding to the appeal of this chart as a training tool, encouraging my DS students to participate. This will form part of a workplace based learning initiative, pursuant to which I will collect qualitative data, based upon my own observations and the observations and experiences of my DS students, to see if the preliminary set of exercises I have produced in my chart are beneficial to their voice production and quality, with particular attention paid to their vowel formation, diction and embouchure when singing. The exercise chart I have

prepared is attached as Appendix 1 to this assignment. I intend to supplement and develop this exercise chart progressively.

In addition to reduced tongue strength, individuals with DS exhibit apparent macroglossia, which is an enlargement of the tongue such that it protrudes beyond the alveolar ridge whilst in its resting position (Dieguez, 2008). However, interestingly, a study which measured the tongue using X-rays (Ardran et al., 1972) concluded that, in fact, macroglossia in Down syndrome could be an illusion, and that the perception of its size was due to the small size of the oral cavity typically found in individuals with DS; this was reviewed and agreed in more recent studies using an MRI, which concluded that individuals with Down Syndrome did not have true macroglossia, only tongues that were relatively large to their typically small oral cavities (Guimaraes et al., 2008; Mitchell, 2009). Further, studies revealed that the illusion of macroglossia was perpetuated by other typical features of individuals with DS, namely, hypotonia of the tongue and lower lip; the need to mouth breathe because of a small nasopharynx and disposition towards upper respiratory tract infections; large tonsils; and the protrusion of the lower jaw (Krmptotic-Nemanic and Schulz, 1970; Ardran et al., 1972; Purely et al., 1987; Yarom et al., 1987). Regardless of whether the tongue of a DS singer is objectively large or relatively large to their oral cavity, the tongue filling the oral cavity in this way may contribute to particular acoustic alterations, such as a lower fundamental frequency and decreased distinction between vowels (Moura et al., 2008). Further, structural differences in the lips, tongue and velopharynx, and difficulties coordinating speech movements involving the lips, tongue, velopharynx and larynx have been reported in individuals with DS (Barnes et al., 2006). However improvement in diction may be possible, and I have taken this into account when preparing the exercises shown in my Appendix 1; a large tongue or a forward or flattened tongue position would not of itself guarantee a decrease in speech clarity - normal speech can be found with any anatomical deviation if the individual has learned to compensate for the defect (Bloomer, 1957).

Other issues relating to vocal production and singing experience

There are other features and impairments, not discussed above, which may impact upon the voice quality and the singing experience of a vocal student with DS.

Some of these additional features are anatomical or physiological impairments, such as hypothyroidism, absence of facial sinuses, or anomalies in laryngeal structures (Benda,

1949;Novak et al. 1972;Leddy, 1996) which hamper the strength and quality of the singing voice. In a study carried out in 1994 (Pryce, 1994) microvolts used by participants when vocalising were measured, and it was reported that individuals with DS required almost twice the amount of energy to set in motion vocal fold vibration and initiate and sustain voice production.

Individuals with DS typically have restricted vision (Krinsky-McHale et al., 2013), lack of postural control (Guzman-Muñoz et al., 2017); hearing impairment (Manickam et al., 2016;Nightengale, 2018) and poor memory retention (Jarrold and Baddeley,2001; Godfrey and Lee, 2020; Landuran and N'Kaoua, 2020), all of which have a negative impact on the student's ability to sing. Problems with hearing, sight and memory retention may cause additional challenges for DS singers such as poor pitch, difficulty reading music or lyrics, and difficulty recalling lyrics, melody or form of songs.

Other issues which may also impact a DS vocal student, include a tendency to dehydrate (Lazenby, 2007), problems with comprehension (Morgan et al., 2004), problems with communication (Jackson et al., 2014), lack of self confidence (Cunningham et al., 2004), difficulties with socialisation (Barisnikov and Lejeune, 2018), and depression (Garvía Peñuelas, 2010). I intend to comprehensively explore these other issues in future research relating to the challenges faced by singers with Down Syndrome.