The impact of vocal load on the vocal function of professional music theatre singers

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A thesis submitted in total fulfillment of the requirements for the degree of
Doctor of Philosophy

Department of Surgery

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Notice 1

Notice 2

Supervisors-

Professor Julian Smith (Principal supervisor) and Mr Neil Vallance (Co-supervisor)

Associate Professor Susan Thibeault and Professor Michael Benninger
(Adjunct Supervisors)

I dedicate this thesis to my truly inspirational and beloved father

Graeme John Law

who is forever in my heart xx

Contents

Monash University
Declaration for thesis based on conjointly published work

General Declaration

In accordance with Monash University Doctorate Regulation 17.2 Doctor of Philosophy and Research Master's regulations the following declarations are made:

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes three original papers published in peer reviewed journals. The core theme of the thesis is The impact of vocal load on vocal function of professional music theatre singers. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the candidate, working within the Faculty of Medicine, Nursing and Health Sciences under the supervision of Professor Julian Smith.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapters 3-5 my contribution to the work involved the following:

Thesis chapter	Publication title	Publication status*	Nature and extent of candidate's contribution
3	Perspectives on the impact on vocal function of heavy vocal load among working professional music theater performers	Published	Primary author and contributor >80% of conceptualisation, design, data collection, analysis, manuscript writing & preparation
4	Development and preliminary validation of the EASE: A tool to measure perceived singing voice function	Published	Primary Author and contributor >75% of conceptualisation, design, data collection, analysis, manuscript writing & preparation
5	Measuring vocal function in professional music theatre singers: Construct validation of the Evaluation of the Ability to Sing Easily ASE	Published	Primary author and contributor >80% of conceptualisation, design, data collection, analysis, manuscript writing & preparation

I have not renumbered sections of published papers in order to generate a consistent presentation within the thesis.

Signed: [redacted]……

Date: …18th November 2014……

Thesis Overview

Working singers rely on a vocal mechanism that can meet performance demands and be so-called ‘‘performance-fit.’’ Professional singers must be vocal athletes to meet the rigors of performance requirements. Typically, performances require extreme vocal loads in terms of measures of vocal function (intensity, frequency, and duration) and may be repeated four to eight times per week often under less than ideal conditions. Although the singer population has not been well studied, anecdotal reports suggest that it is a normal occurrence for performance-fit singers to experience positive and negative variabilities in vocal function across time and performances and significant fatigue effects after heavy vocal load. Whether these experiences are transient or whether, if sustained or cumulative, they can become symptomatic of vocal impairment and thereby threaten short- or long-term vocal health is not known. There is an obvious need to measure these vocal status shifts to determine vocal load thresholds and to establish normative data for working singers. Furthermore, prediction and management of vocal injury among singers is predicated on assumptions as to what constitutes normal.

Vocal function among working professional singers had not hitherto been systematically measured using reliable and valid tools. This thesis (including three published papers) introduces EASE, a self-report tool designed to measure singers’ perceptions of the physical state of the singing voice. The psychometric properties of EASE are evaluated and differences in EASE performance according to demographic and voice-use characteristics among professional music theatre singers are explored.

The format of the dissertation is ‘Thesis by Publication’ and comprises three published studies. A fourth study will be prepared for publication and represents a continuation and extension of the research described herein. However, it is not included in the dissertation as it is considered to exceed the scope of this doctorate.

Acknowledgements

I have been on a wonderful journey for which I am truly grateful. The opportunity to pursue this goal, to be auspiced and supported to learn, explore and satiate my curiosity, to be supervised and advised by expert and generous mentors, and to work with a subject population that inspires and fuels my energy is indeed a privilege.

I am indepted to so many people as there are many who have made valuable contributions to this process. First, I wish to express my deepest gratitude towards my supervisors. In particular, their complementary approaches provided an excellent and balanced learning opportunity for me.

I extend my heartfelt thanks firstly to Professor Julian Smith who took me under his care even though my area of research endeavour was in a completely different sphere than his own academic interests and activities. Throughout the doctoral process, Julian has been exceptionally responsive, supportive and expert in his role as my primary supervisor and I thank him sincerely. I also thank him and the Department of Surgery for the scholarship and other financial support and thank his wonderful secretary Mira Petrazulek for her efficiency in managing logistics and her interest in my wellbeing.

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To my adjunct supervisors Susan Thibeault and Michael Benninger, I give big thanks for their willingness to be part of this journey across the seas, exceptional content supervision during the term of my candidature and valued friendships. I have felt part of the Madison UW postgraduate family over the past four years thanks to Susan's generous hospitality and regular inclusion of me in bi-annual symposia and Department meetings (including the skypes across time zones frequently in the dead of the night). I also thank her for being so welcoming and hosting me in her home with her lovely family. I have relished her high expectations and candour, her speedy and extraordinary brain and her

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I also extend my warm thanks to Ken Greenwood who was an adjunct supervisor for the first year of my candidature but understandably was unable to continue with this role once he moved interstate. I am very pleased however that he was part of the initial phase and guided me in the project design with his habitual humour, skill and patience.

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To my family, especially my mum and dad, Coral and Graeme Law, I owe so much and am truly grateful they instilled me with a sense of self-belief and inquiry by their inspiring examples, active encouragement, pride in all our achievements and continual love and support. I am especially proud of Mum over this past year as she has shown me how to be truly courageous in the face of great adversity and loss. To have lost Dad during this doctoral process is beyond words but I know his big heart also carried me through the last phase.

To my gorgeous boys Tom & Joey, I apologise for the many compromises in time and attention they have had to endure and I thank them for being so understanding and supportive. For his love, unfailing emotional and practical support during all stages of this research, I will always be indebted to my husband and best friend, Chris Phyland. He was beside me every step of this journey and gave more than I should have asked for and more than I deserved. I love you to bits Chris and count myself the luckiest girl around.

Published Study 1

Phyland, D.J., Thibeault, S.L., Benninger, M.S., Vallance, N., Greenwood, K.M., & Smith, J.A. (2013). Perspectives on the Impact on Vocal Function of Heavy Vocal Load Among Working Professional Music Theater Performers. Journal of Voice, 27 (3): 390-31e.

Abstract 1

Music theatre singers (MTS) typically have a heavy vocal load, but the impact on their voices has not been previously evaluated. A group of 49 MTS from two professional productions were administered the Singing Voice Handicap Index (SVHI). Responses for the SVHI demonstrated that, although the SVHI supported the performers' self-report of healthy vocal status, it lacked the sensitivity to detect potential subtle fluctuations or changes in physical functioning of the voice for working singers. Secondarily, descriptive data regarding professional working singers' perspectives were collected regarding how their singing voices typically responded to performing in a music theater production after a show, across a working week, and across a production season. Seventy-nine currently performing MTS were involved in a series of focus group interviews (n =43) or a written survey (n = 36) to detail their perception of the impact of performing in an eight-show per week professional production on their vocal function and vocal health. Thematic analysis revealed the MTS commonly perceived transient and variable changes in their singing voice status in both positive and negative directions after heavy vocal load. Based on these data, a list of 97 descriptors of these perceptual changes was generated using the singers' own terminology and experiences. These included symptoms of vocal impairment and vocal fatigue but also some novel descriptors of positive vocal changes to the physical functioning of the singing voice as a perceived consequence of heavy vocal load. This study offers new and valuable insights into performers' perceptions of the impact of performing in a musical theater production on physical aspects of vocal function.

Published Study 2

Phyland, D.J., Pallant, J., Benninger, M.S., Thibeault, S.L., Greenwood, K.M., Vallance, N., and Smith, J.A. (2013). Development and Preliminary Validation of the EASE: A Tool to Measure Perceived Singing Voice Function. *Journal of Voice*, 27 (4): 454-462.

Abstract 2

Objectives. *Most voice self-rating tools are disease-specific measures and are not suitable for use with healthy voice users. There is a need for a tool that is sensitive to the subtleties of a singer's voice and to perceived physical changes in the singing voice mechanism as a function of load. The aim of this study was to devise and validate a scale to assess singer's perceptions of the current status of their singing voice.*

Methods. *Ninety-five vocal health descriptors were collected from focus group interviews of singers. These were reviewed by 25 currently performing music theater (MT) singers. Based on a consensus technique, the number of descriptors was decreased to 42 items. These were administered to a sample of 284 professional MT singers using an online survey to evaluate their perception of current singing voice status.*

Results. *Principal component analysis identified two subsets of items. Rasch analysis was used to evaluate and refine these sets of items to form two 10-item subscales. Both subscales demonstrated good overall fit to the Rasch model, no differential item functioning by sex or age, and good internal consistency reliability. The two subscales were strongly correlated and subsequent Rasch analysis supported their combination to form a single 20-item scale with good psychometric properties.*

Conclusions. *The Evaluation of the Ability to Sing Easily (EASE) is a concise clinical tool to assess singer's perceptions of the current status of their singing voice with good measurement properties. EASE may prove a useful tool to measure changes in the singing voice as indicators of the effect of vocal load. Furthermore, it may offer a valuable means for the prediction or screening of singers ''at risk'' of developing voice disorders.*

Published Study 3

Phyland, D.J., Pallant, J.F., Thibeault, S.L., Benninger, M.S., Vallance, N., & Smith, J.A. (2014). Measuring Vocal Function in Professional Music Theater Singers: Construct Validation of the Evaluation of the Ability to Sing Easily (EASE). Folia Phoniatrica et Logopaedica, 66(3), 100-108.

Overview: *Working music theatre singers (MTS) typically have a heavy vocal load and measurement of the impact of this load on vocal function is problematic. In this study, the singer self-report tool, EASE, is used to assess MTS' perceptions of their current singing voice status. The aims are to compare scores across different demographic and performance characteristics and to evaluate the external validity of EASE and its' subscales.*

Methods: *Professional MTS (n=284) completed an online survey including all twenty items from the EASE (including the two subscales named Vocal Fatigue (VF) and Pathologic Risk Indicator (PRI) plus two additional vocal concern (VC) items. Scores were compared across the variables of age, gender, whether currently working in a music theatre production, role, perceived vocal load over past 24 hours and perception as to whether currently experiencing a voice problem.*

Results: *Statistically significant group differences in the total EASE or subscale were found for all variables except gender. Younger performers were more likely to report higher scores on all EASE scales than older performers, as were those holding a supporting lead role compared to swing or alternate roles. Similarly for the total EASE and all subscales, higher scores were reported by those perceiving themselves to currently have a problem with their voice. MTS currently in a musical recorded significantly higher scores than those not performing on the VF (p=.002) and Total (p=.014), however no statistically significant differences were detected on PRI or VC. Significantly higher VF scores were recorded for those singers who recorded heavy vocal load (p=.0001) but there were no differences on the PRI or VC subscales.*

Conclusions*: Group differences in perceived singing voice function as measured by EASE among working MTS were demonstrated according to several demographic or voice-use characteristics. Scores on the EASE subscales differed across some of these variables justifying the recommendation to score these separately. These findings*

provide further validation of EASE as a useful tool for measuring singers' perceptions of vocal function. Evaluation of the predictive validity of EASE by comparison with objective clinical assessments such as videostroboscopy is now recommended.

Publications, conference presentations, awards and grants obtained during Doctoral Candidature

1. International conference presentations directly related to doctoral research

2011 Pan European Voice Otolaryngology Conference, 4 days, Marseilles, France
Paper- *A new tool proposed for singer self-assessment of vocal status*
Debra Phyland*, Michael S. Benninger, Susan Thibeault, Ken Greenwood, Neil Vallance & Julian Smith

2013 42nd Annual Symposium: Care of the Professional Voice, Philadelphia, USA
Paper-*Development and preliminary validation of a tool to measure perceived singing voice function (EASE)*
Debra Phyland*, Michael S. Benninger, Susan Thibeault, Julie Pallant, Neil Vallance & Julian Smith

2013 International Congress of Voice Teachers, Brisbane, Queensland
Paper- *There's no vocal business like show business*
Debra Phyland*, Michael S. Benninger, Susan Thibeault, Julie Pallant, Neil Vallance & Julian Smith

2013 International Congress of Voice Teachers, Brisbane, Queensland
Paper-*There's no vocal business like show business.*
Debra Phyland*, Michael S. Benninger, Susan Thibeault, Julie Pallant, Neil Vallance & Julian Smith

2013 Australian Voice Association 'Healing the Voice' Brisbane, Queensland
Paper-*Singers and performance fitness*. Debra Phyland*

2014 2nd Laryngology Society of Australasia Conference, Hobart, Tasmania
Paper-*Measuring Vocal Function in Professional Music Theatre Singers: Evaluation of the Ability to Sing Easily (EASE).*
Debra Phyland*, Neil Vallance & Julian Smith

* Primary author and presenter

2. Financial Grants

2010-2013 Postgraduate Scholarship-Faculty of Medicine, Nursing & Health Sciences
2013 Postgraduate Monash University Travel Grant
2011 & 2014 Faculty of Medicine, Nursing & Health Sciences-travel support

3. Awards

2014 Awarded Fellow Category- Speech Pathology Association of Australia
2014 Awarded 'Outstanding contribution to performance and voice in Australia' Australian Voice Association
2012 Recipient of Green Room Award (Victoria State Government, Department of Arts) 'Outstanding Contribution to the Melbourne Stage'
2010 Recipient of Elinor Wray Award for Innovation, Promotion & Outstanding Contribution to Speech Pathology, Speech Pathology Australia Association, http://www.speechpathologyaustralia.org.au/library/Media_Releases/Speechie_to_the_stars_wins_highest_award.pdfs

4. Additional publications and presentations conducted during candidature not directly

related to doctoral research

Publications

1. Tay, E., Phyland, D. & Oates, J.M. (2012) The effect of Vocal Function Exercises on the voice of ageing community choral singers, Journal of Voice, 26 (5), 672-675.

2. Phyland, D. Resonant Voice therapy. In Behrman, A & Haskell, J., (ed) Exercises for Voice Therapy, 2nd edition. Plural Publishing, San Diego, CA, 2013.

3. Phyland, D. Teaching Loud Speech. In Behrman, A & Haskell, J., Exercises for Voice Therapy, 2nd edition. Plural Publishing, San Diego, CA, 2013.

4. Low, K., Lau, K. K., Holmes, P., Crossett, M., Vallance, N., Phyland, D., ... & Bardin, P. G. (2011). Abnormal vocal cord function in difficult-to-treat asthma. American Journal of Respiratory and Critical Care Medicine, 184(1), 50-56.

5. Perju-Dumbrava, L.D., Phyland, D.J., Lau, K.K., Finlay, P., Antonopoulos, V., Kempster, P., Bardin, P.G., Stuckey, S.L., & Thyagarajan, D. (2012) Multimodal assessment of vocal cord function in early Parkinson's disease and essential tremor, Movement Disorders, 6, 27.

6. Low, K., Lau, K.K., Holmes, P., Crossett, M., Vallance, N.A, Phyland, D., Hamza, K., Hamilton, G., & Bardin, P.G. (2012). Difficult-to-treat asthma or vocal cord dysfunction? American journal of respiratory and critical care medicine, 185(3), 340-341.

Conference presentations (not exhaustive)

2011 Co-convenor, ASOHNS Pre-conference Voice workshop, Melbourne
2012 11th Phonosurgery Symposium, Madison, Wisconsin, USA
2012 Co-convenor, Australia & Pacific Laryngology & Swallowing Conference, Melbourne
2012 Singing in Schools, Australian National Association Teachers Singing (ANATS), Melbourne
2013 42nd Annual Symposium: Care of the Professional Voice, Philadelphia, USA
2013 9th Asia Pacific Parkinson Meeting, Sydney Australia
2013 17th International Congress of Parkinson's Disease & Movement Disorders Conference, Sydney Australia
2013 International Congress of Voice Teachers Brisbane, Queensland
2014 The Voices of Music Theatre (2 day) conference, ANATS, Melbourne
2014 12th Phonosurgery Symposium, Madison, Wisconsin, USA
2014 2nd Laryngology Society Australasia Conference, Hobart, Tasmania

Professional training media-author and presenter

Phyland, D.J. The Voice Independent Study Resource: Reverberating Good Vibrations, Speech Pathology Australia, 2010 (4 hour commissioned training DVD for Overseas & Re-entry Program)

Chapter 1

LITERATURE REVIEW

1.1 Introduction

Extraordinary vocal function is an essential requisite of performance for professional singers and entails optimal, efficient and enduring access to pitch, loudness and quality extremes. A singer relies on the health of the vocal instrument and the determination of performance fitness is predicated on decisions related to the status of vocal function at the time. Vocal function among working professional singers has not been systematically measured using reliable and valid tools, even though reports abound that this may alter after a large vocal load. Music theatre performers (MTP) are one singer group that, due to the regular, sustained and repetitive performances associated with the genre, make them a unique voice-user population to investigate the effect of vocal load. Although MTPs have been shown to have a heavy vocal load, the impact of this load on vocal function immediately after a show and across shows and seasons has not been reported.

In the following review of the literature, the impact of heavy vocal demands on singers, and the potential risks to vocal health, are explored. Heavy vocal load has been causally associated with the development of voice disorders, although the exact relationship and thresholds for acquiring laryngeal pathology require further elucidation and surprisingly little is known about the development of voice disorders among singers. Further understanding of the short term and

cumulative effect on the vocal folds of performing as a singer and the nature and prevalence of voice problems among singers is crucial to the determination of appropriate prevention and therapeutic management.

1. 2 Singers as heavy voice-users

1.2.1 Singers in general

Differences between singers and non-singers in their occupational voice use, vocal demands and vocal health awareness have been well described (Behlau, Zambon, & Madazio, 2014; Benninger, Jacobson, & Johnson, 1994; Brown Jr, 2000; Phyland, Greenwood, & Oates, 1999; Sapir, Mathers-Schmidt, & Larson, 1996). In general, singing requires the use of greater vocal ranges (e.g., pitch, loudness and quality) than speaking, and like other professional voice-users, singers use their voice more often, for longer periods of time and frequently under less than ideal conditions for vocal health than most non-professional voice users because of inherent occupational voice demands. These occupational demands may include extensive performance and rehearsal schedules, limited periods of vocal rest, high stress and anxiety levels and singing in poor environmental conditions (Batza, 1971; Benninger et al., 1994; Phyland, 1998; Sataloff, 1991; Shewell, 2009; Stemple, 2000). For example, a singer may be required to sing with a loud orchestra without amplification or in a venue with poor acoustics and high levels of background noise and/or smokiness. For these reasons, within the scientific literature, singers have typically been ranked as the highest voice user group on a hierarchy of vocal demands (Benninger et al., 1994; Petty, 2011; Sataloff, 1991).

In addition to the vocal demands for singing, singers can also differ from non-singers within the general population in their vocal demands related to the speaking voice (Phyland, 1998; Stemple, 2000). Specifically, the lifestyles of singers may inherently involve periods of excessive non-performance socialising, frequent public appearances, promotions and speeches and the use of potentially abusive vocal behaviours such as loud talking while backstage or at parties (Eller, Skylv, Dahlin, Suadicini, & Gyntelberg, 1992; Phyland, 1998). The environmental conditions of such voice use typically involve high levels of background noise and are considered to be detrimental to vocal health (Benninger & Murry, 2006; Sataloff, 1991; Stemple, 1993a). In addition, many singers, particularly those involved in musical theatre may be required to speak, yell and make other vocally demanding sounds in performance contexts as well as sing. Singers also frequently have teaching roles which can require extended periods of voice use (Fritzell, 1996; Phyland, 1998). Singers therefore have greater vocal requirements than the general population due to their singing and, similar to other professional voice users, their vocal demands for speaking (Benninger et al., 1994; Phyland et al., 1999; Sataloff, 1991; Van der Merwe, Van Tonder, Pretorius, & Crous, 1995).

1.2.2 Music theatre performers

Music theatre singers, like all singers could be considered vocal ‘athletes’ in the sense that they have to execute complex phonatory manoevres and require endurance, flexibility and vocal tract control that exceed requirements of the speaking voice. By virtue of the inherent vocal demands associated with this genre, these singers may well represent one of the heaviest voice-user groups within the singing population.

Music theatre refers to a performance genre in which musicals represent the principal performance form, although cabaret and vaudeville can also be included in this category.

> *"The 'musical' eludes easy definition….so it is probably best to begin by defining it broadly as a type of performance made up of the basic creative processes that all such practices have in common. These include, above all, talking (almost always), singing (most often accompanied by unseen instruments) and dancing (generally mixed and interspersed with other kinds of movement)". p.2-3* (Stempel, 2013).

Julian Woodford similarly defined musicals as "theatrical presentations where the story is communicated through speech, music and movement in an integrated fashion to create a unified whole" (Woodford, 2012).

In this thesis, the term music theatre refers to a genre of musicals typically associated with Broadway or London's West End regions, as distinct from opera, contemporary opera productions, experimental theatre or rock concerts (Salzman, 2008). They represent a form of theatre and dramatic story-telling based in music and dance and the majority of contemporary Broadway productions are produced as mega-musicals- "Integrated musicals, with large budgets, epic storylines, lavish sets and imposing orchestras, tend to be hits that are extended for multiple runs and achieve evergreen status, being reproduced for many years to come" (Yeoh, 2011) p. 9).

When assigning the musical theatre genre to a singer taxonomy for the purpose of scientific research on vocal requirements, Bunch and Chapman (2000) categorized the

music theatre population into two groups (musical theatre and contemporary music theatre) (Bunch & Chapman, 2000). It is presumed that this classification delineates traditional classical styles from rock and popular but the criterion for each group is not given and the differences between traditional and contemporary musical theatre forms are not obvious (Atkey, 2013; Ewen, 1970; Jones, 2003). Within contemporary musicals, the music styles may range from classical to rock and conversely many of the traditional musical comedies employed non-classical vocal styles, such as belt. A prime example is afforded in the belt voice used in the role of Mama Rose for her signature song 'Everything's Coming Up Roses', played famously by Ethel Merman in the 1959 musical theatre show Gypsy (Knapp, Morris, & Wolf, 2011). It is therefore difficult to dichotomize shows or singers according to the voice requirements or musical era, as there may be a variety of styles within and across shows.

Musicals can significantly differ from one another in the quantity and type of speaking, singing, and dancing, and in the scale of production (for e.g., the cast number, size of stage and theatre). What is common to this genre, however, is that performance requirements are typically different and distinguishable from other singer groups, as music theatre singers may be required to dance while singing, use character voices in dialogue, yell, scream and produce prolonged excessive voicing by performing eight shows per week over five or six days for extended production seasons without vocal rest (Eller et al., 1992; Evans, Evans, Carvajal, & Perry, 1996). Music theatre production seasons can last for weeks to years, depending on the nature and success of the production (Jones, 2003; Phyland, 1998; Phyland et al., 1999; Strong, 1988). Lifestyle characteristics of performing music theatre singers (such as

disrupted sleep patterns, mealtimes and domestic routines, extended periods away from home etc.) may also differ from singers of other genres and to those music theatre singers not involved in a production due to the performance demands, scheduling and potential touring requirements (Eller et al., 1992). In addition, there are specific environmental influences on the music theatre voice which may be challenging to vocal health, such as singing across sound effects and with stage smoke, loud orchestration, limited humidification and limited or no foldback (Richter, Löhle, Knapp, Weikert, Schlömicher-Thier, & Verdolini, 2002; Richter, Löhle, Maier, Kliemann, & Verdolini, 2000).

Singers within and across music theatre productions typically sing a wide variety of vocal styles such as pop/rock, opera, legit, belt, broadway mix and belt mix (Bourne & Garnier, 2010; Bourne & Garnier, 2012; Bourne, Garnier, & Kenny, 2011; Green, Freeman, Edwards, & Meyer, 2014; Lader, 2013; Melton, 2013; Osborne, 1979). Some of these styles of singing particularly belt and belt mix, are considered vocally demanding, and may be more so than those vocal styles principally used in other genres such as jazz, folk and opera, although this has not been unequivocally established (Björkner, 2006; Bjorkner, Sundberg, Cleveland, & Stone, 2006) (Björkner, 2008; Edwin, 2008; Lader, 2013; LeBorgne, Lee, Stemple, & Bush, 2010; Osborne, 1979; Spivey, 2008). Some contemporary productions comprise multiple vocal styles within the same musical show and singer may be required to interchange between styles such as opera, pop/rock and the well-recognised and often maligned belt (Green et al., 2014). Although considerable debate exists about the defining perceptual and physiologic characteristics, the Broadway belt vocal style or technique is typically characterized as loud, resonant or ring-like and chest-dominant with

limited to no vibrato (Bourne et al., 2011; LeBorgne et al., 2010; Miles & Hollien, 1990; Schutte & Miller, 1993; Sundberg, Thalen, & Popeil, 2012). The physiologic correlates comprise an elevated larynx, exclusive use of modal register, high subglottal pressure, predominance of closed quotient of phonatory cycle (otherwise described as long duration of glottal adduction) and high vibratory (or pulse) amplitude (Barlow & LoVetri, 2010; Bourne et al., 2011; Evans & Howard, 1993; Miles & Hollien, 1990; Schutte & Miller, 1993; Sundberg, Gramming, & Lovetri, 1993). Such voice production, involving long duration of glottal adduction, high subglottal pressures and large vocal fold vibratory amplitudes, entails potentially excessive vibration of vocal fold tissues and high collision or impact forces, and has been thereby theorised to constitute phonotrauma (Dikkers & Nikkels, 1995; Haben, 2012; Ingram & Lehman, 2000; Verdolini, Druker, Palmer, & Samawi, 1998; Verdolini, Hess, Titze, Bierhals, & Gross, 1999). Further, according to Titze et al. (2003), excessive vibration of vocal fold tissues due to loud or prolonged vocalization has been assumed to contribute to development of voice disorders and presents a significant health concern (Titze, Svec, & Popolo, 2003).

Whether vocal styles commonly used in music theatre, such as belt, are potentially injurious has not been ascertained (Miles & Hollien, 1990; Thurman, Theimer, Welch, Grefsheim, & Feit, 2000) but the inherent heavy vocal demands are undisputed. The common repetition of this voice production over eight shows per week while dancing and interchanging with dialogue (some of which may be vocally extreme such as screaming) make this performance genre unique and add to the overall load on the voices of these performers (Ziegler, 2014). Because of these potentially heavy and repetitive vocal demands, MTS may be a potentially higher risk

group for the development of specific types of voice disorders, such as overuse injuries, although there is a surprising lack of controlled studies investigating this premise.

1.3. Vocal load

The determination of performance fitness relies on the performer's self-evaluation of their vocal capacity for performance, based, amongst other factors, on the person's vocal status. The speaking and singing voice rely on the structural integrity and efficient functioning of the vocal folds. These folds are composed of various tissue types including the epithelium, lamina propria, striated muscles, vascular structures and cartilage (Gray, 2000). Of particular relevance to the singer's voice are the epithelium and the lamina propria that together constitute the cover and intermediate layer of the vocal folds (Hirano, Kurita, & Nakashima, 1981). Glottic closure patterns and vibratory characteristics of the vocal folds are dependent, amongst other factors, on the status of the cover and body of the vocal folds. Even subtle alterations to the structure may impact on the mechanics of vocal fold vibratory patterns, in turn influencing the perceptual quality and reliability of phonation. One important influence on the mechanics of vocal function, and potential threat to vocal health if excessive, is vocal load.

Vocal load is a term commonly used to quantify voice use and is chiefly derived from characteristics such as loudness, pitch and duration of phonation time (Vintturi, 2001). Therefore heavy vocal load describes phonatory activity that is at greater than usual levels (for e.g., frequency and intensity) and or durations (Laukkanen, 2006; McCabe

& Titze, 2002; Solomon, 2008; Titze, 1999). Physiologically speaking, the effect of increasing loudness on the vocal folds results in increased vibrational amplitude, increased phonation threshold pressure, and thereby energy loss due to increased friction (Titze, 1999). An increased pitch results in a greater frequency of vibration and therefore increased quantity of vocal fold impacts across time. Furthermore, the surface tissues of the vocal folds are traumatized by rapid accelerations and decelerations or by contact forces between the two vocal folds associated with vibration. The accumulated exposure of the vocal fold tissues to such collision forces and vibration can be quantified as vocal dose (Titze et al., 2003). Excessive exposure due to loud or prolonged vocalisation, namely high vocal doses, can lead to edema and increased vocal fold mass and tissue viscosity, promoting increased energy expenditure for voicing and probable symptoms of vocal fatigue and potentially dysphonia (Levendoski, Leydon, & Thibeault, 2014; Titze, 1982).

Heavy vocal load can constitute phonotrauma and Branski et al. (2006) speculate that "multiple episodes of acute phonotrauma can result in long-standing tissue damage" (Branski, Verdolini, Sandulache, Rosen, & Hebda, 2006), p.434). They propose a vocal recovery trajectory akin to dermal wound healing processes and assert that repeated phonotrauma sets healing and repair mechanisms into a state of constant and chronic repair (Branski et al., 2006). Li, Heris and Mongeau (2013) proposed that accumulated phonation causes biomechanical stress and induces many changes in vocal fold cell activity and tissue structure. Phonatory forces may alter the vocal fold tissue's physical structure by disrupting the intracellular adhesion and cellular structure as well as by inducing a cell-mediated response to tissue damage. Specifically, acute edema may be the outcome of submucosal capillary rupture,

vasodilation, leakage of blood plasma into the extravascular compartment, and inflammatory cytokine release (Li, Heris, & Mongeau, 2013; Li, Verdolini, Clermont, Mi, Rubinstein, Hebda, & Vodovotz, 2008; Thibeault, 2009).

Haben (2012) classifies repair processes into three broad categories: non-compounded, compounded and irreversibly compounded injury. A non-compounded phonotraumatic episode involves short-term and reversible oedema, progressing to a compounding injury if a second overuse injury occurs prior to complete resolution of the initial injury and necessitates a more prolonged healing phase before it resolves. Again, if this healing phase is insufficient and there is repeated phonotrauma, the injury becomes irreversible which may be in the form of more pronounced edema or the byproducts of tissue healing from the vibratory trauma. To compensate for the effect of these changes on vibration, the injured voice is pushed even more, increasing collision forces in injured tissues, precipitating a negative destructive cycle (Haben, 2012). However, these proposed vocal fold repair stages are only theoretical and further research is needed to fully elucidate the nature of vocal fold response to phonotrauma.

According to Gray, (2000) "almost every voice illness can be related to a tissue change or to suboptimal or inappropriate functional use of normal or abnormal tissue" (Gray, 2000)p. 121. One potential risk to vocal fold integrity and hence vibratory characteristics is vocal fold oedema, a benign laryngeal pathology that is multifarious in nature and impact. Vocal fold oedema involves accumulation of fluid or swelling within the superficial layer of the lamina propria (SLP) or Reinke's space. Such oedema can be diffuse or localised, acute or chronic, reactive or systemic and can range in severity from slight to severe. The histopathology of oedema is dependent on

the severity and chronicity (Milutinović & Bojić, 1996). Oedema of the SLP alters the mechanical properties of the vocal fold cover so it becomes more pliable with reduced stiffness. Vibratory characteristics are altered by the presence of the oedema and further reflected by changes in vocal quality output (Sato, Hirano, & Nakashima, 1999).

As previously noted, mild forms of oedema described by Haben (2012) as compounded or non-compounded may develop after episodes of heavy voice usage and may fully resolve after rest and time. This form of oedema is seen in other parts of the body after exercise (Ehrman, Gordon, Visich, & Keteyian, 2013). In the vocal folds, oedema can arise as a consequence of vocal trauma, where the repeated stress and strain associated with the collision forces of vocal fold vibration causes an increase in tissue permeability and accumulation of fluid in the SLP (Stemple, Stanley, & Lee, 1995; Titze, 1994). Oedema can be subtle and diffuse however it can also become more severe, chronic or localised in the form of phonotraumatic benign laryngeal pathologies such as nodules and polyps (Cipriani, Martin, Corey, Portugal, Caballero, Lester, & Taxy, 2011; Dikkers, Hulstaert, Oosterbaan, & Cervera-Paz, 1993; Gray, Hammond, & Hanson, 1995; Loire, Bouchayer, Cornut, & Bastian, 1988; Milutinović & Bojić, 1996). Histological evaluations of these pathologies typically reveal oedema, fibrin and inflammation as the primary findings (Thibeault, 2009; Wallis, Jackson-Menaldi, Holland, & Giraldo, 2004). They have been causally associated with excessive voice use and voice misuse and are thereby coined phonotraumatic lesions (Rosen & Murry, 2000a). Gunter (2004) asserted the causative relationship between mechanical stress during vocal fold collision and benign pathologies is based on observations of high-velocity impact between vocal folds during speech (Titze, 1994), of structural disruptions of the basement membrane in

these lesions (Catten, Gray, Hammond, Zhou, & Hammond, 1998; Czerwonka, Jiang, & Tao, 2009; Gray & Titze, 1987) and expanded extracellular matrix (Mossallam, Kotby, Ghaly, Nassar, & Barakah, 1986). Although the exact mechanism for development of pathology has not been fully elucidated (Levendoski et al., 2014; Tao, Jiang, & Czerwonka, 2010), changes in vocal fold structure occurring with the formation of phonotraumatic pathologies such as oedema, mucosal tears, nodules and polyps can affect vocal fold function leading to increased phonatory effort and potentially compromised voice quality, pitch and loudness ranges (Dikkers & Nikkels, 1995; Gunter, 2004; Hoover, Sataloff, Lyons, & Hawkshaw, 2001).

There is therefore general agreement in the literature that voice overuse and misuse can result in both organic and functional voice disorders and hence the development of vocal impairment (Branski et al., 2006; Dikkers et al., 1993; Dikkers & Nikkels, 1995; Milutinović & Bojić, 1996; Morrison & Rammage, 1993). Vocal misuse refers to inefficient functioning of the laryngeal muscles associated with voicing and has been long identified as one of the major contributing factors for the development of voice disorders (Colton & Casper, 1996; Morrison & Rammage, 1993; Stemple, 1993b). Vocal overuse, whereby voice use exceeds an undefined normal or achievable level has also been implicated. Vilkman (2004) identified several voco-ergonomic factors that influence vocal health, highlighting extensive voice use without enough time for voice rest as a prime factor (Vilkman, 2004). Gelfer, Andrews and Schmidt (1996) also emphasised that clinical experience and anecdotal evidence suggest a strong relationship between vocal health and amount of voice use (Gelfer, Andrews, & Schmidt, 1996). Similarly, the regular and/or prolonged use of high intensities and pitch extremes, such as occur in singing, has been historically associated with an

increased risk for the development of vocal disorders (Milutinović & Bojić, 1996; Punt, 1968). Although the impact of heavy vocal load on the vocal folds and vocal function has received much research attention in recent years (Boucher & Ayad, 2010; Branski et al., 2006; Carroll, Nix, Hunter, Emerich, Titze, & Abaza, 2006; Chang & Karnell, 2004; Eustace, Stemple, & Lee, 1996; Hunter & Titze, 2009; Titze et al., 2003; Verdolini & Ramig, 2001; Welham & Maclagan, 2003b), the optimum voice doses that predate any negative impact on vocal function (creating vocal fatigue) and those that may have a deleterious effect on vocal health have not been determined (Schloneger, 2010). Whether or what stage sustained high vocal doses become potentially injurious also remains unclear (Welham & Maclagan, 2003b). However, the exact threshold for vocal change does appear to be multi-factorial and individuals may vary significantly in their physiologic response to vocal load (Hunter & Titze, 2009). Also, it has been suggested that slight fluctuations in vocal function can occur from day to day or according to time of day without vocal loading due to vocal fold tissue changes in fluid content and viscoelastic properties (Artkoski, Tommila, & Laukkanen, 2002; Laukkanen, Lindholm, & Vilkman, 1998; Leino, Laukkanen, Ilomäki, & Mäki, 2008; Nanjundeswaran, 2013; van Mersbergen, Verdolini, & Titze, 1999). Research to date therefore indicates there can be significant inter and potentially intra-individual differences in dose thresholds and vocal resilience (Dejonckere, 2001; Gray & Thibeault, 2002; Gray, 1999; Hunter, Tanner, & Smith, 2011; Leino et al., 2008; Vintturi, 2003) and objective measurement of vocal decrement with loading is problematic (Hunter & Titze, 2009; McCabe & Titze, 2002).

As summarised by Schweinfurth & Thibeault (2008), research shows that a healthy adult has difficulty sustaining submaximal phonation at 85 dB for over 20 minutes without developing dysphonia and stroboscopic changes (De Bodt, Wuyts, Van de Heyning, Lambrechts, & D., 1998; Schweinfurth & Thibeault, 2008; Titze, 1982). Specifically, vocal fold oedema can develop after these conditions, as evident by altered vibratory characteristics, although detection is difficult and measurement of this tissue change is not reliable (De Bodt et al., 1998; Hoover et al., 2001). In addition, the exact threshold for vocal change does appear to be multi-factorial and individuals may vary significantly in their physiologic response to vocal load (Hunter & Titze, 2009). Measurement of physiologic response to vocal load is also problematic as there is not currently a reliable clinical method for sensitively capturing vocal fold tissue changes induced by heavy load. Present laryngeal imaging technology relies on ultrasound, CT or MRI to diagnose disease (with 1 mm tissue resolution at best) and cannot detect subtle changes in the SLP, such as the oedematous changes that occur in the vocal folds after use or overuse (Colton, Woo, Brewer, Griffin, & Casper, 1995; Woo, Colton, Casper, & Brewer, 1991). Videostroboscopic evaluation, an office-based procedure commonly used in voice clinics, yields valuable information about vibratory characteristics (Woo, 2010; Woo, 2014) and permits inferences about the SLP status and pathologies (Eysholdt, Rosanowski, & Hoppe, 2003; Haben, 2003). However despite the ability to detect many benign pathologies, it is not highly sensitive to microscopic changes such as can occur in early stage oedema (Hirano & Bless, 1993). The clinical assessment of subtle vocal fold oedema, such as that which may develop after non-compounded and milder forms of compounded phonotrauma (Haben, 2012), remains less than optimal at present.

At present, the tracking of the effects of tissue loading and recovery as a continuum of vocal dysfunction relies on subjective ratings of vocal effort and vocal quality (Hunter & Titze, 2009). Even subtle changes of vocal fold structure as a consequence of vocal load can alter function but quantifying the impact is challenging. In addition, the vocal fold tissue (particularly the superficial lamina propria) represents only one aspect potentially impacted by loading. There are also other physiologic mechanisms involved in voice production that may be influenced by heavy voice use, such as intrinsic and extrinsic laryngeal and respiratory muscle function (Boucher, Ahmarani, & Ayad, 2006; Eustace et al., 1996; Morrison & Rammage, 1993; Sander & Ripich, 1983; Stemple, 1993b; Welham & Maclagan, 2003b), cardiovascular and metabolic processes (Nanjundeswaran, 2013) and other under researched areas such as afferent/sensory mechanisms. For example, it is proposed that neuromuscular inefficiency in voice production can develop as a consequence of heavy load and the associated signs or symptoms (such as dysphonia and/or increased phonatory effort) may be similar to those reported for tissue effects (Nanjundeswaran, 2013; Solomon & DiMattia, 2000; Welham & Maclagan, 2003a). Tracking physiologic change or decline in vocal function as a consequence of load is therefore inherently complex due to the potential interplay of multiple factors.

One functional consequence of vocal load represented by a symptom or collection of symptoms (Stemple et al., 1995) is the somewhat nebulous and global concept of vocal fatigue. This term has eluded any precise definition that is convergent across authors and thus is particularly problematic for the evaluation of the effects of load on the voice (Boucher & Ayad, 2010; Kitch, Oates, & Greenwood, 1996;

Nanjundeswaran, 2013; Sander & Ripich, 1983; Solomon, 2008; Welham & Maclagan, 2003b). Definitions vary in whether fatigue should be defined according to symptoms experienced by an individual subsequent to voice use or in terms of physiological changes that arise as a consequence of vocal loading (Nanjundeswaran, 2013). McCabe and Titze (2002) defined vocal fatigue as a progressive increase in perceived phonatory effort accompanied by a progressive decline in phonatory capabilities (McCabe & Titze, 2002). Vilkman (2004) defined vocal fatigue as a self-perceived condition involving negative sensations related to voicing (Vilkman, 2004). Solomon (2007) similarly proposed that vocal fatigue could be defined as "a perception by the voice-user manifested primarily as a sense of increased vocal effort that increases over time with voice use, and subsides with voice rest" (Solomon, 2007).

Eustace, Stemple and Lee (1996) described the acoustic, aerodynamic and videostroboscopic findings for 86 patients without laryngeal pathology complaining of vocal fatigue. Results showed an abnormally high airflow rate, decreased maximum phonation time and incomplete glottic closure patterns consistent with significant reduction in vibratory efficiency. Other researchers have investigated the relationship between heavy load and fatigue using aerodynamic measures such as glottal resistance and phonatory threshold pressures (Chang & Karnell, 2004; Kostyk & Putnam Rochet, 1998; Solomon & DiMattia, 2000). An increase in phonatory threshold pressure (PTP) was shown to be associated with increased vocal loading and increased complaint of vocal fatigue. The increased PTP values are posited to specifically arise from changes to hydration and tissue viscosity and currently represent the most sensitive clinical measure available for the measurement of tissue

loading effects (Solomon, 2008; Solomon & DiMattia, 2000; Welham & Maclagan, 2003b).

As it relates to all aspects of voice production, the perception of fatigue is multifaceted and therefore there is no one physiologic correlate. Whether or at what stage symptoms of fatigue are indicators of impairment and predate physiological changes that may arise from phonotraumatic episodes is subject to conjecture (Welham & Maclagan, 2003b). Attempts to distinguish individuals with vocal fatigue from others with throat discomfort or hoarseness have not been successful (Nanjundeswaran, 2013) and, further, fatigue is not itself diagnostic as it is also a frequent complaint for patients with vocal pathology (Aronson & Bless, 2011; Stemple, 1993b). Although measurement of symptoms of perceived change in the physical aspects of vocal function may be of use, vocal fatigue alone as a perceptual entity is therefore of limited value for the measurement of the effects of vocal load and prediction of vocal pathology.

1.4 Singers at risk for the development of voice disorders

1.4.1 Occupational health among singers

Singers are frequently identified among the occupational groups as having a high prevalence of voice problems (Bastian, Keidar, & Verdolini-Marston, 1990; Coyle, Weinrich, & Stemple, 2001; Herrington-Hall, Lee, Stemple, Niemi, & McHone, 1988; Peppard, Bless, & Milenkovic, 1988; Titze, Lemke, & Montequin, 1997; Van Houtte, Van Lierde, D'haeseleer, & Claeys, 2010; Verdolini & Ramig, 2001). Specifically, voice disorders resulting from functional trauma of the vocal folds (phonotraumatic

lesions) have been identified as common forms of vocal impairment for performers including singers, particularly vocal nodules, cysts, oedema and haemorrhage (Altman, 2007; Bastian, 1996; Behlau, Oliveira, & Pontes, 2009; Guss, Sadoughi, Benson, & Sulica, 2014; Milutinović & Bojić, 1996).

Phyland, Oates and Greenwood (1999) surveyed 167 professional singers and 86 friendship-matched non-singers and found 44% of the singers (compared to 21% of non-singers) reported a medically-diagnosed vocal condition over the previous 12 months. Of the conditions reported by the singers, phonotraumatic lesions including vocal fold oedema were reported by approximately 20% of the singers and accounted for nearly half of the diagnosed conditions. Laryngitis associated with upper respiratory infection accounted for most of the other diagnoses (Phyland et al., 1999). Bastian et al. (1990) reported on 2,200 stroboscopic evaluations as a result of which 87 patients were diagnosed with vocal fold swelling (Bastian et al., 1990). Fifty-four of the 87 (62%) diagnosed were singers. Although the purpose of the study was not to evaluate the relative incidence of this voice problem among singers, vocal fold swelling was a reported primary laryngeal finding in the majority of singers experiencing long-term symptoms of vocal disturbance.

What we know about professional singers' vocal health is largely restricted to treatment-seeking singers (Altman, 2007; Bastian, 1996; Bastian et al., 1990; Bouchayer & Cornut, 1992; Brandfonbrener, 1991; Coyle et al., 2001; Guss et al., 2014; Herrington-Hall et al., 1988; Milutinović & Bojić, 1996; Peppard et al., 1988; Titze et al., 1997; Van Houtte et al., 2010; Verdolini & Ramig, 2001; Zeitels, Hillman, Desloge, Mauri, & Doyle, 2002), the majority of whom, by virtue of them

seeking treatment, presumably perceive they have a problem with their voice. It is commonly asserted that singers are more likely than non-singers to seek medical treatment and notice subtle changes in their voice. As early as 1962, Baker identified that singers know their own voices and will differ from non-singers in whether they perceive it to be disordered or not. "The singer can usually tell whether his voice is behaving in normal fashion. The changes that I have observed in early cases of laryngeal dysfunction have been redness of the cords with increased vascularity and oedema" (Baker Jr, 1962). Several other laryngologists similarly report that singers generally present with voice changes much earlier than their nonperforming counterparts and that oedema is a common diagnosis (Benninger et al., 1994; Colton et al., 1995; Haben, 2012; Woo, 2010). On the basis of his clinical experience, Woo (2010) also emphasises that early oedema in singers may be difficult to diagnose via strobosopy and relies on symptom description " Early in the course of oedema the patient may have a normal speaking voice. Singing especially high singing is particularly affected. Many singers will complain that, although phonation is possible, they have to use increased phonatory effort. Early vocal fatigue and chronic throat clearing may be other symptoms suggestive of swelling of the vocal fold margin" (Woo, 2010. pp.267-268).

1.4.2. Music theatre performers and voice problems

Singers are not a homogenous group and may vary in aspects of vocal health according to many factors, including the music genre in which they are involved (Bartlett, 2011; Batza, 1971; Phyland, 1998; Phyland et al., 1999; Sataloff, 1991). For example, Baker (1962) suggested that singers from popular and classical singing genres differ considerably in their consideration of vocal health. On the basis of his

medical experience, Baker stated that "the laryngoscopic appearance of the vocal cords has nothing to do with the ability of the popular singer to make a good living. Some popular singers have nodular thickening or even polypoid thickening of the cords" (Baker Jr, 1962), p. 904). Baker suggested that this finding, although often not of concern to popular singers, would be uncommon among classical singers and would prevent them from pursuing a successful career. Lawrence (1983) claims that "continuing vocal excellence is not such a vital issue with the musical comedy star, and perhaps even less so with the rock singer" (Lawrence, 1983)p. 233). Surprisingly there is little known about genre differences in singers' expectations of vocal health and therefore whether assertions such as these are accurate.

The incidence and prevalence of occupation-related voice disorders among music theatre singers has not been well researched, despite the aforementioned contention that they have heavy vocal loads and would therefore seem at high risk for the development of phonotraumatic sequelae. As a treatment-seeking singer group, music theatre singers have been anecdotally reported to be well represented in laryngologists' caseloads and to have a high rate of diagnosed phonotraumatic lesions relative to other singing groups and to non-performers (Altman, 2007; Guss et al., 2014; Haben, 2012). Whether music theatre singers differ from singers of other genres in the diagnosis of voice disorders is not clear but oedema does seem to be a regularly reported diagnosed condition amongst these treatment-seeking performers (Bastian et al., 1990; Sataloff, 1991).

Historically, much of the occupational health data regarding music theatre performers relates only to musculoskeletal and dance injuries (Chmelar, 1990a, 1990b). More

recent reports however have included vocal injuries as an occupational risk among working singers (Evans, Evans, Carvajal, & Perry, 1998; Gehling, Sridharan, Fritz, Friedmann, Fang, Amin, & Branski, 2014). Evans et al. 1996 reported on survey results for Broadway performers and found that musical theatre singers experienced voice problems at a significantly higher rate than their non-singer performers. This study involved a survey on injuries among 767 Broadway performers from 23 theatre productions and identified voice problems as a common form of injury among Musical Theatre (MT) actors. Performers included both actors and dancers and, of the 318 who responded, 152 were actors. Although it was not stated that the actors were required to sing, the productions were all musical and hence singing was an inferred activity for the actor subjects. It was acknowledged that the method of sampling excluded those potentially disabled performers who were no longer in the production due to injury, but the authors reported that only a small percentage of performers would fit this category. The range of time over which a production ran was 9.3 to 146.4 weeks with a mean of 78.6 weeks. Fifteen percent of the MT actors reported that they had seen an Ear, Nose and Throat physician for voice/larynx injuries and 21% reported that they had been diagnosed by a medical practitioner as having laryngeal problems related to injury over the course of the musical production. In comparison, none of the 166 dancers reported voice/ laryngeal problems and none had sought medical assessment for such difficulties. Information regarding the type, frequency, nature and impact of the vocal difficulties experienced by the MT actors in the study by Evans et al. (1996) was not given. However, the finding that 22% of actors experienced vocal problems compared to none of the dancers suggests that MT actors/singers are at risk of developing voice problems related to the performance demands (Evans et al., 1996).

Gehling et al. (2014) specifically surveyed Broadway performers on their vocal habits and vocal health. One hundred thirty-five performers completed the survey from seven actively running shows. Over 25% of respondents reported that they had been diagnosed with a vocal injury over the previous year (Gehling et al., 2014). This figure is lower than that reported by Phyland et al. (1999) whereby over half the professional music theatre singers (n=57) reported they had been diagnosed with a vocal condition in the previous 12 months. Of these, laryngitis accounted for nearly half of the diagnoses as upper respiratory tract infections were not excluded from the survey. It is probable that laryngitis was perceived by some respondents to be a generic term covering upper tract respiratory infections and the high prevalence of diagnosed vocal conditions found in the study may therefore reflect the inclusion of laryngitis. To further examine the possibility that the inclusion of laryngitis influenced the present results, the prevalence of diagnosed vocal conditions without the inclusion of laryngitis was also calculated. Once this category of diagnosed vocal condition was removed from the analysis, the prevalence of diagnosed vocal conditions over a one year period became 29.5% for MT singers (Phyland, 1998; Phyland et al., 1999).

Although it is widely accepted that singers experience a high occurrence of both temporary and established vocal fold oedema, particularly those singers with a high vocal load such as music theatre singers, there is surprisingly little research regarding the incidence and prevalence of oedema among singers (Welham & Maclagan, 2003a). However, there is a need to determine whether all singers experience oedema as a natural consequence of vocal ‘work’ due to vocal performance, and if so, what is the recovery time for return to original or resting state. Despite our current lack of

knowledge as to what constitutes normal for the vocal folds of working singers, clinical judgements, for treatment-seeking singers attending voice clinics, are regularly made as to whether a singer is fit to perform (Sataloff, 1991). These judgements are most usually predicated on information yielded from videostrobosopic examination and perceptual evaluations (Benninger et al., 1994; Sataloff, Spiegel, & Hawkshaw, 1991). As previously raised, however, the ability of these evaluations to detect and quantify subtle changes and to predict potential for development of pathology is reduced. There is an obvious need to develop assessment tools that are sensitive to changes in vocal fold structure and the vocal function of singers so that decisions about performance fitness are judicious and preventative for vocal health.

Although reports abound that singers are a high-risk group for the development of benign laryngeal pathologies, there is an obvious need for further prevalence studies of voice disorders among singers and for the identification of influences on the development of phonotraumatic lesions. Factors which account for variation among singers in their speaking and singing voice characteristics and vocal load need to be considered because of their potential importance for the prediction of voice problems among subgroups of singers. In particular, genre of singing may be an important variable to consider in future epidemiological studies of voice problems among singers particularly because of the inherent differences in vocal load.

1.5 Singers' perception of a voice disorder

> "An acceptable definition for normal voice does not exist. There are no established standards, and no boundaries of accepted norms have been set.

> Voice comes in many different varieties. Cultural, environmental and individual factors contribute to the determination of what is designated normal. And voice, again like appearance does not stay constant. It changes throughout the life-span; it changes in reaction to emotion; it changes in response to environment" (Colton & Casper, 1996) p. 235).

Some twenty years later, Colton and Casper's (1996) observation remains valid. It reflects the dynamic, multi dimensional nature of both the speaking and singing voice, and emphasises the difficulty in achieving a single definition of normality. Further, there can be no single system used to describe or measure the multifarious characteristics of voice (Bless & Hicks, 1996). Many researchers have attempted to qualify or quantify the perceptual, acoustic or physiologic characteristics of the healthy singing voice and findings have highlighted the enormous variability in these characteristics according to age, gender, music genre, singing style, voice type, training and other factors (Bele, 2007; Brown Jr, Hunt, & Williams, 1988; Brown Jr, 2000; Ekholm, Papagiannis, & Chagnon, 1998; Heuillet-Martin, Garson-Bavard, & Legré, 2007; Lamarche, Ternstrom, & Pabon, 2009b; Leino et al., 2008; Mendes, 2003; Oates, Bain, Davis, Chapman, & Kenny, 2006; Omori, Kacker, Carroll, Riley, & Blaugrund, 1996; Radionoff, 1996; Shrivastac & Wingate, 2006; Sundberg et al., 1993; Sundberg & Rothenberg, 1986). Singers are clearly not a homogenous group so it is therefore difficult to establish normative data and clinical cut off points such as the demarcation of normal from abnormal. It therefore follows that defining the 'unhealthy' speaking and singing voice is similarly problematic and indeed the literature is replete with discrepancies in operational or measurable definitions of a voice disorder (Phyland et al., 1999).

A disruption to the functioning of the vocal instrument can be as distressing and debilitating to a singer as an orthopaedic injury is to an athlete (Benninger & Murry, 2006; Mishra, Rosen, & Murry, 2000). Such a disruption, the impairment aspect of a voice disorder (Enderby, 1996), may temporarily, or permanently, result in a less than optimal singing performance (a restriction to activity) or even prevent the singer from performing (thereby a limitation to participation) (Skevington, Lotfy, & O'Connell, 2004). The personal, financial, vocational and medico-legal consequences of poor singing performances or, at worst, cancellations may be dire (Chmelar, 1990; Strong, 1988). The determination of performance fitness relies on the performer's self-evaluation of their vocal capacity for performance. Prior to potentially seeking medical advice regarding vocal health, singers make decisions about their vocal health based on their perception as to what is normal for their voice and whether it meets their vocational and personal needs (Moreti, Zambon, & Behlau, 2014; Phyland et al., 1999). Factors that can influence the perception and self-management (for e.g., treatment-seeking and adherence behaviours) of a voice disorder among professional voice users, particularly singers, have been reported to be multifactorial and complex in nature (Behlau et al., 2014; Behrman, Rutledge, Hembree, & Sheridan, 2008; Behrman, Sulica, & He, 2004; Benninger, Ahuja, Gardner, & Grywalski, 1998; Cohen, Noordzij, Garrett, & Ossoff, 2008; Gilman, Merati, Klein, Hapner, & Johns, 2009; Heuillet-Martin et al., 2007; Moreti, Ávila, Rocha, Borrego, Oliveira, & Behlau, 2012; Phyland et al., 1999; Señaris González, Núñez Batalla, Corte Santos, & Suárez Nieto, 2006; Silva, Moreti, Oliveira, & Behlau, 2014).

Self-evaluation of vocal health and conversely the identification of voice disorder incorporates the dimensions of quality of life and wellbeing and these aspects can be comprehensively measured by voice-disordered quality of life instruments (VDQOL). VDQOLs evaluate impairment, psychosocial wellbeing, activity limitations and participation restrictions in accordance with World Health Organisation (1946) constructs of health and wellbeing (Skevington et al., 2004) The most commonly used are the Voice Handicap Index (Jacobsen, Johnson, Grywalski & Benninger, 1997) and the shorter adaptation, the Voice Handicap Index-10 (Rosen, Lee, Osborne, Zullo, & Murry, 2004), the Vocal Performance Questionnaire (Carding, Horsley, & Docherty, 1998), the Voice Symptom Scale (Deary, Wilson, Carding, & MacKenzie, 2003), the voice-related quality of life (VRQoL) instrument (Hogikyan & Sethuraman, 1999) and the Voice Activity and Participation Profile (Ma & Yiu, 2001). Almost all of these tools are developed for the evaluation of clinical outcomes, particularly for voice therapy. They can be used as a gauge by which the success of voice therapy and the resumption of vocal health for an individual can be measured (Zraick & Risner, 2008). By nature, the focus of VDQOL instruments is the evaluation of physical, mental and social well-being consequences arising from vocal disorders or impairment, namely dysphonia, not the evaluation of fluctuations in vocal status that may occur in the absence of disorder or impairment. In other words, VDQOL instruments are disease-specific in the sense that they measure quality of life related to dysphonia.

There is a need for VDQOL tools that are specific to the singer population since, as previously noted, the voice requirements for this group are different, and they have a higher rate of voice disorders, than non-singers (Phyland et al., 1999). Also,

perception of vocal handicap may be different for singers than non-singers. Rosen and Murry (2000) reported that scores on VHI were lower for singers than non-singers, highlighting the need to ensure measurement tools address the specific concerns of singers (Rosen & Murry, 2000b). Issues with the speaking voice may not be as important as they are to a non-singer or hold the same significance to a singer as issues with the singing voice.

The evaluation of self-perceived handicap for singers with singing problems has been more recently addressed by the development of the Singing Voice Handicap Index (Cohen, Jacobson, Garrett, Noordzij, Stewart, Attia, Ossoff, & Cleveland, 2007). The SVHI is a 36-item survey that Cohen et al. validated with dysphonic and normal singers. The physical, functional and emotional subsets that comprised the original VHI were discarded in preference for a single scale structure. Cohen et al. reported that scores on the SVHI were significantly worse for singers with voice problems than those without impairment and that the correlation between the SVHI and self-rated vocal impairment was moderate.

Similarly, Morsomme et al. created the 'Voice Handicap Index adapted for singers' written in French (Morsomme, Gaspar, Jamart, Remacle, & Verduyckt, 2007). In this adaptation of the VHI, the subscales of physiological, emotional and functional were maintained. This index was also subsequently translated into Swedish and then validated with 126 singers as the Revised Voice Handicap Index adapted for singers (RHI-s) (Lamarche, Westerlund, Verduyckt, & Ternström, 2010). Lamarche et al. reported that the translated tool offers a valid and reliable measurement of vocal handicap that is sensitive to singers' concerns and is useful in the assessment of both

healthy and vocally unhealthy singers. Other authors have also translated either the RHI-s or SVHI for cultural appropriateness and report its usefulness for quantifying and qualifying the impact and nature of voice disorders experienced by singers (Baracca, Cantarella, Forti, Pignataro, & Fussi, 2014; Lee & Sim, 2013). Further adaptations of these instruments specifically tailored to the classical and popular singing genres with the Classical and the Modern SVHIs have also been produced in Italian and Portuguese (Fussi & Fuschini, 2008; Moreti, Rocha, de Menezes Borrego, & Behlau, 2011).

The RVI-S, SVHI and adaptations are all instruments designed to measure the vocal health of singers from a functional, psychological and physiological perspective. For the vocally impaired singer, these instruments offer a means for evaluating the effect of the impairment on the person's overall health and wellbeing and, to some extent, for tracking change in the status of this impairment. For those singers who experience vocal impairment but continue to perform without significant compromise of activity or participation (i.e., minimal disability or handicap), these instruments are less applicable. In addition, for the healthy singer, these instruments do not, however, provide a sensitive measure of the vocal changes that may have more subtle or transient effects on the singer. Furthermore, the ability of such instruments to predict the potential for the development of pathology or to provide a screen for early pathology among singers has not been established.

1.6 Symptoms of voice disorders among singers

Clinical evaluations of singers' voices rely on the interpretation of voice signs and

symptoms (Bastian, 1996; Benninger et al., 1994; Benninger & Murry, 2006; Franco & Andrus, 2007; Shlömicher-Thier & Weikert, 2006). Benninger (2006) identifies the importance of ascertaining the chief symptom complaints of singers, such as hoarseness, fatigue and breathiness, and the probable diagnoses (Benninger & Murry, 2006)p.63). It is however difficult to determine whether or which symptoms relate to a voice disorder, individual variations or a technique issue as there is considerable variability among normal subjects for many of these parameters, and it is often difficult to determine truly abnormal values (Celona-VanGorden, 2009; Lehto, Laaksonen, Vilkman, & Alku, 2006). In the pedagogical voice evaluation, similar dilemmas exist in delineating normal from disordered voice. Milo (2014) argues that while an anomaly in voice function may be more easily noticeable by the experienced singer, it is more challenging to differentiate a symptom of a voice disorder from a manifestation of faulty technique in voice students (Milo, 2014). Haben (2012) also suggests perceptual changes in the singing voice can be subtle and may not affect the speaking voice and that the better trained or more experienced the singer is, the earlier and subtler the voice disturbance tends to be at presentation. He further specifies that such subtle changes commonly occur in the uppermost aspect of the singer's range, or at the passagio, the transition from the lower register to the upper register, although the evidence on which he bases this assertion is not provided (Haben, 2012).

The relationship between the presence or absence of symptoms and the diagnosis of a voice disorder is seemingly not straight-forward (Moreti et al., 2014; Phyland et al., 1999; Señaris González et al., 2006). Several studies have shown that asymptomatic singers can have abnormal laryngeal findings (Elias, Sataloff, Rosen, Heuer, & Spiegel, 1997; Heman-Ackah, Dean, & Sataloff, 2002; Lundy, Casiano, Sullivan,

Roy, Xue, & Evans, 1999; Sataloff, Hawkshaw, Johnson, Ruel, Wilhelm, & Lurie, 2012). Whether such singers are asymptomatic or do not consider the occurrence of certain phenomenon to be so-called 'symptoms' of impairment is unclear. In other words, although symptoms of vocal difficulties may be reported by singers, such symptoms may not be seen as indicators of vocal disorder but attributed to technical issues or short-term fluctuations in vocal function. For example, from a sample of 79 undergraduate and graduate singing students who did not perceive themselves to have voice disorders, Sapir (1993) found only 13% reported to be free from symptoms of vocal impairment, while the remainder ranged from 1 to 4 concurrent symptoms (Sapir, 1993). Similarly 47 popular singers who were surveyed regarding their vocal behaviours by Zimmer, Cielo and Ferreira (2012) reported regular symptoms of hoarseness, throat pain and excessive throat clearing (Zimmer, Cielo, & Ferreira, 2012).

Several recent studies from Brazil have specifically investigated symptoms of pain associated with voicing and the relationship between these symptoms and the perception of voice problems (Guerrieri & Behlau, 2008; Rocha, Moraes, & Behlau, 2012; Vaiano T, Guerrieri AC, & M., 2010). Rocha et al. surveyed 100 popular singers on the frequency of pain symptoms proximal to the throat and found that the mean number of regular painful throat symptoms was 2.9 and that there were no significant gender differences. The findings for this genre of singers were reportedly similar to those for classical singers and asserted to be lower than symptom prevalence among the general population. They proposed that this was due to singers' vocal training and experience, which mitigated the potential for such symptoms of vocal misuse. The researchers also found a strong negative relationship between

perception of vocal health and pain symptoms (Rocha et al., 2012)

Previous research by Phyland (1998, 1999) sought self-report information from singers regarding their perception of voice problems. Specifically, singers were asked to report regular experience of a speaking voice symptom and whether they perceived that symptom to be an indicator of a voice problem. Of the 9 potential impairment symptoms, the overall average number of symptoms reported as regular occurrences by singers was 4 with hoarseness being the most prevalent symptom followed by vocal fatigue, throat pain and throat tickle. Although singers reported regular experience of these symptoms, most did not perceive these collectively or in isolation to be indicators of a voice disorder (Phyland, 1998). Differences between singing genres in frequency of vocal symptoms were also explored and the MT singers reported the highest number of speaking and singing voice impairment symptoms overall and more frequently reported throat discomfort, difficulty with volume and voice breaks during speaking than the two other singer groups: opera and contemporary other than rock (Phyland, 1998).

Other researchers have similarly reported that not all professional voice-users with vocal symptoms of overuse have complaints or seek treatment or professional help but that these symptoms may be considered as 'normal' experiences and consequences of occupational voice use (de Assis Moura Ghirardi, Piccolotto Ferreira, Pimentel Pinto Giannini, & Dias de Oliveira Latorre, 2013; Van Lierde, Dijckmans, Scheffel, & Behlau, 2012). The significance attached to these experiences by singers and whether, when and to what extent the experiences are signs of fatigue or symptomatic of impairment has not been established. In addition, the presence or absence of

impairment symptoms is evidently insufficient for the determination of a voice disorder.

The singer population has not been well studied but there are abundant anecdotal reports that it is a normal occurrence for singers to experience significant fatigue effects and variability in vocal function across time and performances (Phyland et al, 1999; Benninger et al, 1994; Welham, 2003). There is an obvious need to measure these potential vocal status shifts in order to determine vocal load thresholds and establish normative data for working singers. Further, the prediction and management of vocal injury among singers is predicated on assumptions as to what constitutes normal. At present, there is an absence of normative data to support these assumptions since there are no appropriate tools to perceptually measure vocal status changes in singers. Current vocal health assessment instruments such as the SVHI & the RHI-S are inadequate for this purpose since they lack the sensitivity to detect small changes within the range of normal function. In addition, these instruments are designed to assess several voice-related quality of life aspects and therefore incorporate measurement of activity and participation restrictions. For singers who experience vocal impairment but minimal to no impact on singing activity, these tools are not suitable. Other VDQoL scales such as VOISS (Deary et al., 2003), which is an impairment symptom scale, are not specific to the singing voice so are limited in their applicability to singers.

1.7 Tracking vocal load effects on singers

The immediate, short-term, long-term and cumulative impact of heavy vocal load on the vocal function of singers (as for all voice-users) is not well understood. According

to Welham and Maclagan (2003) “there is a particularly critical shortage of data concerning the nature of vocal function (Ostwald, Baron, Byl, & Wilson, 1994) on changes following singing or acting performance” (Welham & Maclagan, 2003b). Although singers can report both short term and perhaps long-term positive and negative changes in their vocal function after vocal ‘work’ (Phyland, 1998; Vintturi, Alku, Lauri, Sala, Sihvo, & Vilkman, 2001), the load thresholds before changes in either direction are perceived, are not known. Also the positive effects of singing training and specific exercises on singing voice function are well established ((Lawrence, 1983; Vintturi et al., 2001; Wrycza Sabol, Lee, & Stemple, 1995) but whether and how singers can increase vocal fitness across time, improve endurance and mitigate fatigue effects has not been fully elucidated. Similarly, it is unknown whether fatigue effects among singers are common or inevitable, and also what periods of rest are required for recovery. Moreover, the relationship between heavy singing load and development of vocal pathology is complex with some authors positing that increased vocal doses among singers is not associated with a decrease in all aspects of vocal health quality (Hunter & Titze, 2009; Schloneger, 2010; Wrycza Sabol et al., 1995) but may even enhance vocal health (Gehling et al., 2014). Improved insight into these areas is crucial to the prediction and prevention of vocal injuries among singers and may also assist in the establishment of occupational guidelines related to performance schedules and vocal requirements.

At present, the tracking of the effects of tissue loading and physiologic recovery as a continuum of vocal dysfunction relies on subjective ratings of vocal effort and vocal quality (Hunter & Titze, 2009; Titze et al., 2003). At present, there is seemingly a lack of appropriate means to enable detection of these early vocal alterations amongst professional voice-users, such as singers, who rely on their voice for their occupation.

Many voice-rating tools, by virtue of their clinical purpose, including those designed for singers, are disease-specific, physician-derived and rely on recall or retrospection rather than ratings of current voice status (Benninger et al., 1998; Cohen et al., 2007; Morsomme, Simon, Jamart, Remacle, & Verduyckt, 2005; Murry, Zschommler, & Prokop, 2009). Although highly valuable to the clinical assessment and management of voice disorders, these tools are not designed for, nor sensitive to, the working voice or those who do not perceive themselves to have a voice problem. They are therefore limited in scope for non-clinical populations as they are not designed for the non voice-disordered or so-called "normophonic" singer. Frequent discrepancies between the perception of disorder and vocal function among singers has been well reported (Phyland et al., 1999). In addition, for the seemingly healthy singer without an overt pathology, these instruments do not provide a sensitive measure of the more subtle or transient physical changes such as fatigue to the vocal mechanism that may have more variable impacts on the singer and their performances. Although clinically useful, these scales do not provide a sensitive or appropriate means of evaluating the effect of vocal load on vocal function unless the impact of that load relates to the perception of a voice disorder. This proves especially problematic to the assessment of singers' voices across time, and to the evaluation of impact of load on vocal function among professional voice users.

In the field of sports medicine, much attention has been paid to physical fatigue thresholds, recovery, and repair (Ehrman et al., 2013; Lambert & Borresen, 2010; Wylie, 1981). Identification of exercise tolerance and load dosage levels is used to assist in determining training regimes, so as to optimize performance and fitness. Perceptions of recovery and impact of exercise have been evaluated by self-report

scales (Hemmings, Smith, Graydon, & Dyson, 2000; Kellmann & Kallus, 2001). One scale known as the Recovery-Stress Questionnaire for Athletes-Sport (Nederhof, Brink, & Lemmink, 2008) is commonly used to assess the psychosocial stress and physical recovery state of sport players and there are many others used within specific areas of sport such as for football, cycling, and boxing (Brink, Visscher, Arends, Zwerver, Post, & Lemmink, 2010; Dvorak & Junge, 2000; Hemmings et al., 2000; Kellmann, 2010 ; Lamberts, Swart, Noakes, & Lambert, 2011). Scales such as these provide valuable information to assist in the profiling of the physical and functional impact and recovery from exercise; a necessary precursor to the prediction and prevention of overuse injuries and help delineate these from traumatic injuries sustained by athletes.

Similar knowledge pertaining to singers could be highly valuable in the prevention of vocal overuse injuries and may also assist in determining programming of performances, rest days, and performance seasons. Therefore, for the same reasons that understanding impact and recovery among physical athletes is crucial to performance and longevity, there is a need to explore the relationship between the physical and psychological impact of heavy vocal load among our vocal athletes (singers). Hitherto, there has been no self-report scale for singers, equivalent to those devised for athletes, to measure physical aspects of current function. It would therefore seem a priority to develop a valid and reliable scale for singers permitting self-evaluation of the physical aspects of vocal status. The scale needs to be clinically appropriate, valid and reliable but also should be simple, quick to complete, easy to score and useful (Zraik & Risner, 2008). In addition, the language or terminology of

the scale items should be tailored to the respondent and the content should reflect the respondent's concerns (Marx, Bombardier, Hogg-Johnson & Wright, 1999).

1. 8 Summary and rationale for the present studies

In summary, there is a well accepted intention and need to identify and mitigate risk factors to occupational health and thereby develop preventative programs to optimize vocal performance and vocal longevity (Behlau et al., 2014; Benninger et al., 1994; Epstein, Remacle, & Morsomme, 2011; Hazlett, Duffy, & Moorhead, 2011; Vilkman, 1999; Vilkman, 2004). Working singers constantly self-evaluate their vocal function and make decisions about performance fitness. The criteria by which singers make these decisions are unknown (and also the decision to seek treatment) but appear to be based on self-awareness of vocal function, vocal expectation and demands, vocal health information or knowledge base ((Behrman et al., 2008; Gilman et al., 2009; Sapir et al., 1996). Further information regarding the physical aspects of normal vocal function among singers would be of obvious assistance in the determination of performance fitness. In addition, this would be of value in (a) determining load thresholds/doses, recovery times to assist performance scheduling and quotas; (b) predicting the development of voice problems; and (c) evaluating therapeutic outcomes in management of the specific needs of the singer's voice.

As previously described, the impact of vocal load on vocal health and vocal function of all types of singers has not been established and the impact of singing and performing in a music theatre production is similarly not known. A review of the literature has highlighted that there is a strong need to capture singers' perspectives on the impact of heavy vocal load on the physical functioning of

their voices. These perspectives should provide the impetus and material to develop a singer self-report tool for the evaluation of physical aspects of singing voice function and to identify potential changes across time and contexts. Information gleaned from singers' self-reported data may further enhance our understanding of the complex mechanisms of vocal fatigue, repair, and recovery. Singers working in the music theatre genre offer an obvious starting point for study because of their known heavy vocal demands over extended periods of time and voice use characteristics.

1.9 Overall research aims

The overarching purpose of the studies described in this thesis was to develop a singer self-report scale for the evaluation of physical aspects of singing voice function, based on professional music theatre singers' perceptions of the criteria by which they determine performance fitness. Three published studies are provided which document the preliminary investigations and scale-development processes to date. The discrete aims of each study were:

Study 1.

- To determine if present voice quality of life scales are adequate for quantifying the vocal function of working music theatre singers; and,

- To gather data regarding working music theatre singers' perceptions of their vocal health, criteria for judging performance fitness and the impact of performing in a professional music theatre production on their voices.

Study 2.

- To develop a singer self-report scale for the evaluation of physical aspects of singing voice function; and,
- To test the psychometric properties and undertake preliminary validation of the newly developed instrument.

Study 3.

- To evaluate the construct validity of the EASE by comparing scores among professional music theatre singers across a range of demographic and voice-use characteristics; and
- To explore the usefulness of the proposed two subscale structure of EASE to quantify perceived singing voice function by comparing the pattern of results for the Vocal Fatigue (VF) and Pathologic-risk indicators (PRI) subscales.

Chapter 2

METHOD AND RESULTS

2.1 Scope of research

Despite increased clinical and research interest in the occupational health of performers and significant research activity within sports medicine regarding training and performance optimisation, understanding of the impact of training and performance load on the voices of singers is limited. The preceding literature review demonstrated areas that require further investigation. In particular, the perceived physical status of the singing voice for singers as a consequence of performing and thereby loading the voice has been a relatively unresearched area.

An objective of the research presented in this dissertation was to provide new information concerning professional singers' perspectives regarding the impact of performing and factors influencing vocal function, recovery and vocal health. To address this objective, the first study sought to determine if any current voice-related quality of life scales were suitable and could provide sufficient information regarding vocal heath, in terms of the physical aspects of singing voice function for currently working singers. Working music theatre singers then participated in a series of focus interviews and written surveys to garner insights into their perspectives on the impact of performance on their voice. From the discussion themes, a list of descriptors of perceived changes in vocal functioning were generated.

A second objective was to develop a self-report instrument for the assessment or profiling of singers' perceived vocal status, generating scale items from the

descriptors provided by the singers in the interview and survey phase. Study two details the scale development process involving scale item refinement and reduction, online distribution and completion by professional music theatre performers and preliminary validation.

The third objective was to further test the psychometric properties of the instrument (now titled the EASE) and, in so doing, to also glean further insight into singers' perceptions of the physical aspects of vocal function. To realise this objective, in the third study the scores derived from professional music theatre singers' responses on the EASE scale are compared across a range of demographic and voice-use characteristics and the construct validity and scale structure are investigated.

The three published studies represent a chronological development and testing of the EASE scale. To avoid redundancy, the following section is a summary of the processes and the reader is referred to each publication for full details of the methods employed for this purpose.

2.2 Ethics

Approval for the conduct of the three studies and subject recruitment was obtained from the Monash University Human Ethics Committee (Approval CF11/0298-2011000103).

2.3 Initial scale development considerations

There are three principal ways to measure the physical aspects of vocal function: self-report, objective or independent assessment (for e.g., instrumental measures) and performance evaluation. As previously described in the literature review, there is a lack of suitable measures for all three methods within the singing field yet singers regularly make self-determined decisions about their performance or occupational fitness on the basis of the physical functioning of the instrument. Limitations of current singer self-report scales are the reduced sensitivity to mild impairment in function, and to transient yet potentially significant fluctuations over time, and the lack of applicability to singers who do not perceive a voice disorder. In addition, many existing self-report (or voice-related quality of life) scales have not followed rigorous scale development processes, as recommended by The Scientific Advisory Committee of the Medical Outcomes Trust (SACMOT) (Aaronson, Alonso, Burnam, Lohr, Patrick, Perrin, & Stein, 2002).

Therefore, in order to quantify singers' perceptions of the physical aspects of vocal function, a new measurement tool needs to be developed that is valid, reliable and useful for occupational or performance fitness and potentially for clinical purposes as a patient-reported outcome measure. Patient-report scales can measure any aspect of a person's health ranging from symptomatic to increasingly complex, multi-domain constructs such as quality of life (Branski, Cukier-Blaj, Pusic, Cano, Klassen, Mener, Patel, & Kraus, 2010). The proposed scale is intended to measure perceived physical functioning of voice only so as to provide a unique and potentially valuable measure for singers. In addition, the underlying philosophy is for measurement of health

without presumption of disorder or disease, as recommended by the World Health Organisation (Skevington et al., 2004).

The scale is proposed to represent a self-assessed physical status index (akin to similar scales in the sports medicine field used as physical performance indices) and therefore not a multi-dimensional quality of life measure. In line with recommendations made by Streiner and Norman (2008), the scale is required to be clinically appropriate, valid and reliable but also to be simple, quick to complete, easy to score and useful (Streiner & Norman, 2008). The language or terminology of the scale items should be tailored to the population of respondents and the content should reflect the respondent's concerns at the time and not be reliant on recall of previous experiences (Halpern & Schmier, 2004; Lee, Drinnan, & Carding, 2005). A self-report symptom scale needs to account for both positive and negative changes in physiological aspects. In addition, the instrument development processes should comply with the guidelines for the development and evaluation of patient reported outcome measures (PROMs) outlined by the Scientific Advisory Committee of the Medical Outcome Trust (2002) (Aaronson et al., 2002). Finally the scale should comprise singer-derived items and have strong psychometric properties so that it is valid, reliable and responsive (Branski et al., 2010).

2.4 Scale Development

A rigorous scale development process of item generation, reduction and psychometric evaluation was undertaken and is fully described in the three publications. Scales items were derived from qualitative interviews and surveys of singers (Study One)

and the subsequent evaluation and refinement of the 42 items pool was undertaken in two stages (Study Two). Exploratory factor analysis was conducted initially to assess the dimensionality of the items, and to identify subsets of items for use in the Rasch Analysis. The items from each component were then subjected to Rasch analysis to assess their measurement properties and to select the best set of items to form a concise, psychometrically sound scale to represent each aspect identified. Rasch analysis provides a very detailed assessment of all aspects of a scale's internal functioning, including its overall internal consistency, the suitability of the items, the response scale, dimensionality, and potential item bias across groups.

Finally, construct validation was undertaken (Study Three) which involves subjecting a scale to a series of analyses designed to test that it behaves in a manner consistent with expectations concerning the underlying construct. Although the convergent validity of a scale is often tested by comparing scores on similar scales, this was not appropriate for the EASE, given the lack of suitable tools. One other type of construct validity that is appropriate is to explore the ability of the EASE to distinguish groups based on pre-existing characteristics or behaviour. This is referred to as 'known-groups validity" (Streiner & Norman, 2008). In this case it was expected that the EASE subscales should be sensitive to variables such as whether currently performing, perceived load, role and self-reported voice problems among singers.

2. 5 Music theatre singers as subjects

The literature review established that professional music theatre performers have a heavy vocal load and rely on a vocal instrument that is sufficiently healthy to meet

these vocal demands for sustained and regularly repeated periods (for example, in productions that average two and a half hours per performance and are repeated eight times per week for many months or several years). This genre of singers therefore offers a unique and appropriate research population for exploration of the perceived physical aspects of vocal health, for generation of the proposed scale content and for subsequent testing of the scale psychometric properties. All of the participants in the three studies described in this thesis were therefore professional music theatre singers who were either currently performing in a professional production or had done so within the previous year. Whether singers were currently working was considered a potentially useful variable for comparing the effects of being involved in a show, or not, on vocal status.

2.6 Music theatre singers' perceptions of physical aspects of vocal function

A primary purpose (inherent in the preliminary phases, development and psychometric testing of the EASE) was to investigate singers' perspectives regarding the impact of performing and factors influencing physical aspects of vocal function, recovery and vocal health. Two approaches were taken for this purpose: 1) the focus interviews and surveys, thereby involving a qualitative research design (Study One) and 2) the administration of the EASE and singer questionnaire, constituting quantitative exploration (Study Two and Three). The information and results gleaned from each of these approaches are also fully detailed in the following three chapters, comprising the three published papers that constitute the three studies.

Chapter 3

THESIS PUBLICATION-Study One

Perspectives on the Impact on Vocal Function of Heavy Vocal Load Among Working Professional Music Theater Performers

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Summary: Music theater singers (MTS) typically have a heavy vocal load, but the impact on their voices has not been previously evaluated. A group of 49 MTS from two professional productions were administered the Singing Voice Handicap Index (SVHI). Responses for the SVHI demonstrated that, although the SVHI supported the performers' self-report of healthy vocal status, it lacked the sensitivity to detect potential subtle fluctuations or changes in physical functioning of the voice for working singers. Secondarily, descriptive data regarding professional working singers' perspectives were collected regarding how their singing voices typically responded to performing in a music theater production after a show, across a working week, and across a production season. Seventy-nine currently performing MTS were involved in a series of focus group interviews (n = 43) or a written survey (n = 36) to detail their perception of the impact of performing in an eight-show per week professional production on their vocal function and vocal health. Thematic analysis revealed the MTS commonly perceived transient and variable changes in their singing voice status in both positive and negative directions after heavy vocal load. Based on these data, a list of 97 descriptors of these perceptual changes was generated using the singers' own terminology and experiences. These included symptoms of vocal impairment and vocal fatigue but also some novel descriptors of positive vocal changes to the physical functioning of the singing voice as a perceived consequence of heavy vocal load. This study offers new and valuable insights into performers' perceptions of the impact of performing in a musical theater production on physical aspects of vocal function.

Key Words: Singing–Voice–Larynx–Quality of life–Music theater–Load–Vocal fatigue–Symptoms–Interviews–Performers.

INTRODUCTION

Professional singers must be vocal athletes to meet the rigors of performance requirements. Typically, performances require extreme vocal loads in terms of measures of vocal function (intensity, frequency, and duration) and may be repeated four to eight times per week often under less than ideal conditions.[1,2] Vocal function among working professional singers has not been systematically measured using reliable and valid tools. This is unfortunate because reports abound that vocal function may alter after a large vocal load and because singers have been identified as being at increased risk for the development of voice disorders.[1–6]

Music theater singers (MTS) in particular have a heavy vocal load typically performing eight shows over 5–6 days per week for seasons that can last for weeks to years, depending on the nature and success of the production.[2,5–8] There have been reported associated lifestyle characteristics and environmental influences on music theater voice, such as physical exertion while singing and stage smoke that distinguish the demands that these singers have from other singer groups.[6–8] Typically in contemporary music theater productions, singers sing a variety of vocal styles such as rock, belt, and belt mix, considered to be more vocally demanding than other musical styles.[8–12] Whether some of these vocal styles, such as belt, are potentially injurious has not been ascertained but the possible repetition of this voice production over eight shows per week while dancing and interchanging with dialogue make this performance genre unique. Consequently, because of these potentially heavy and repetitive vocal demands, MTS may be a potentially higher risk group for the development of specific types of voice disorders, such as overuse injuries,[2,6,7,13,14] although there is a surprising lack of controlled studies investigating this premise.

For singer athletes, a disruption to the physical functioning of the vocal instrument can be as distressing and debilitating as an orthopedic injury is to an athlete.[1,2,6,13] Such a disruption to the physical functioning of the voice represents the impairment aspect of a voice disorder[6,14,15] and may have a further impact on the person by temporarily, or permanently, resulting in less than optimal singing performances or even prevent the singer from performing. The personal, financial, vocational, and medicolegal consequences of poor singing performances, or, at worst, cancellations may be dire.[6,16,17] If the impact of heavy vocal loads on vocal function of working music theater performers were better understood, it might prevent or reduce vocal function impairment. There is a need to understand the impact of heavy vocal load on the vocal folds of these performers to elucidate the nature of the relationship between the load and development of voice disorders.

Perception of vocal health is multidimensional involving physical, functional, and psychosocial perspectives. To date, instruments that measure vocal health have adopted a disorder or disease-based framework.[18] Voice-disordered quality of life instruments (VDQoL) and voice disorder outcome measures evaluate aspects of activity limitations and participation

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restrictions in accordance with World Health Organization (2001) constructs of health and well-being. The most commonly used are the Voice Handicap Index[19] and its shorter adaptation, Voice Handicap Index-10,[20] Vocal Performance Questionnaire,[21,22] Voice Symptom Scale (VoiSS),[23,24] and Voice Activity and Participation Profile.[25,26] Almost all these tools are developed for the evaluation of clinical outcomes among the voice-disordered population. They can be used as a gauge by which the success of treatment and the resumption of vocal health for an individual can be measured.[27] By nature, the focus of these instruments is the evaluation of physical, mental, and social well-being consequences arising from vocal disorders, namely dysphonia. VDQoL instruments are disease-specific in the sense that they measure aspects of quality of life and psychosocial functioning related to dysphonia.

There is a need for VDQoL tools that are specific to the singer population because the voice requirements for this group are different, and they have a higher rate of voice disorders, than nonsingers.[2–4] Also, perception of vocal handicap (activity and participation restrictions or limitations) may be different for singers than nonsingers.[2,28–30] The evaluation of these aspects for singers with singing problems has been recently addressed by the development of the Singing Voice Handicap Index (SVHI).[30] The SVHI is a 36-item survey that Cohen et al[30,31] validated with dysphonic and normal singers. Similarly, Morsomme et al[32,33] created the "Voice Handicap Index adapted for singers" written in French (VHI-s). This index was subsequently translated into Swedish and then validated with 126 singers as the Revised Voice Handicap Index adapted for singers (RHI-s).[34] Lamarche et al[34] reported that the tool offers a valid and reliable measurement of vocal handicap that is sensitive to singers' concerns and is useful in the differential diagnosis and assessment of both healthy and vocally unhealthy singers.

The VHI-s, RVI-s, and SVHI are singer-specific instruments designed to measure the vocal health or conversely vocal dysfunction of singers from a functional, psychological, and physiological perspective. For the vocally impaired singer, these instruments offer a means for evaluating the effect of the physical impairment on the person's overall health and well-being. For the healthy singer without an overt pathology, these instruments do not, however, provide a sensitive measure of the more subtle or transient physical changes to the vocal mechanism that may have more variable impacts on the singer and their performances, as they are not designed for the nonvoice-disordered or so-called "normophonic" singer.[30–34] Therefore, these scales do not provide a means of evaluation of the effect of vocal load on vocal function unless the impact of that load leads to a voice disorder.

Although the healthy singer population has not been well studied, there are abundant anecdotal reports that it is a normal occurrence for singers to experience significant fatigue effects and variability in vocal function across time and performances.[1,6,35–41] In an extensive review of the literature, Solomon[41] defines the hallmark of vocal fatigue to be the self-reported increased sense of effort with prolonged phonation, irrespective of whether or not there are observable or measurable decrements in phonatory function. Clinically, fatigue was defined by the symptoms of increased vocal effort and discomfort, reduced pitch range and flexibility and reduced control of voice quality. Solomon[41] further describes the increase in severity of these symptoms with further use and improvement after rest. It would be useful to determine whether these fatigue effects are commonly perceived among working singers. As emphasized by Welham and Maclagan,[37] there is a critical shortage of data concerning the vocal function changes following singing or acting performance. If such effects could be documented, it could help define what is "normal" for performers and perhaps even what constitutes "overload" rather than a load resulting in temporary shift. Moreover, because the prediction and management of vocal injury among singers is based on assumptions as to what constitutes normal, this information could be applied to prevent vocal injuries and develop healthy management plans. It is currently unclear whether vocal fatigue is an isolated phenomenon or whether, along with the associated compensatory behaviors, these symptoms may predispose one to phonotrauma and the subsequent development of laryngeal pathology.[37] A better understanding of normal vocal effects and recovery after heavy vocal load is therefore essential to the prediction of vocal injury.

In the field of sports medicine, much attention has been paid to physical fatigue thresholds, recovery, and repair.[42–44] Identification of exercise tolerance and load dosage levels is used to assist in determining training regimes, so as to optimize performance and fitness. Perceptions of recovery and impact of exercise have been evaluated by self-report scales. One scale known as the Recovery-Stress Questionnaire for Athletes-Sport[45] is commonly used to assess the psychosocial stress and physical recovery state of sport players and there are many others used within specific areas of sport such as for football, cycling, and boxing.[46–48] Scales such as these provide valuable information to assist in the profiling of the impact and recovery from exercise; a necessary precursor to the prediction and prevention of overuse injuries and help delineate these from traumatic injuries sustained by athletes.[42–48]

Similar knowledge pertaining to singers could be highly valuable in the prevention of vocal overuse injuries and may also assist in determining programing of performances, rest days, and performance seasons. Therefore, for the same reasons that understanding impact and recovery among physical athletes is crucial to performance and longevity, there is a need to explore the relationship between the physical and psychological impact of heavy vocal load among our vocal athletes (singers). Singers working in the music theater genre offer an obvious starting point for study because of their known heavy vocal demands over extended periods of time.[2,5–8]

Therefore, the aim of the present study was twofold: (1) to determine if present voice quality of life scales are adequate for quantifying the vocal function of working singers and (2) to gather data regarding working singers' perceptions of their vocal health and the impact of heavy load on their voices. Because singing voice function is of prime importance to singing performers, more specifically, the objective was to determine their perception of the relationship between performance and

status of singing voice function. The primary question was "what is normal voice" during a production for MTS in their experience and when might they become concerned about their vocal status?

METHOD

The purpose of this study was to gather information related to singers' perceptions of the impact of heavy vocal load on their vocal function and overall vocal health. To determine whether current scales could provide sufficient information regarding vocal health, the preliminary phase of the study focused on a review of existing instruments and completion of the SVHI and the Medical Outcomes Study Short Form Survey-Version two (SF-12v2) by a cohort of professional and currently working MTS (n = 49). For the main study, a different group of 79 currently performing MTS were involved in a series of focus group interviews (n = 43) or a written survey (n = 36), which sought to gather more detailed insight into their perceptions of the impact of performance on the physical and psychological aspects of the vocal mechanism.

Approval for the conduct of this study and subject recruitment was obtained from the Monash University Human Ethics Committee (Approval CF11/0298 - 2011000103).

Selection of survey instruments

To verify if any scales existed to suit the purposes of this study, a review of existing instruments that evaluate perceptions of the singing voice was undertaken by extensive searching of computerized databases (medical, health, and performing arts), published bibliographies of related topics, unpublished theses, and citations in the articles reviewed. The review was limited to publications from the past 20 years. From this review, the SVHI was the instrument chosen as it met our search criteria of being a validated instrument, written in English, and specific to the evaluation of the health of the singing voice. Although it is primarily used to differentiate healthy singers from voice-disordered singers and to evaluate functional impact of a voice disorder, the SVHI was selected to determine whether variability in perceived singing voice function is detectable among healthy singers.

In addition to this survey, the 12-item SF-12v2 was selected to evaluate the perception of health status among the performers in terms of overall physical and mental health.[49,50] It contains eight domains with a physical component score (PCS) and mental component score (MCS). These scores are normalized values that compare the eight mean domain subscores of a study population with previously published scores of the general population. PCS and MCS scores above 50 will indicate that a respondent has scored above the general population in physical or mental categories. This health status survey was selected to provide a brief "snapshot" of the overall physical and mental health of the performers. The Short Form (SF)-12 Health Survey was originally developed in the United States to provide a shorter alternative to the SF-36 and this version was therefore selected for this study to minimize respondent burden.[49,50]

Subject recruitment for SVHI

From a list of eight current Australian professional music theater productions, three company managers were sent a letter requesting permission to distribute surveys to performers involved in their respective production. Two company managers responded expressing willingness to participate in this phase of the study and invited the researcher to attend a rehearsal to distribute the surveys. A total of 49 MTS performers (30 from one and 19 from the other production) were recruited. The company managers requested that no demographic information was sought so the age of the participants and other background information (such as the singing experience and role in the show) was not obtained. All these 49 performers (28 females and 21 males) were working in one of the two professional music theater productions in Melbourne and Sydney and deemed themselves vocally healthy. The SVHI and SF-12v2 surveys were handed out during a rehearsal at each of the two productions and a box was left for return of forms. Company managers allocated 15 minutes of time during the rehearsals for survey completion.

Subject recruitment for interviews

Four months after the preliminary phase, correspondence was sent to the company managers of five other Australian professional music theater companies to seek permission to arrange focus group interviews. All five of the company managers agreed to distribute letters inviting their performers to participate, but because of heavy rehearsal schedules, an interview for performers from one of these companies was unable to be arranged. Focus groups of working professional music theater performers (MTS) were held on four separate occasions. None of these performers had participated in the previous phase of the study that involved completion of the SVHI. To get a wide representation of the varied demands of music theater productions, each group comprised cast members from four different professional productions. Each production involved eight performances over 6 days with a minimum of 44 hours rest between the last and first show of the week. The total number of participants was 43 (24 females and 19 males) with each group comprising at least 10 performers. The exact ages of the interviewees were unknown as these data were not available and were considered by the company mangers to be too sensitive to gather. All performers were required to be currently working as a singer in one of the four professional music theater productions and to have performed eight shows per week for the past month. Participants were to be excluded if they had been diagnosed with a voice disorder in the past month or did not sing in the production. All volunteers satisfied the inclusion criteria and none were excluded.

Interviews

The interviews were approximately 90 minutes in duration and were held between a matinee performance and evening show at the theater relevant to each group. Each interview was facilitated by a speech pathologist with more than 25 years of clinical experience in the voice field. In addition to the face-to-face focus groups, 36 other MTS performers from the same music

theater productions responded to the same interview questions via written electronic response. These singers were recruited by the company managers but were not available for the focus groups. The data from both survey methodologies were combined.

Interview questions (Table 1) were formulated by the researchers to elicit attitudes toward the voice including the physical domain (Q1–Q4) and also emotional and psychosocial aspects of managing performance load (Q5–Q8). Each group was asked the same broad questions. All interviews were audio-recorded and interviews were then transcribed and the written responses were also added to these records. All transcripts were de-identified and then reviewed by a speech pathologist independent of the research with more than 10 years of clinical experience in the voice field and by two of the investigators to develop a content analysis of the major themes revealed by the singers. Key words and concepts for the first two questions were entered onto a spreadsheet with a frequency count to highlight common themes. These questions were represented in rows and responses were divided in columns between positive or negative descriptors. For all interviews, responses to questions 5–8 were maintained as transcripts because these responses took the form of a debate or discussion and were more suited to narrative form. For the written surveys, because the questions were open-ended, all responses were combined with the interview transcripts as narrative form.

Two investigators performed content analysis independently. There were three discrepancies in the classification of the voice descriptors whereby reviewers differed in whether they categorized comments as representing positive or negative phenomenon (eg, "I feel like I'm singing through the eye of a needle"). Consensus was reached with all three discrepancies when the transcripts were reviewed together. Because of the nature of this qualitative analysis, no quantitative statistical tests were performed.

RESULTS

SF12v-2 and SVHI

In the preliminary phase involving completion of the SF-12v2 and SVHI surveys, all forms were returned but only 32 (26 females and 6 males) completed the SF-12 scale and 41 (26 females and 15 males) completed the SVHI survey.

All the singers who did not complete the SF-12v2 were male. All 32 respondents scored above average on the SF-12v2 with a mean score of 89 ± 10 indicating above average mental and physical health. There were no significant differences in responses for males and females. Scores on the individual domains ranged minimally for general health, social, and physical functioning.

Of the eight singers who did not complete the SVHI surveys (two females and six males), six performers started the scale but then wrote that the questions were not applicable as they did not have a voice problem. The mean score on the SVHI for the 41 completed surveys was 22 and ranged from 4–66 (out of a potential 144).

Interview themes

Descriptors of sound and sensation changes. The main responses for the first four questions given by the performers, to describe the physical impact of singing and performance on vocal function, were related to throat sensation, pitch, quality, consistency, perceived effort, loudness, and resonance. Both positive and negative terms were used to describe how the voice typically sounded and felt after singing and performing. Tables 2 and 3 contain a summary of the interview themes for the first two questions. Singers' responses to Q1 and Q2 regarding the perception of how voice sounds and feels after singing and performing included descriptions of indicators that they had sung enough or oversung. However, when asked specifically in Q3 and Q4 about these thresholds, additional descriptors were provided and are listed in Table 4.

A total of 97 different terms or phrases (including metaphors) was used by the singers to describe their perceptions of voice alterations after performing or singing. Positive descriptions included responses such as "my voice pings," "rings," "feels buzzy," and "is rich and resonant," which were in contrast to the negative experiences such as "after I perform, I feel as if the space I have to sing through has narrowed" and "I feel vocally weak." When it was not clear whether a descriptor was perceived as a positive or negative feature, for example, breathiness, clarification by the interviewer was sought.

The most commonly described negative vocal changes were breathiness and difficulty singing softly (each reported by 14 singers), followed by difficulty with high notes (12). Of the 45 positive descriptors used by singers to explain how their

TABLE 1.
Interview Questions

1a. How does your voice usually feel after singing?
1b. How does your voice usually sound after singing?
2a. How does your voice usually feel after performing?
2b. How does your voice usually sound after performing?
3. What factors (feelings or sound) if any tell you that you have sung long enough?
4. What factors (feelings or sound) if any tell you that you have over-sung?
5. Does your voice commonly vary across a working week and if so, in what way/s?
6. How does your voice respond to a heavy vocal load/vocally demanding days?
7. What factors affect your voice the most?
8. Which days of a performance week do you perceive to be the hardest vocally?

TABLE 2.
Summary of Descriptors Used by Singers Regarding How the Voice Sounds After Singing and Performing

Category	Positive Descriptor	n	Negative Descriptor	n
Quality	Good	7	Breathy	14
	Clear	6	Cracks and breaks	7
	Normal	5	Top notes are breathy	5
	Its best	5	Husky	5
	Exciting	4	Hoarse	4
	Mellow	3	Rough	4
	Clean	3	Raspy	3
	Great	3	My note onsets are breathy	3
	Musical	2	Dusky	1
	Listenable	2	Noisy	2
Pitch	Flexible across pitch range	6	Difficulty with high notes	12
	Speaking voice sits higher	5	Cannot sing high notes softly	9
	Easy to hit top notes	3	Speaking voice is lower	8
			Speaking voice is lower	8
			Can hear me changing registers	4
Resonance	Rings/brighter	8	Sounds forced and strident	3
	Rich and resonant	5	Thin resonance	3
	Warm/alive	5	Hollow	2
	Pings	3	Muffled	2
	Harmonic	2	Dark	2
Reliability	Consistent	3	Voice cuts out on some notes	7
	Continuous	2	Some gaps in my voice	3
Loudness	Easier to sing louder	2	Cannot sing soft for a while	14
			Not as loud	4
Breathing			Difficulty sustaining long notes	3
			Need more support to sing	3
			Breathless	4
			Struggle to breathe	2

n, number of MTS participants who used the descriptor.

voice sounded or felt, 16 of these were considered to relate to how the voice "felt," 10 to voice quality, eight to global impressions, and five to resonance. There were no descriptions of positive changes to breathing and "being able to sing louder" was the only positive descriptor used for loudness, although there were two singers who reported this feature. Of the 52 negative experiences, 16 were related to sensation and 10 were perceived alterations in voice quality. Many of the singers spoke of the interrelationship between well-being and voice emphasizing that if they were stressed, emotionally "drained," or physically exhausted, their voice was negatively affected, and conversely, if their voice was problematic, they felt tired and stressed. Other

TABLE 3.
Summary of the Positive and Negative Descriptors Regarding How the Voice Feels After Singing and Performing

Positive Descriptor	n	Negative Descriptor	n
Warm	6	Sore/hurts/painful/aches	12
Strong	5	Tired and weak	8
Energized	4	Excess phlegm or mucous	8
Free	4	Dry and scratchy/irritated	7
"Normal" tired	4	Throat muscles feel overworked	7
Refreshed and recharged	4	Hard work	7
Slides/moves easily	3	Need to throat clear	2
Activated	3	Narrow	2
Loose	3	Like I am singing into a box	1
Flexible	2	Singing through the eye of a needle	1

n, number of MTS participants who used the descriptor.

TABLE 4.
Summary of Additional Responses to Interview Questions 3 and 4—When Do You Know You Have Sung Enough (Q3) or That You Have Over Sung (Q4)?

Question	Descriptor	n
Q3. Have sung enough	Adrenaline high/buzzing/voice energized	9
	Managing my current load well	5
	Lasted well for the performance	5
	I am relaxed about my voice	4
	My voice recovers easily	4
	I feel performance fit	4
	I feel good about singing	4
	Feel better after singing	2
Q4. Have oversung	I become worried by my voice	4
	Feels wrong/bad	6
	Have to concentrate harder	5
	I do not feel like singing	4
	Not ready to sing again	4
	Generally worn out/cannot be bothered singing	3
	It takes a long time to warm up	3
	I become concerned by my voice	3
	It stops happening naturally	2

n, number of MTS participants who used the descriptor.

performers argued that solid singing technique enabled the two to be independent so that their performance was not compromised by their "state-of-mind."

Differences in the impact of performing and singing. Questions 1 and 2 sought to determine whether there were differences in the singers' perception of vocal function after singing compared with performing. Singers reported that the vocal demands of the show and the role they played created specific challenges to their vocal stamina, technique, fitness, and recovery from performing. Some discussion occurred in one group about the varying vocal responses to different repertoire stating that sustained singing in a belt or rock style was more vocally demanding than singing in legit or classical styles. Similarly, the higher intensity or higher pitched singing was seen as more demanding than the overall duration of singing time. The responsibility, emotional demands of the role, and adrenalin of performance were also perceived to be an important aspect that differentiated singing simply from performing.

Importance attached to changes in vocal function. A strong theme throughout all the interviews in responses to the first two questions was the lack of concern about negative changes in vocal function after a show or across a working week. Approximately two-thirds of the singers in the interviews indicated it was normal for them to regularly feel vocally tired, to have a lower speaking voice, or to have a reduction in their normal pitch range while involved in a show. When participants were asked when and what factors might make them concerned about their voice, the responses were widely varied. Most agreed that pain would be a significant cause for concern and that persistence of any negative changes in voice quality or pitch range after a day off performing would also concern them. In three of the focus groups, a performer commented that they would not be concerned about any negative changes to their voice unless they were not able to sing well enough for the show. Others agreed with this and most acknowledged that they had performed regularly with a suboptimal singing voice but were confident they could manage this with rest and time off singing. Five singers countered these comments, stating they would not perform if their voice was not "normal" and reported that their voice was too important for them to compromise their vocal health for a production.

Variability in vocal function across performances and season. Additional information was also yielded from the interview regarding the variability of the singing voice profile (Q5–Q8). In the interviews, the singers reported regular patterns of voice change according to the day in the performance week and number of shows per day. Ten singers commented that they "struggled most" or worked the hardest with their voice on the first show of the week (after a 2-day rest) and the second last show of eight shows per week. Specific questioning on these concepts clarified that these performers perceived increased effort to achieve the same voice output on their so-called struggle days. Six performers reported their voice took longer to warm up after the days of rest. Although it was difficult to quantify the number of singers in the interviews who agreed, most performers across both genders indicated that their best vocal shows were in the middle or the last show of the performing week. However, there were three performers who denied any changes in their voice across the performing week.

Singers varied widely in the management of their own vocal recovery regime with 12 performers reporting they regularly underwent 36 hours of complete voice rest on their first day of the week off from performing. Others chose to have a singing

lesson or sing other repertoire on this day to give the voice an "alternative workout," "to do something different," or to develop new material for future employment opportunities. This concept sparked much debate among one of the focus groups with two male performers confessing they regularly performed in other contexts additional to the current show (eg, a private function rock band or in late night drag shows). Both the vocal demands of the show and the specific responsibilities and role of the performer (eg, whether playing a lead, featured role, or ensemble) were decided by this group to be very important in the decision about vocal health. Many of the singers with major performance roles preferred to undergo weekly complete voice rest or limited voice use on one of their nonperformance days than the ensemble performers. No performers said they smoked but the quantities and timing of alcohol consumption varied among the performers.

Global change in singing voice status across the production season was also described by the performers in the interviews. Some performers described a sense of becoming vocally stronger and fitter as the season progressed, whereas others reported a decline in vocal flexibility and stamina. Factors that were noted to influence the direction of these changes were mostly related to the vocal demands of the show and included the role, show scheduling, nature of the repertoire, length of the season, and the theater acoustics. For example, two performers reported feeling more "vocally muscular" but less flexible at the end of a season because they had been required to "use their voice regularly in only one part of their dynamic range, aiming for power more than flexibility."

DISCUSSION

Responses for the SF-12v2 showed that the singers perceived themselves to be in excellent general health, according to their SF-12 scores. The SVHI scores showed that the singers perceived themselves to be vocally healthy according to low handicap and activity scores on the survey. These results are not surprising as the instrument was designed to differentiate those singers with voice problems from those without a voice problem and to evaluate self-perceived handicap resulting from singing impairment and the singers in this study were currently working and perceived themselves as vocally healthy. As all the singers who completed the survey were currently performing, it was unlikely that there would be significant findings of vocal handicap or restricted activity. Although there was some sensitivity within the instrument to detect a singer's perception of the frequency of a reduction in physical voice status according to some features (such as breathiness), it was unclear whether this reduction represents a normal fluctuation in physical function of the vocal mechanism for singing or whether this signifies mild vocal impairment (as a component of a voice disorder).

The focus group discussions provided rich and varied information about singer perceptions of the impact of singing and performing on the vocal mechanism. The singers commonly described physical changes including kinesthetic or auditory shifts in both positive and negative directions that they interpreted as evidence of a heavy vocal load. These vocal experiences were not perceived to be the symptoms of impairment but were identified as regular and normal occurrences for the working voice.

In contrast to the SVHI findings, the interview data revealed many themes of singers' experiences of changes to the physical vocal mechanism secondary to both singing and performing. The singers' perspectives provided by the interviews were in keeping with previously published reports regarding the perception of vocal load on voice that described positive changes or sensations as well as symptoms of fatigue and vocal impairment.[2,35–41,51–54] Laukannen et al[35] evaluated the subjective symptoms of voice and throat change after a heavy speaking voice load among trained voice users and reported both positive and negative changes. All the descriptors that were used in the study conducted by Laukannen et al, for example, "ease of phonation," "tiredness," "hoarseness," and "tickling," were similarly reported by singers in the interviews in this study.

Most of the singers interviewed in this study reported regular experience of vocal fatigue over a given performance week, particularly those with a heavy vocal load. They described all the symptoms identified by Solomon[41] as indicators of fatigue (increased vocal effort and discomfort, reduced pitch range and flexibility, and reduced control of voice quality) although the singer terminology was often different (such as "raspy," and so forth). For this study, breathiness, difficulty with high notes and soft notes, and throat discomfort were all regular descriptors used by the singers (Tables 2 and 3). There were marked individual differences in the importance attached to these symptoms or sensations with approximately two-thirds of the performers perceiving the aforementioned sensations to be normal, whereas others perceived them to be concerning. For some of these descriptors, their mere presence was perceived to be a reason for concern (eg, pain), whereas other descriptors (such as breathiness) were perceived by the performers to be normal unless they persisted after vocal rest, were constant phenomenon, or impacted on their performance.

The descriptors used by the singers were varied and could be loosely ascribed to the categories of vocal quality, pitch, loudness, resonance, sensation, effort, and consistency. Most of the descriptors of negative singing voice changes have been previously identified as symptoms of possible vocal impairment. In a previous study, Phyland et al[6] surveyed 229 professional singers regarding self-reported singing voice impairment over the past 12 months as indicated by their experience of 20 singing voice symptoms from a checklist. These symptoms were derived from review of the literature and expert clinical opinion and comprised symptoms of changes in singing voice quality, pitch, loudness, continuity, breath, resonance, and throat sensations. Although singers identified each symptom as occurring regularly, the methodology for this part of the study was somewhat limited. Singers were asked to recall the regularity of their symptom experiences over the past 12 months. The validity of retrospective evaluation of symptomatology is questionable so little insights were gleaned from this component of the singer survey. However, the data did reveal that all singers, irrespective of whether or not they reported voice problems, identified regular experience of vocal impairment as defined by the

symptom list. This finding suggested that singers in this previous study perceived it was normal to experience fluctuations in the physical aspects of vocal function. In the present study, these same features have also been identified as a normal consequence of a heavy vocal load but at what stage the transient vocal "experiences" become a symptom of impairment is not clear. The findings highlight that singers regularly perceive positive and negative transient changes in the physical mechanism secondary to the act of singing and performing.

Although the negative singing voice changes described in the singers' interviews have been previously reported,[2,6] the descriptions of positive changes, improved vocal function (or vocal "fitness"), and of fluctuations in vocal status across a performance week and season offers new and valuable information. Wide individual differences in thresholds for vocal change were also a strong theme with 12 performers reporting minimal change across a working week, five reporting wide variability in vocal status over a week, and the others describing a regular and predictable pattern of vocal improvement, followed by decline and recovery.

In summary, the interviews with the MTS performers yielded rich descriptive information suggesting potential trends in vocal fitness, improvements, fatigue, and recovery. Although no singers reported in the interviews that they had experienced a voice problem, symptoms of impairment were a common theme. Further knowledge and quantification of these trends could be invaluable to facilitate the determination of load thresholds/doses, recovery times so as to help predict the development of voice problems. This information could further help in the evaluation of therapeutic outcomes in the management of the specific needs of the singer's voice and provide supportive data for determination of performance fitness. There is a need for a tool that is sensitive to potential changes in the singing voice as a function of performance load that could quantify these fluctuations. Current vocal health assessment instruments, such as the SVHI and the RHI-S,[30–34] although invaluable for the voice-disordered singer, are inadequate for these other purposes because they lack the sensitivity to detect small changes within the range of normal function. These instruments also include self-evaluation of restriction to activity and participation aspects that may not be pertinent to the currently working singer. Other voice disorder self-report scales, such as VoiSS,[23,24] although primarily an impairment symptom scale, are not specific to the singing voice so are limited in their applicability to singers. In addition, such scales gather information about negative physical change only and the singers in this study also reported positive changes in the vocal mechanism after performance.

SUMMARY

Surprisingly little is known about MTS performers' perceptions of the effect of load on singing voice function despite the recognition that these performers have a heavy load and may be a higher risk group for the development of voice problems given the environmental factors and the demands of the vocal styles used in contemporary music theater productions.[2,6–11] The information yielded from the qualitative focus groups in this study is unprecedented as it represents the actual lived experiences of MTS and not the opinions of voice experts. Also, these singers were all currently working and reported themselves to be vocally healthy, whereas previous research has predominantly focused on treatment-seeking singers.

In this prospective interview study, the MTS reported regular positive vocal sensations as well as vocal fatigue over a performing week and indicated vocal status varied according to the day of the performance week. Although individual variability was common, many performers described definite trends across a working week with the first and last day of the week commonly perceived to be more vocally difficult than the midweek performance days.

This study coupled with the review of the literature demonstrates that there is a need to develop and validate a vocal function self-assessment tool that is sensitive to the subtleties of the singer's voice and can identify potential changes in vocal function across time, vocal load, and contexts. Such a tool may provide a means to measure changes in the singing voice as indicators of the effect of vocal load and might potentially predict or screen for "at risk" symptoms for the development and description of voice disorders. The interviews provided here have provided the necessary preliminary data on which to base design of an instrument for the self-assessment of singing voice function in the MTS population.

Moreover, the information yielded from the interviews and performer reviews of voice descriptors has provided valuable insights into the complexities of perceptual judgment of the singing voice in the working performer. Such insights are a precursor to our understanding of the nature of recovery and repair from heavy vocal load among singers and the progression from normal functioning to the pathological voice.

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Chapter 4

THESIS PUBLICATION-Study Two

Erratum- Paper 2 Appendix B page 462

Phyland, D. J., Pallant, J. F., Benninger, M. S., Thibeault, S. L., Greenwood, K. M., Smith, J. A., & Vallance, N. (2013). Development and preliminary validation of the EASE: a tool to measure perceived singing voice function. *Journal of Voice*, *27*(4), 454-462.

Final Items for each subset.

Factor 1-'My voice is worse than usual' is incorrect. It should be deleted and replaced by 'My voice feels strained'.

Development and Preliminary Validation of the EASE: A Tool to Measure Perceived Singing Voice Function

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Summary: Objectives. Most voice self-rating tools are disease-specific measures and are not suitable for use with healthy voice users. There is a need for a tool that is sensitive to the subtleties of a singer's voice and to perceived physical changes in the singing voice mechanism as a function of load. The aim of this study was to devise and validate a scale to assess singer's perceptions of the current status of their singing voice.

Methods. Ninety-five vocal health descriptors were collected from focus group interviews of singers. These were reviewed by 25 currently performing music theater (MT) singers. Based on a consensus technique, the number of descriptors was decreased to 42 items. These were administered to a sample of 284 professional MT singers using an online survey to evaluate their perception of current singing voice status.

Results. Principal component analysis identified two subsets of items. Rasch analysis was used to evaluate and refine these sets of items to form two 10-item subscales. Both subscales demonstrated good overall fit to the Rasch model, no differential item functioning by sex or age, and good internal consistency reliability. The two subscales were strongly correlated and subsequent Rasch analysis supported their combination to form a single 20-item scale with good psychometric properties.

Conclusions. The Evaluation of the Ability to Sing Easily (EASE) is a concise clinical tool to assess singer's perceptions of the current status of their singing voice with good measurement properties. EASE may prove a useful tool to measure changes in the singing voice as indicators of the effect of vocal load. Furthermore, it may offer a valuable means for the prediction or screening of singers "at risk" of developing voice disorders.

Key Words: Singing voice–Survey–Scale–Measurement–Self-report–Assessment–Music theater–Performers–Impairment–Symptoms–Voice disorders–Vocal health.

INTRODUCTION

Working singers rely on a vocal mechanism that can meet performance demands and be so-called "performance-fit." Although the singer population has not been well studied, anecdotal reports suggest that it is a normal occurrence for performance-fit singers to experience positive and negative variabilities in vocal function across time and performances and significant fatigue effects after heavy vocal load.[1–10] Whether these experiences are transient or whether, if sustained or cumulative, they can become symptomatic of vocal impairment and thereby threaten short- or long-term vocal health is not known. There is an obvious need to measure these vocal status shifts to determine vocal load thresholds and to establish normative data for working singers. Furthermore, prediction and management of vocal injury among singers is predicated on assumptions as to what constitutes normal. At present, there is an absence of normative data to support these assumptions because there are no appropriate tools to measure vocal status changes in singers or the physical effects of vocal load.

The focus of voice disorder-related quality of life (VDQoL) instruments is the evaluation of physical, mental, and social well-being consequences arising from vocal disorders or impairment, namely dysphonia.[11–17] For those voice users who experience mild impairment, but minimal or no restriction to voice activities and participation, scores on these instruments will be typically low. Similarly, VDQoL instruments will not fully detect fluctuations in vocal status that may occur in the absence of disorder or impairment. In other words, VDQoL instruments are disease-specific in the sense that they measure quality of life related to dysphonia.

There is a need for a tool that is sensitive to the subtleties of the singer's voice and to potential perceived physical changes in the singing voice as a function of load. At present, there appears to be no such instrument available. Current self-report scales that evaluate singing voice[18–24] focus on disorder and include limitations to activity and participation, but lack sensitivity to singers who continue to perform with or without impairment. To evaluate the impact of load on the voice of singers, there is a need for the development of a valid and reliable scale for singers permitting self-evaluation of vocal status. The scale needs to be clinically appropriate, valid, and reliable but also must be simple, quick to complete, easy to score, and useful.[25] The language or terminology of the scale items should be tailored to the population of respondents and the content should reflect the respondent's concerns at the time and not be reliant on recall of previous experiences.[26,27] A self-report symptom scale needs to account for both positive and negative changes in physiological aspects because singers can report positive

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changes in their voice,[4] for example, after warm-up,[6,7] as well as negative changes after overuse.[8–10] In addition, the instrument development processes should comply with the guidelines for the development and evaluation of patient-reported outcome measures (PROMs) outlined by the Scientific Advisory Committee of the Medical Outcome Trust as suggested by Branski et al.[28,29] In particular, a scale should undergo a rigorous development process, comprise patient-derived items, and have strong psychometric properties so that it is valid, reliable, and responsive.

The aim of the study was, therefore, to develop a vocal function self-report instrument that is sensitive to the subtleties of the singer's voice and adhered to the aforementioned recommendations for scale development and testing.

METHOD

Approval for the conduct of this study and subject recruitment was obtained from the Monash University Human Ethics Committee (Approval CF11/0298-2011000103).

Phase 1: Item generation

The initial content of the proposed instrument was generated from a previously reported series of four focus groups (n = 43) and written survey responses (n = 36) of professional music theater (MT) singers.[4] All these singers were currently performing in professional productions of over 1-year duration and averaged eight shows per week of performance, in Melbourne or Sydney, Australia. The singers were asked to describe how their voice typically felt or sounded after performing and singing. Their responses generated a total of 95 positive and negative descriptors related to the physical functioning of the singing voice.

Phase 2: Item review

The 95 items were presented to 25 performer reviewers and refined using a consensus technique via two rounds of online survey following the Delphi Method.[30,31] The Delphi Method is a group facilitation technique that seeks to obtain consensus on the opinions of "experts" through a series of structured questionnaires (commonly referred to as "rounds"). Responses are summarized between rounds and communicated back to the participants through a process of controlled feedback. This process is repeated until consensus is reached or until the number of returns for each round decreases. The process gathers opinion without the need to bring panelists together physically. In this study, the experts were MT singers who had performed professionally over the past 12 months and had not participated in the previously described focus group interviews.

The initial 95 items were presented in a written list and performers were asked to assess each item using the following options: "I like the descriptor," "I don't like the descriptor," "I am not sure," or "I don't understand the descriptor." The top scoring items were retained, excluding any items that were responded to by two or more respondents with either "I don't understand …"or "I don't like the descriptor." A list of 60 items was then represented to the same 25 singers and they were asked to rank their top 40 and to identify any items they considered redundant or ambiguously worded. Review of responses was undertaken to eliminate redundant or inappropriate items and decrease the number to a total that was feasible to administer. Finally, a consensus set of 42 items was achieved, based on importance of rankings. The final 42 items are provided in Appendix A.

Phase 3: Item evaluation phase

In the next phase of this study, the reliability and internal validity of the refined instrument, the Evaluation of the Ability to Sing Easily (EASE), were tested using the initial list of 42 items. Invitations to participate were sent to 10 company managers of professional MT productions in Australia and were also posted on a "member-only" professional MT performers' Web site. Over a period of 8 weeks, a total of 284 professional MT singers (157 females and 127 males) from Australia, Asia, London, and the United States completed an online survey. This comprised demographic and singer background questions as well as the initial list of 42 vocal descriptors. Nearly half (48.2%) of the respondents were aged between 21 and 29 years. One hundred sixty-five of the respondents were currently performing in an MT production at the time of survey completion (participant characteristics are listed in Table 1). For each of the descriptors, respondents were required to choose from five response options "not at all, slightly, mildly, moderately, and extremely" describing how their voice felt or sounded at the time of survey completion.

Statistical analysis

Thirteen of the 42 items were worded positively (eg, "my voice feels strong"). These were reverse scored so that high scores indicated a negative change in voice function. The evaluation and refinement of the 42-item pool was undertaken in two stages. Exploratory factor analysis was conducted initially to assess the

TABLE 1.
Participant Characteristics

MT Singer Characteristics	(N = 284)
Age (y)	
≤17	5 (1.8%)
18–20	12 (4.2%)
21–29	137 (48.2%)
30–39	79 (27.8%)
40–49	41 (14.4%)
50–59	10 (3.5%)
Gender	
Female	157 (55.3%)
Male	127 (44.7%)
Currently performing in an MT production	
Yes	165 (58.1%)
No	119 (41.9%)
Country where living or performing	
Australia	219 (77.1%)
Asia	29 (10.2%)
UK	15 (5.3%)
USA	21 (7.5%)

dimensionality of the items and to identify subsets of items for use in Rasch analysis. The items from each component were then subjected to Rasch analysis to assess their measurement properties and to select the best set of items to form a concise, psychometrically sound scale to represent each aspect identified.

Principal components analysis (PCA) was conducted using the *SPSS* statistical software, Version 20 (SPSS Science, Chicago, IL), after first ensuring that the data were suitable for factor analysis. This was indicated by a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy value[32,33] above 0.60 and a highly significant ($P < 0.001$) Bartlett test of sphericity.[34] The number of factors to be retained was identified using three decision rules: Kaiser criterion (eigenvalues above 1), inspection of the scree plot,[35] and Horn parallel analysis.[36] Parallel analysis has been identified as one of the most accurate methods to identify the number of factors to be retained.[37] Using the software developed by Watkins,[38] eigenvalues obtained from PCA were compared with those generated from a random data set of the same size. Only those components with eigenvalues exceeding the corresponding value from the random data set were retained. Selected components were rotated using an oblique rotation technique (Oblimin) to allow for assessment of the correlation between the components.[39]

Rasch analysis was conducted using the partial credit model of the *RUMM2030* program.[40] Rasch analysis provides a very detailed assessment of all aspects of a scale's internal functioning, including its overall internal consistency, the fit of the items, the response scale, dimensionality, and potential item bias across groups.[41,42] Rasch analysis has been extensively used to review and improve existing questionnaires that were constructed using Likert scales.[43] It also provides a conversion of ordinal raw scores to interval-scaled scores, allowing the use of parametric statistical analyses. Rasch analysis techniques have also been used to construct new questionnaires and are recommended by Branski et al[28] as a preferred psychometric method for the development of PROMS. Detailed descriptions of the process of Rasch analysis are provided elsewhere.[43–45] The aim was to test if the observed responses to the items conform to the expectations of the mathematical measurement model developed by Rasch.[42] Deviation from this measurement model indicates problems with the scale and its items. The process of Rasch analysis involves a specified protocol,[43–45] which systematically identifies areas of misfit. Modifications can be made (eg, removal of an item) with subsequent retesting of the scale to assess improvement. Initially, overall fit to the model is evaluated; with good fit indicated by a nonsignificant summary of chi-square interaction fit statistic and a fit residual standard deviation (SD) of less than 1.5. Bonferroni adjustment is made to the alpha level used to assess the significance of the chi-square statistic by dividing .05 by the number of items. The fit of individual items and persons is evaluated using chi-square statistics (should be nonsignificant) and fit residual values (should fall within the range ±2.5). High positive fit residuals indicate misfit, whereas high negative fit residuals may suggest item redundancy. Potential bias among the items across subgroups (eg, male/female) can be detected by the assessment of differential item functioning (DIF) using analysis of variance with a Bonferroni-adjusted alpha level. The internal consistency of the scale is indicated by a Person Separation Index (PSI) (similar to Cronbach alpha), which ideally should be above 0.7.[46]

The suitability of the response format is determined by inspecting the item thresholds, which should show a systematic increase across the range of the characteristic being measured. Thresholds refer to the point between each adjacent response category where either response is equally probable. If disordered thresholds are detected, this suggests problems with the response format of the scale, with respondents using the options inconsistently. This could be due to poor labeling or too many response options and can be remedied by collapsing adjacent response categories.

The Rasch model's assumption of local independence requires that items should not show any remaining patterns of association once the variance they share due to the Rasch factor (the underlying characteristic being measured) is extracted.[43] The residual correlation matrix is inspected for positive correlations, particularly values exceeding 0.20. The presence of local dependency among items can artificially inflate the PSI value, suggesting higher internal consistency than is warranted. This possibility is checked by combining items that show elevated residual correlations to form subtests and comparing the PSI values from the original and subtest analysis.[47] A marked difference in these two values would suggest local dependency among the items.

To ensure that the scale is unidimensional, a two-step process is used.[45] PCA of the residuals is conducted to identify two subsets of items (the positively loading items and the negatively loading items on the first component), which are then compared for each individual using a series of *t* tests. If more than 5% of respondents show a statistically significant difference in their scores (or specifically the lower bound of the binomial confidence interval [CI] is above 5%), then the scale is deemed to be multidimensional.

RESULTS

Exploratory factor analysis

The factorability of the data file was confirmed with a KMO measure of sampling adequacy value of 0.95 and a highly statistically significant Bartlett test of sphericity ($P < 0.0001$). PCA revealed six eigenvalues above 1; however, the scree plot and parallel analysis suggested that only two components should be extracted. Oblimin rotation of the two-component solution showed a clear pattern of loadings, with all except three items loading above 0.4 on their component. The correlation between the two components was strong ($r = 0.63$). The three items with no loadings above 0.4 ("phlegm," "lasted well on my last performance," and "recovers quickly") were removed from the scale with the remaining 39 items retained for further investigation using Rasch analysis.

Rasch analysis

The 22 items of component 1 showed poor initial fit to the Rasch model ($P < 0.0001$, fit residual SD = 2.37, Table 2: analysis 1) with six items recording fit residual values exceeding the

TABLE 2.
Summary of Fit Statistics for Rasch Analyses of EASE Items

Action	Analysis	Overall Model Fit	Item Fit Residual Mean (SD)	Person Fit Residual Mean (SD)	PSI	% Significant *t* Tests*
Component 1, 22 items	1	$\chi^2 = 150.8$ df $= 66$ $P < 0.0001$	0.57 (2.37)	−0.16 (1.32)	0.95	13.73% CI: 11.2–16.3
Component 1, 22 items Rescore all items to four points	2	$\chi^2 = 150.68$ df $= 66$ $P < 0.0001$	0.28 (2.22)	−0.19 (1.30)	0.95	13.73% CI: 11.2–16.3
Component 1 Final 10-item solution	3	$\chi^2 = 29.21$ df $= 30$ $P = 0.51$	0.09 (0.73)	−0.22 (1.06)	0.87	9.15% CI: 6.6–11.7
Component 1 Final 10-item solution subtest analysis	4	$\chi^2 = 37.95$ df $= 24$ $P = 0.04$	0.15 (0.80)	−0.22 (0.99)	0.86	7.04% CI: 4.5–9.6
Component 2, 17 items	5	$\chi^2 = 127.77$ df $= 51$ $P < 0.0001$	−0.13 (1.90)	−0.25 (1.08)	0.87	4.58%
Component 2, 17 items Rescore all items to four points	6	$\chi^2 = 121.87$ df $= 51$ $P < 0.0001$	−0.36 (1.69)	−0.28 (1.14)	0.88	4.58%
Component 2 Final 10-item solution	7	$\chi^2 = 52.46$ df $= 30$ $P = 0.007$	−0.12 (0.98)	−0.29 (1.07)	0.80	3.17%
Component 2 Final 10-item solution Subtest analysis	8	$\chi^2 = 48.69$ df $= 24$ $P = 0.002$	−0.03 (0.79)	−0.22 (0.97)	0.79	3.17%
Combine components 1 and 2, 20 items Subtest analysis	9	$\chi^2 = 13.22$ df $= 6$ $P = 0.04$	0.07 (0.82)	−0.41 (0.79)	0.80	1.15%

Abbreviations: PSI, Person Separation Index; df, degrees of freedom.
* CI only reported if the value exceeds 5%.

recommended value of ±2.5. Over half of the items (13/22) showed disordered thresholds, suggesting a problem with the response scale. To resolve this, it was necessary to reduce the original five-point response scale to four points by collapsing two of the response categories (mildly and moderately) for all items. This corrected the disordered thresholds and improved overall fit slightly (Table 2: analysis 2).

To achieve a concise subscale, with good fit to the Rasch model, items were removed sequentially guided by both statistical and conceptual considerations. This resulted in a final 10-item solution with excellent overall fit, no misfit items, no DIF for sex or age group, and good internal consistency (Table 2: analysis 3). Two pairs of items (7/18 and 5/19) showed correlations between their residuals exceeding 0.2, and the scale showed some evidence of multidimensionality (Table 2: analysis 4). Local dependency among these items was assessed by combining these pairs of items to form separate subtests and comparing the subsequent PSI values with the original (Table 2: analysis 3 and analysis 4). There was a very little difference in the values (0.87, 0.86) suggesting that the high PSI value was not due to local dependency among the items. The formation of these subtests also resolved the multidimensionality (Table 2: analysis 4) with the CI containing the required value of 5% (CI: 4.5–9.6%).

Rasch analysis of the 17 items from component 2 revealed poor fit to the model ($P < 0.0001$, fit residual SD = 1.90, Table 2: analysis 5), with three items recording individual item fit residual values exceeding ±2.5. Most items (14/17) showed disordered thresholds, which was resolved by collapsing the "mildly" and "moderately" response options (Table 2: analysis 6).

Using the same procedures adopted for component 1, a process of refinement was undertaken to remove misfitting items and to identify the best 10 items to be retained in the subscale. The final 10-item solution showed adequate fit to the model (Table 2: analysis 7), no misfitting items, and good internal consistency (PSI = 0.80) with no DIF for gender or age. The scale showed no evidence of multidimensionality. Two pairs of items recorded residual correlations above 0.2 (12/42 = 0.40 and 4/17 = 0.25). Subtests were created using these pairs of items and the original and subsequent PSI values compared. The values were very similar (0.80 and 0.79, Table 2: analysis 7 and 8) supporting the retention of these items in the scale.

Given the strong correlation between the two components noted from the previous PCA results, it was decided to test the suitability of combining the two 10-item subscales to form a total score. Rasch analysis was conducted on the two subtests, representing the 10 items in each of the final version of the subscales. The overall fit to the model was satisfactory ($P = 0.04$, Table 2: analysis 9) with support for the unidimensionality of the combination of the two subtests. The EASE items were well targeted for the sample (Figure 1).

These results suggest that the two subscales may be used independently or combined to give an overall total score. Component 1 items were dominated by physical symptoms of vocal fatigue, whereas component 2 items were suggestive of laryngeal edema or pathology. The final version of each subscale is presented in Appendix B along with scoring instructions. A conversion table is provided to allow users to convert the raw score to a Rasch-derived interval-scaled score suitable for both clinical and research purposes (Appendix C).

DISCUSSION

The aim of this study was to devise and refine a scale to measure singers' perceptions of physical aspects of singing vocal status. Exploratory factor analysis of a pool of 42 items generated from qualitative interviews and surveys identified two components. Rasch analysis was used to evaluate and refine these sets of items to form two 10-item subscales. After collapsing the scale from a five-point to a four-point response scale, both subscales showed good overall fit to the Rasch model, no DIF by sex or

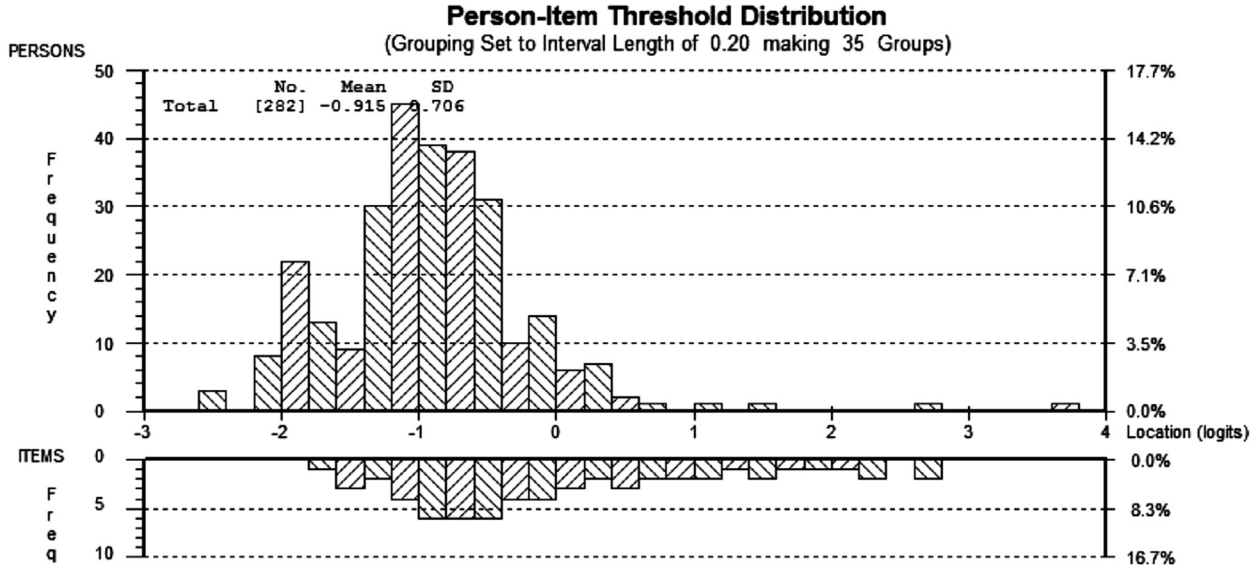

FIGURE 1. Person-item threshold map of the EASE showing distribution of scores and item thresholds. *Note:* The topic section shows the distribution of respondents' total Rasch-derived scores. The bottom section shows the range and distribution of item thresholds.

age, and good internal consistency reliability. The two subscales were strongly correlated and subsequent Rasch analysis supported their combination to form a single 20-item scale with good psychometric properties.

The final 20 items contained descriptors of vocal fatigue and impairment, most of which have been previously described in the voice literature for professional voice users, whether singers or not.[13] Most items in subscale 1 represented physical symptoms of vocal fatigue. The symptoms: "my throat muscles feel overworked," "my voice is tired," "husky," and "dry/scratchy" are in keeping with previous anecdotal reports of symptoms of vocal fatigue among heavy voice users.[4–9] The descriptors "my top notes are breathy" and "the onsets of my notes are delayed or breathy" are specific to the singing voice and do not appear in other symptom inventories, although they were regular interview themes in our previous study of MT performers.[4] Novel descriptors are three items that were worded positively ("my voice feels good," "sounds rich and resonant," and "is ready for performance if required"). Although these items have not been previously reported, even anecdotally, lower scores on these items were found to be associated with vocal fatigue.

Items of subscale 2 relate to mucosal changes (eg, edema) that can occur with chronic overuse, the common cold or vocal fold pathology. Items such as "my voice cracks and breaks, cuts out on some notes, and is breathy;" "singing feels like hard work;" and "I have difficulty changing registers, singing softly, and with my high notes" have been described by Bastian et al[48] as common signs of vocal fold edema among singers. Other items in this subscale such as "difficulty projecting, sustaining long notes, and with my breath for long phrases" have been associated with laryngeal valving impairment and so may be symptomatic of laryngeal pathology or upper respiratory tract infection.[1,12,13]

Whether the two subscales are clinically distinguishable and therefore differentially predictive of vocal fatigue and/or specific vocal conditions (such as edema) will require further investigation. Validation of the scale with voice-disordered singers is also necessary, and, until then, the potential independence of the two components is speculative. Our recommendation is therefore to use the items as a total scale score based on the results of the statistical analyses conducted in this study.

All the items generated for the scale were descriptors derived from singers and from expert opinion, representing areas of importance for singers. The final 20 items were related to the physical aspects of singing voice function only and most have been previously described as regular occurrences after vocal load.[4–11] Selection of the final items was based on both psychometric analyses and conceptual grounds. Psychosocial descriptors such as "I am worried about my voice" or "I do not feel like singing" that required singers to judge the effect of their voice on well-being or *vice versa* were removed. Although these descriptors may be important to a singer's perception of vocal health, they relate to a different domain than the physical-based items. These can be administered separately as an adjunct to the final 20 EASE items.

A major difference of EASE as a symptom scale compared with other PROMs is with the period surveyed. Respondents are required to evaluate their voice based on their current perception rather than relying on recall of previous experiences. In this way, EASE offers a "snapshot" of the voice at the time of the completion. This immediacy of response eliminates potential for recall bias and has been previously demonstrated to be more clinically reliable for symptom evaluation than retrospection.[26,27] Retrospective self-report data are often used for a wide range of research purposes and are especially prominent in the behavioral and medical fields to determine whether an individual has experienced the required symptoms for the length, frequency, and severity necessary to receive a diagnosis. However, the purpose of EASE was not to quantify or diagnose a voice disorder but to seek a singer's perception of current vocal function so the response time domain is appropriate. Although the internal validity of the scale has been evaluated, future studies are needed to investigate the construct and predictive validity of EASE. Specifically, the ability of EASE to predict findings on instrumental assessment of vocal function (eg, videostrobocopy or aerodynamic measures such as phonation threshold pressure) requires future investigation and will be of great interest.

Through a rigorous, three-stage process of content development involving item generation, item reduction, and detailed psychometric evaluation, a reliable self-report scale "EASE" has been developed for use with singers. Content was derived from singer interviews, expert opinion, and refinement using a consensus approach. To decrease potential for cultural differences, responses were collected from professional MT singers in the four continents of Australia, United States, United Kingdom, and Asia.

The person-derived item generation and item reduction processes used in this study conform to the recommendations made by Branski et al[28] for instrument development. EASE appears to be one of the first scales developed within the voice field to use Rasch analysis as part of the evaluation process. It provides a detailed investigation of many aspects of the scale, not available using traditional techniques based on classical test theory. In the present study, Rasch analysis identified problems with the response format that were resolved by collapsing the scale from five to four response options. It also identified items that were not clear contributors to the overall scale, resulting in their removal. Each subscale was reduced to 10 items making the scale quicker to administer and therefore more user-friendly. The use of Rasch analysis also allows the generation of a conversion table to convert the ordinal raw scores to an interval-scaled Rasch score, making it potentially suitable for parametric analysis.

Although EASE may prove a valuable clinical outcome measure for symptomatic aspects of compromised vocal health, the tool is not primarily designed to be a disease-specific instrument. It aims to profile a singer's perception of the physical functioning of their voice using language and terminology that does not assume disorder and therefore can capture the nuances of the healthy singer as well as those with impairment. In this way, the tool can measure potential changes in the singing voice as indicators of the effect of vocal load and may

potentially predict or screen for singers "at risk" of developing voice disorders. Whether the EASE can be used clinically to differentiate vocal impairment from "normal" vocal impairment has yet to be determined.

EASE shows promise as a useful singer-specific symptom tool based on its psychometric properties and offers a first step in the investigation of changes to the physical functioning of singer's voices. Items include both positive and negative descriptors of perceived change and so there is no presumption of disease but a "healthy" framework to suit the working singer. In addition, the response format prevents recall bias as it relies on self-appraisal of current status.

Further exploration of the scale's external validity by comparison to findings on instrumental voice evaluation is recommended. Once external validity has been established, this scale can be used to identify potential changes in the physical aspects of vocal function across time, vocal load, and contexts. Specifically, EASE may prove useful for singers in (a) determining load thresholds/doses, recovery times to assist performance scheduling and quotas; (b) predicting the development of voice problems; (c) evaluating therapeutic outcomes in management of the specific needs of the singer's voice; and (d) providing supportive data for determination of performance fitness. Such information gleaned from singers' perceptions of the impact of heavy vocal load on the physical functioning of their voices may further enhance our understanding of the complex mechanisms of vocal fatigue, repair, and recovery.

CONCLUSIONS

The EASE is a concise, easy to use, clinical tool to assess singer's perceptions of the current status of their singing voice. EASE may prove a useful tool to measure changes in the singing voice as indicators of the effect of vocal load. Furthermore, it may offer a valuable means for the prediction or screening of singers at risk of developing voice disorders.

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APPENDIX A

Singers' Descriptors of Singing Voice Status (original list)

Please answer the following questions based on how your voice feels or sounds now. If it has varied over the day, simply choose the response that most suits how your voice is right now.

1. My voice is husky
2. My voice feels dry/scratchy
3. My voice feels strong
4. My voice cracks and breaks
5. My throat muscles are feeling overworked
6. My voice is breathy
7. I feel good about singing
8. My top notes are breathy
9. My muscles are rejuvenated
10. The onsets of my notes are delayed or breathy
11. My voice feels strained
12. I have difficulty with my breath for long phrases
13. I feel phlegm or mucous in my throat
14. My voice is flexible across my pitch range
15. The pitch of my speaking voice is lower than usual
16. My voice sounds rich and resonant
17. My voice cuts out on some notes
18. My voice feels ready for performing today if it was required
19. My voice is tired
20. My voice is worse than usual
21. My voice feels fragile
22. My voice feels fit for performance
23. I have to concentrate hard to achieve my usual sound
24. My voice recovers quickly after performing
25. My voice takes a long time to warm up
26. I am worried about my voice
27. My voice feels lubricated and/or smooth
28. I have difficulty changing registers
29. I have difficulty singing loudly
30. My voice lasted well throughout my most recent performance
31. I have difficulty with my high notes
32. Singing feels like hard work
33. I am relaxed about my voice
34. I have difficulty singing high notes softly
35. My voice is at its best
36. I have difficulty with my low notes
37. I have difficulty projecting my voice
38. I am concerned about my voice
39. I am managing my current vocal load well
40. My voice feels refreshed and recharged
41. I have difficulty singing softly
42. I have difficulty sustaining long notes

APPENDIX B

Final Items for Each Subset

Items	Not at All	Mildly	Moderately	Extremely
Factor 1				
My voice is husky				
My voice is dry/scratchy				
My throat muscles are feeling overworked				
My voice feels good*				
My top notes are breathy				
The onsets of my notes are delayed or breathy				
My voice sounds rich and resonant*				
My voice is ready for performance if required*				
My voice is tired				
My voice is worse than usual				
Factor 2				
My voice cracks and breaks				
My voice is breathy				
I am having difficulty with my breath for long phrases				
My voice is cutting out on some notes				
I am having difficulty changing registers				
Today I am having difficulty with my high notes				
I am having difficulty projecting my voice				
I am having difficulty singing softly				
Singing is hard work				
I am having difficulty sustaining long notes				

* Reverse scored.

APPENDIX C.

Conversion of Raw EASE Scores to Rasch Converted (0–100) Scores

Raw	Rasch Converted (0–100)	Raw	Rasch Converted (0–100)	Raw	Rasch Converted (0–100)
0	0	21	31	41	47
1	8	22	32	42	48
2	12	23	32	43	50
3	15	24	33	44	51
4	17	25	33	45	52
5	19	26	34	46	54
6	20	27	35	47	56
7	22	28	35	48	57
8	23	29	36	49	59
9	23	30	37	50	61
10	24	31	37	51	63
11	25	32	38	52	65
12	26	33	39	53	68
13	27	34	40	54	70
14	27	35	41	55	73
15	28	36	42	56	76
16	28	37	42	57	79
17	29	38	44	58	84
18	29	39	45	59	90
19	30	40	46	60	100
20	31				

Instructions for use: Raw scores are calculated by summing the total of responses to all 20 items scored as 0 = not at all, 1 = mildly, 2 = moderately, and 3 = extremely. Identify the raw score value in either column 1,3 or 5 and read across to determine the matched Rasch converted equivalent. These Rasch converted scores have been rescaled to range from 0 to 100. Only respondents that have answered all items can be scored.

Chapter 5

THESIS PUBLICATION-Study Three

Additional information regarding Publication Three

Paper 3 reported findings for a five options response mode despite the prior recommendation to use four response choices for the EASE scale ranging from ‘not at all’ to ‘extremely’. The data reported in this paper had been collected prior to the recommendation but the authors continue to recommend the four options response format and will provide support for this in future publications.

The two items included in the optional Vocal Concern (VC) subscale of ‘worried’ and ‘concerned’ can be considered synonyms but, in the development of the EASE, singers reported subtle differences in their interpretation of each item. In addition, scores on these items were not in complete agreement so redundancy was not demonstrated. Both items were therefore included to facilitate internal consistency for this construct and to provide additional information related to the significance attached to the currently perceived singing voice functional status.

Paper 3-Measuring vocal function in professional music theatre singers: construct validation of the Evaluation of the Ability to Sing Easily (EASE)

Phyland, D. J., Pallant, J. F., Thibeault, S. L., Benninger, M. S., Vallance, N., & Smith, J. A. (2014). Measuring Vocal Function in Professional Music Theater Singers: Construct Validation of the Evaluation of the Ability to Sing Easily (EASE). *Folia Phoniatrica et Logopaedica*, *66*(3), 100-108.

Overview: Working music theatre singers (MTS) typically have a heavy vocal load and little is known about their perception of vocal function. The EASE was used to assess professional MTS' perceptions of current singing voice status and to compare scores across demographic and performance characteristics and to evaluate the construct validity of the EASE and its' subscales (VF: Vocal Fatigue, PRI: Pathologic Risk Indicators).

Methods: Professional MTS (n=284) completed an online survey including the EASE and two additional vocal concern (VC) items. Scores were compared across age, gender, whether currently working, role, perceived vocal load over past 24 hours and self-reported voice problem.

Results: For the whole cohort, statistically significant differences were found on all subscales according to whether or not singers perceived themselves to have a voice problem ($p<0.001$). Currently performing singers were significantly different to those not performing in a show on the EASE-Total ($p=0.014$) and VF ($p=0.002$), but not for PRI and VC. In the currently performing singer group, significant differences were found for gender, role and perceived voice problem on the total EASE and all subscales ($p<0.01$). Significantly higher VF scores were recorded for singers with heavy vocal load ($p=0.01$) but there were no differences on the EASE-Total ($p=0.57$), PRI ($p=0.19$) or VC subscales ($p=0.53$). Among these performing singers, no significant age differences were found for any EASE subscales.

Conclusions: These findings provide further validation of the EASE as a useful tool for measuring singers' perceptions of vocal function and suggest that the subscales should be scored separately. Future evaluation of the EASE against objective clinical assessments (e.g. videostroboscopy) is recommended.

Introduction

Performing in a professional music theater production entails a high vocal load due to the inherent performance and genre requirements [1-3], although investigations as to the extent of this load and scientific research in this field are scant. Performance requirements are typically different from those experienced by other singer groups, as music theatre singers may be required to dance while singing, use character voices in dialogue and produce prolonged excessive voicing by performing eight shows per week over five or six days for extended production seasons without vocal rest [1-3]. Often the conditions in which music theatre performers sing are also potentially challenging to vocal health, including singing with stage smoke, sound effects, loud orchestration and limited or no foldback [1, 4]. Styles of singing and techniques commonly used in music theatre, particularly belt are considered vocally demanding and may be more so than vocal styles used in other genres, although this has not been established [5-7]. Lifestyle characteristics of performing music theatre singers (MTS) may also differ from singers of other genres and to those music theatre singers not involved in a production due to the performance demands, scheduling and potential touring requirements [8]. Consequently, performing MTS commonly have a sustained heavy vocal load and are unique due to the inherent vocal and performance demands of this genre.

Vocal load is a term commonly used to quantify voice use and is chiefly derived from characteristics such as loudness, pitch and duration of phonation time [9] [10]. Therefore heavy vocal load describes phonatory activity that is at greater than usual levels (for eg, frequency and intensity) and or durations [10-14]. Physiologically speaking, the effect of increasing loudness and/or pitch on the vocal folds results in increased vibrational amplitude, decreased mucosal wave amplitude, increased phonation threshold pressure, and thereby energy loss due to increased friction ([13]). Furthermore, the surface tissues of the vocal folds are traumatized by rapid accelerations and decelerations or by contact forces between the two

vocal folds associated with vibration. The accumulated exposure of the vocal fold tissues to such collision forces and vibration can be quantified as vocal dose ([15]). Excessive exposure due to loud or prolonged vocalisation, namely high vocal doses, can lead to edema and increased vocal fold mass and tissue viscosity, promoting increased energy expenditure for voicing and probable symptoms of vocal fatigue and potentially dysphonia [16].

Although the impact of heavy vocal load on the vocal folds and vocal function has received much research attention in recent years [16-21], the optimum voice doses that predate any negative impact on vocal function (creating vocal fatigue) and those that may have a deleterious effect on vocal health have not been determined [22, 23]. Whether or at what stage sustained high vocal doses become potentially injurious also remains unclear [20]. Heavy vocal load can constitute phonotrauma and it is theorized that multiple episodes of acute phonotrauma can result in long-standing tissue damage [21] [23] and the development of vocal fold pathology [24].

The immediate, short-term, long-term and cumulative impact of heavy vocal load on the vocal function of singers is not well understood. According to Maclagan and Welham (2003) "there is a particularly critical shortage of data concerning the nature of vocal function changes following singing or acting performance" p.28 [20]. Although singers can report both short term and perhaps long-term positive and negative changes in their vocal function after vocal 'work' [25], the load thresholds before changes in either direction are perceived, are not known. Also, the positive effects of singing training and specific exercises on singing voice function are well established ([9] [26]) but whether and how singers can increase vocal fitness across time, improve endurance and mitigate fatigue effects has not been fully elucidated. Similarly, it is unknown whether fatigue effects among singers are common or

inevitable, and also what periods of rest are required for recovery. Moreover, the relationship between heavy singing load and development of vocal pathology is complex with some authors positing that increased vocal doses among singers is not associated with a decrease in all aspects of vocal health quality ([22] ([27]) but may even enhance vocal health [28]. Improved insight into these areas is crucial to the prediction and prevention of vocal injuries among singers and may also assist in the establishment of occupational guidelines related to performance schedules and vocal requirements.

At present, the tracking of the effects of tissue loading and recovery as a continuum of vocal dysfunction relies on subjective ratings of vocal effort and vocal quality [17] [16]. Many voice-rating tools by virtue of their clinical purpose, including those designed for singers, are disease-specific, physician-derived and rely on recall or retrospection rather than ratings of current voice status [29-33]. Although highly valuable to the clinical assessment and management of voice disorders, these tools are not designed for, nor sensitive to, the working voice or those who do not perceive themselves to have a voice problem. They are therefore limited in scope with non-clinical populations as they are not designed for the non voice-disordered or so-called ‘‘normophonic’’ singer [25]. Frequent discrepancies between the perception of disorder and vocal function among singers has been well reported [3][29-32]. In addition, for the seemingly healthy singer without an overt pathology, these instruments do not provide a sensitive measure of the more subtle or transient physical changes such as fatigue to the vocal mechanism that may have more variable impacts on the singer and their performances. Although clinically useful, these scales do not provide a sensitive or appropriate means of evaluating the effect of vocal load on vocal function unless the impact of that load relates to the perception of a voice disorder (25). This proves especially problematic to the assessment of singers’ voices across time, and to the evaluation of impact

of load on vocal function among professional voice users.

A recently developed scale EASE [34] offers a promising alternative to these previous scales. It was developed from a series of currently performing singer focus groups and designed to provide a self-report tool for the functional profiling of current singing voice status. It comprises a singer-derived inventory of positive and negative vocal descriptors related to the singing voice that were perceived by currently performing professional music theater singers to typify how their singing voice felt or sounded after performing. As previously described in the scale development [25] [34], singers reported some positive changes to vocal function after singing but the scale is largely dominated by negative descriptors many of which are typically associated with vocal impairment [28-33]. However, the EASE was designed to evaluate perceived current singing voice function without assumption of disorder. The purpose is therefore not to profile vocal capability, measure singing satisfaction or technical prowess but to potentially detect changes in vocal function perceived by singers and be sensitive to subtle levels of emerging pathology [25] [34]. It may therefore prove useful in quantifying vocal fatigue and for tracking vocal changes among singers across time and vocal load.

Although the internal validity of the scale has been reported, the construct validity and potential clinical utility require further investigation. Rasch analysis supported the identification of two discrete sets of items, although further testing was recommended to determine whether these subscales should be scored and used separately. These subscales represented potentially different descriptors of vocal function[34]. Due to their voice use characteristics, music theatre singers provide an ideal voice user population to explore the distinctiveness of these two subscales.

Therefore, the aims of this study were to:

1. Evaluate the construct validity of the EASE by comparing scores among professional music theater singers across a range of demographic and voice-use characteristics;
2. Explore the usefulness of the proposed two subscale structure of EASE to quantify perceived singing voice function by comparing the pattern of results for the Vocal Fatigue (VF) and Pathologic-Risk Indicators (PRI) subscales.

Methods

Approval for the conduct of this study and subject recruitment was obtained from the Monash University Human Ethics Committee (Approval CF11/0298-2011000103).

Procedure

Data used in this study were collected as part of an ongoing program of research involving the development and validation of the EASE [34]. Exploring the variation in EASE scores across various demographic and performance voice use characteristics provides the opportunity to assess the construct validity of the tool. Construct validation of an instrument involves subjecting it to a series of analyses designed to test that it behaves in a manner consistent with expectations concerning the underlying construct [35]. There are a number of different aspects of the construct validity that can be assessed. Although the convergent validity of a scale is often tested by comparing scores on similar scales, this was not appropriate in this case, given the lack of suitable tools. One other type of construct validity that is appropriate is to explore the ability of the EASE to distinguish groups based on pre-existing characteristics or behaviour. This is referred to as ‘known-groups validity” [35, 36].

In this case it was expected that the EASE subscales should be sensitive to variables such as whether currently performing (vs. not performing), perceived load, role 9if currently performing), and self-reported voice problems among singers.

Invitations to participate in the study were sent to 10 company managers of currently running professional music theatre (MT) productions in Australia and were also posted on a global ‘‘member-only’’ professional MTS web site.

Material

The questionnaire contained a series of demographic (age, gender and country where currently residing) and voice-use questions in addition to the EASE. Respondents were asked to indicate whether they were currently in a musical theatre production and if so, what type of role they held (e.g., principal, ensemble etc.). All singers were asked to rate their perceived vocal load over the past 24 hours from 6 categories ranging from none to heavy. In addition, singers were asked to give a yes/no response to the question ‘Are you currently experiencing a problem with your voice?’

The EASE comprises 20 items of physical descriptors related to perception of sound or feel of the voice. All items require judgment of vocal status at the time of survey administration and are rated on a 5-point Likert scale ranging from ‘not at all’ to ‘extremely’. Three of the items are worded positively and are reverse scored. A total score may be calculated by adding all the remaining 20 items. However, previous research suggested a demarcation of two distinct subscales, each consisting of 10 items. The first subscale is dominated by items representing vocal fatigue and is referred to as the VF subscale. The second group contains items that have been previously associated with vocal pathology and has been labeled the PRI

subscale.

Two additional items labeled Vocal Concern (VC) were also included in the survey that assessed the singer's overall concern about his/her vocal health. These two items are scored separately as an additional EASE subscale to provide an indicator of the level of singers' concern regarding their voice. The final list of items comprising each subscale is provided in table 1.

Table 1. EASE items according to subscale

EASE Subscale Items		
Vocal Fatigue (VF)	**Pathological Risk Indicator (PRI)**	**Vocal concern (VC)**
My voice is husky	My voice cracks and breaks	I am worried about my voice
My voice is dry/scratchy	My voice is breathy	I am concerned about my voice
My throat muscles are feeling overworked	I am having difficulty with my breath for long phrases	
My singing voice feels good*	My voice is cutting out on some notes	
The onsets of my notes are delayed or breathy	I am having difficulty singing softly	
My voice feels strained	I am having difficulty changing registers	
My top notes are breathy	I am having difficulty with my high notes	
My voice sounds rich and resonant*	Singing feels like hard work	
My voice is tired	I am having difficulty projecting my voice	
My voice feels ready for performance if required*	I am having difficulty sustaining long notes	

*Reverse-scored.

Statistical analysis

Statistical analyses were conducted using SPSS Version 21. As the data were not normally distributed, non-parametric statistical analyses were conducted. Spearman correlation coefficients were used to assess the inter-correlation among the EASE scales. The internal consistency of the EASE scales was assessed using Cronbach alpha coefficients, with values over 0.70 considered acceptable [37]. For the whole sample, Mann-Whitney U tests were used to compare EASE scores according to gender, whether they perceived they currently had a voice problem and whether currently performing in a music theater production. Kruskal

Wallis tests were utilized to compare age groups. For the currently performing MTS Total EASE and subscales scores were compared across gender, age and voice-use characteristics (role, vocal load) using Mann-Whitney U tests (two groups) and Kruskal Wallis tests (three or more groups).

Results

A total of 284 professional MT singers comprising 157 females (55.3%) and 127 males (44.7%) living in Australia, Asia, London, and the United States completed an online survey. These singers comprised two groups: those currently performing as a singer in a professional music theater production (n=148, 47.9%) and those not currently performing in a music theater production although may have still been singing and performing in other contexts and had previously worked as a professional MTS (n=136, 52.1%). Participant characteristics are shown in Table 2. Slightly over half of the total sample was female (n=157, 55.3%) with nearly half (48.2%) aged in the 21 to 29 years category.

Table 2. Participant Characteristics

	Total (n=284)	**NCPS (n=136)**	**CPS (n=148)**
Gender			
Female	157 (55.3%)	88 (64.7%)	69 (46.6%)
Male	127 (44.7%)	48 (35.3%)	79 (53.4%)
Age, years			
17-20	17 (6%)	10 (7.3%)	7 (4.8%)
21-29	137 (48.2%)	58 (42.6%)	79 (53.4%)
30-39	79 (27.8%)	47 (35.6)	32 (21.6%)
40-49	41 (14.4%)	20 (14.7%)	21 (14.2%)
50-59	10 (3.5%)	1 (0.7%)	9 (6.1)
Country where living or performing			
Australia	219 (77.1%)	121 (88.9%)	98 (66.2%)
Asia	29 (10.2%)	6 (4.4%)	23 (15.5%)
UK	15 (5.3%)	3 (2.3%)	12 (8.1%)
USA	21 (7.5%)	6 (4.4%)	15 (10.1%)
Currently experiencing a voice problem			
Yes	57 (20.1%)	24 (17.6%)	33 (22.3%)
No	227 (79.9%)	112 (82.3%)	115 (77.7%)

Perceived vocal load over past 24 hours			
None/minimal	86 (30.3%)	60 (44.1%)	26 (18.5%)
Light	32 (11.3%)	16 (11.8%)	16 (10.8%)
Moderate	90 (31.7%)	34 (24%)	56 (37.8%)
Heavy	76 (26.8%)	26 (19.1%)	50 (33.8%)
Role			
Principal	N/A	N/A	50 (33.8%)
Supporting			24 (16.2%)
Swing			15 (10.1)
Featured Ensemble			33 (22.3%)
Ensemble			26 (17.6%)
Number of performances over past week			
None	N/A	N/A	13 (8.8%)
1-2			13 (8.8%)
3-6			35 (23.6%)
7 or more			87 (55.8%)

Number of participants with percent given in parentheses.
NCPS = Not currently performing in a music theater show; CPS = Currently performing in a music theater show; N/A= not applicable

Total sample

Descriptive statistics for the EASE Total and subscales using the total sample are presented in table 3. Each scale showed good internal consistency (Cronbach α above 0.89). Scores on the EASE and each of the subscales covered almost the full range of possible scores. There was a strong, statistically significant correlation between the two EASE subscales (r=0.69) and both subscales correlated strongly and significantly with the Vocal Concern scores (VF r=0.62, PRI r=0.72).

Table 3. Descriptive statistics for EASE Total, Vocal Fatigue (VF), Pathologic Risk Indicator (PRI) & Vocal Concern (VC) subscales

Statistic	EASE: Total (20 items)	EASE: VF (10 items)	EASE: PRI (10 items)	EASE: VC (2 items)
n	260	272	270	281
Median	34	18	15	2
IQR	26, 44	13, 26	12, 21	2, 4
Minimum	20	10	10	2
Maximum	98	48	50	10
Cronbach α	0.94	0.92	0.89	0.94
Inter-correlations [a]				
EASE: Total				
EASE: VF	0.94			
EASE: PRI	0.89	0.69		
EASE: VC	0.72	0.62	0.72	

IQR: Interquartile Range (25^{th}, 75^{th} percentile)
[a] Spearman correlation coefficients. All correlation coefficients significant at $p<0.001$

Statistical analyses of the data presented in table 4 revealed the following. There were no statistically significant gender differences in scores for the EASE Total (p=0.19), VF (p=0.18), PRI (p=0.30), and VC (p=0.23) subscales. No age differences were detected for the EASE Total (p=0.067), VF (p=0.072) and VC (p=0.196) although a significant difference was found for the PRI subscale (p=0.045). The highest PRI scores were reported for the youngest singers (17-29 years) and lowest scores were recorded for older participants. Singers who reported a current problem with their voice, according to a yes or no response, recorded significantly higher scores across all four scales (p<0.001). The median score on the total EASE for those reporting a current voice problem was 45.5 (Total Ease) compared to 30.5 for those who perceived no voice problem.

Performers currently in a musical recorded significantly higher scores than those not performing on the VF (p=<0.01) and EASE Total (p=0.01), however no statistically significant differences were detected on PRI (p=0.51) or VC (p=0.28).

Table 4. Comparison of EASE and subscale scores across demographic and performance characteristics for all singers

Characteristic	EASE:Total	EASE: VF	EASE: PRI	EASE: VC
Gender Md (IQR)				
Male (n=127)	32 (27, 41)	16.5 (13, 24)	15 (13, 19)	2 (2, 4)
Female (n=157)	36 (25.5, 47)	19 (13, 27)	16 (12, 22)	2 (2, 5)
[a]*Statistic: z score (p)*	*-1.30 (0.35)*	*-1.33(0.24)*	*-1.03 (0.30)*	*-1.99 (0.23)*
Age (Years) Md (IQR)				
17-29 (n=143)	36 (26, 47)	20 (14, 28)	16.50 (13, 23)	3 (2, 5)
30-39 (n-88)	32 (25.75, 40.25)	17 (13, 21)	14 (12, 19)	2 (2, 4)
40-49 (n=39)	30 (26, 39)	16 (13, 24.5)	15 (11.5, 17)	2 (2, 4)
50+ (n=12)	28.5 (23.5, 38.5)	14(11.5, 19.5)	14 (12, 18.75)	4 (2, 6)
[b]*Statistic: Chi Sq (p)*	*7.16 (0.07)*	*7.00(0.07)*	*8.03 (0.04)*	*4.69 (0.19)*
Voice Problem Md (IQR)				
Yes (n=57)	45.5 (39, 64.5)	27.5 (21, 36)	20 (16, 29)	4 (4, 7.75)
No (n=227)	30.5 (25, 41)	16 (13, 22)	14 (12, 19)	2 (2, 4)
[a]*Statistics: z score (p)*	*-6.89 (<0.001)*	*-7.26 (<0.001)*	*-6.13 (<0.001)*	*-6.75 (<0.001)*
Currently in a musical Md (IQR)				
Yes (n=148)	36 (28,47)	20 (14,28.5)	15 (13, 21.5)	2 (2,4)
No (n=136)	32 (24, 42)	17 (12,22)	16 (12, 20.5)	2 (2,4)

[a]Statistic: z score (p)	*-2.46 (0.01)*	*-3.11(<0.01)*	*-.67 (0.51)*	*-1.07 (0.28)*

Median (50th percentile) with interquartile range (25th percentile, 75th percentile) in parentheses.
[a]MannWhitney U. [b]Kruskal Wallis test.

Currently performing singers

Additional analyses were conducted for the currently performing singer group to evaluate the Total EASE and subscales scores for gender, age and voice-use characteristics (n=148) (table 5). In contrast to findings for the whole sample, for the currently performing singer group there were statistically significant gender differences in scores for the EASE Total and all subscales ($p<0.01$). Females were more likely to score higher on all subscales than males. There were no significant age differences in scores for this group. EASE scores were compared across various roles, with significant differences detected for all EASE scales ($p<0.01$). Singers in a supporting lead role recording the highest total EASE scores (Median = 55) and those in the alternate or swing roles reporting the lowest total EASE scores (Median =25). Comparison of scores for perceived vocal load over the past 24 hours showed statistically significant results for the VF ($p=0.01$) but not for the Total EASE ($p=0.06$), PRI ($p=0.19$) or VC ($p=0.53$) subscales. As expected, significantly higher median VF scores were recorded for those singers who recorded heavy vocal load.

Table 5. Comparison of EASE and subscale scores across demographic and performance characteristics for currently performing singers only

Characteristic	**EASE:Total**	**EASE: VF**	**EASE: PRI**	**EASE: Concern**
Gender				
Male (n=79)	30 (27, 42)	16 (13, 24)	14 (13, 17)	2 (2, 4)
Female (n=69)	43 (27, 59.5)	24 (15, 30)	17 (12, 28.5)	2 (4, 6)
[a]Statistic: z score (p)	*-2.99 (<0.01)*	*-3.45 (<0.001)*	*-2.18 (0.03)*	*-2.23 (0.03)*
Age (Yrs)				
17-29 (n=86)	37 (26.75,52)	20 (14, 29)	15.5 (12, 26)	2 (2, 4)
30-39 (n-32)	38 (26.25, 45.5)	19.5 (13.25, 27.5)	16 (13, 18.75)	3.5 (2, 5.75)
40-49 (n=21)	33 (29.5, 43.5)	19 (14, 27.5)	15 (13, 17)	2 (2, 4)
50+ (n=9)	28 (23.5, 42.5)	14(12.5, 23.5)	14 (11.5, 19.5)	4 (2, 6)
[b]Statistic: χ^2(p)	*2.03 (0.56)*	*2.30(0.51)*	*0.93(0.82)*	*2.34 (0.5)*
Role				
Principal (n=50)	37 (27, 46.5)	20.5 (14, 28.25)	15.5 (12.75, 20)	4 (2, 4.25)
Supporting (n=24)	55 (28, 67)	28 (14.25, 36.75)	25.5 (13, 30.75)	5 (2, 8.75)
Swing (n=15)	25 (22, 32)	14 (12, 20)	11 (10, 15)	2 (2, 3)

Featured Ensemble (n=33)	30 (25.5, 38.5)	16 (14, 20.5)	14 (12, 16.5)	2 (2, 2)
Ensemble (n=26)	44 (31, 57)	26.5 (16, 31.5)	16.5 (15, 27)	3.5 (2, 4.25)
[b]*Statistic: χ^2 (p)*	*24.55 (<0.001)*	*18.40 (<0.001)*	*24.26 (<0.001)*	*20.60 (<0.001)*
Vocal Load Md				
None/minimal (n=25)	29 (25, 49)	15 (12.75, 26.5)	15 (11.75, 21.5)	2.5 (2,4)
Light (n=17)	29 (22, 42)	14 (11.5, 22)	14 (10, 17)	2 (2,3.5)
Moderate (n=56)	39.5 (26, 49.25)	20 (13.5, 27)	16 (13, 25.5)	3 (2,5)
Heavy (n=50)	37.5 (30, 48)	21.5 (16, 29)	15.5 (12.75, 19.5)	3 (2, 5)
[b]*Statistic: χ^2 (p)*	*7.52 (0.06)*	*11.43 (0.01)*	*4.76 (0.19)*	*2.21 (0.53)*

Median (50th percentile) with interquartile range (25th percentile, 75th percentile) in parentheses.
[a]MannWhitney U. [b]Kruskal Wallis test.

Discussion

The results of this study provide further support for the construct validity of the EASE. The scale was able to identify significant differences in perceived singing voice function across a variety of demographic and voice-use characteristics in this sample of professional MTS. The EASE subscales were sensitive to differences in vocal load, and successfully distinguished singers who perceived they had a current voice problem from those who perceived no current voice problem. For two of the voice-use variables (whether currently performing in a musical, and perceived vocal load), the two EASE subscales: Vocal Fatigue (VF) and Pathologic-risk indicators (PRI) performed differently. This differential pattern of results for the two EASE subscales suggests that they may be measuring different components of vocal function and therefore should be scored and used separately. The finding that those singers who perceived they currently have a problem with their voice, according to a simple yes or no question, recorded higher scores on all subscales provides preliminary support for the construct validity of EASE.

Demographic and performance voice-use characteristics

Gender did not influence EASE scores for the sample as a whole but it did prove an important variable for those singers who were currently performing in a music theater show. Among performers, females were significantly more likely than males to score higher on all

subscales. This finding is in keeping with previous voice research that females are more likely than males to report vocal fatigue symptoms ([9, 38]) and to report voice problems [39] although whether there may be differences in laryngeal response to vocal load has not been established. The findings for this study do suggest that gender may be an important predictor for the development of vocal pathologies among working MTS.

For the whole cohort of professional singers, a significant difference across age groups was found for the PRI subscale but not for the other subscales or total EASE. The lack of effect of age as a predictor of vocal fatigue is perhaps not surprising since previous studies have not shown age to be predictive of vocal fatigue symptoms [9, 11, 20]. However the finding that younger professional singers were more likely to record higher pathological risk indicator scores (PRI) is of interest but must be interpreted with caution. Firstly, a limitation of the study was that the young age category was broad (17-29 years) which may not have captured potential differences in vocal function according to age. We were unable to solicit more exact age data due to confidentiality and the potential sensitivity of this information. Alternatively, it may be that older, and potentially more vocally-experienced, singers can minimise the physical impact of singing on their voice or that there is an inherent survivor bias such that only those with high vocal endurance thresholds continue to sing with age. In contrast to the results for the whole singer group, age was not predictive of scores for any of the EASE subscales for the currently performing singer group alone. It would therefore seem that for performers singing in a professional musical production, age is not as important as other factors such as the perceived vocal load.

Significant differences were demonstrated for VF and the total EASE between those singers currently performing and those not currently performing, although this study found no group

differences for PRI or VC subscales. The finding that performing in a MT production increased the likelihood of vocal fatigue symptoms but did not increase the potential for symptoms that may be associated with pathology-risk or for a higher level of vocal concern bears consideration. Although further exploration of the relationship between singing voice function and perception of vocal health is needed, this suggests that fatigue symptoms may be perceived by singers to be normal consequences of performing rather than symptoms of impairment and potential threats to vocal health. The finding that there were no differences in pathological risk indicator scores may suggest performing in a show does not increase the risk for developing pathology, which is keeping with previous studies that professional music theatre performers do not report a higher level of diagnosed vocal pathology than other singer groups [3, 27].

Similarly, the finding that currently performing singers reporting a higher vocal load over the previous 24 hours were more likely to have higher scores on the vocal fatigue subscale than those with a perceived lower vocal load is of great interest. The variable of perceived vocal load over the past 24 hours is limited as a measure of vocal load since it is self-reported and also does not include perception of potentially cumulative load over the previous weeks or months. Hence we cannot assert on the basis of the findings of this study that EASE provides a one-off measure of the effect of vocal load on MTS vocal function. However, the finding does suggest that EASE may prove sensitive to short-term variability in vocal function. It may therefore prove useful for tracking changes in self-reported vocal function across time and for the purposes of determining and quantifying potential changes across a musical theatre production season.

For those singers currently performing in a music theater production, role differences were found, with supporting lead roles more likely than principal roles to report higher scores for all EASE subscales. This finding that the role of a performer may be important in determining perceived current vocal function has not been previously reported although previous studies have found role differences in the percentage of diagnosed vocal pathologies [3, 27]. In a recent survey of Broadway singers conducted by Gehling et al. (2014) female ensemble members reported more pathologies than the female principals but the male ensemble reported less than the male leads [27]. In contrast, a previous study of professional singers by Phyland et al. (3) did not find any differences in role according to gender among the music theatre singers but reported ensemble singers were more likely than principals to have been diagnosed with vocal pathology. Many factors may account for potential role differences in perception of vocal health including the specific vocal needs for roles within and across shows. Role differences in vocal load or in other aspects such as physicality while singing, employment conditions, years of experience, singing training and commitment to vocal health may all be important predictors of vocal health. These factors warrant further investigation so as to identify potentially higher 'at-risk' roles for increased vocal fatigue or development of vocal pathology.

The EASE structure

In the initial development of EASE [38], it was proposed that the subscale scores could be combined to yield a total score but the results of this study suggest that potentially valuable additional assessment information is provided by the separation of these two subscales. Although correlated, the two physical subscales appear to be measuring different aspects of perceived vocal function among MTS. Specifically, VF seems to be sensitive to perceived vocal load effects, whereas PRI does not. PRI scores were not significantly different

according to singers' perceived vocal load or whether they were currently performing in a musical. Significantly higher PRI scores were recorded however for those with high vocal concern (VC) scores and for those who perceived themselves to have a voice problem.

The results of this study therefore support the initial labeling of the first subscale as VF and provide some preliminary support for the second subscale representing a PRI. Whether this collection of symptoms does indeed constitute risk of laryngeal pathology merits further investigation. This would require an exploration of the relationship between the EASE subscales and instrumental assessments used for the diagnosis of vocal pathology, such as stroboscopic, aerodynamic and acoustic evaluation. Further testing of the predictive or criterion validity of EASE with such instrumental assessments is therefore strongly recommended to determine whether the PRI subscale is predictive of pathology. This may prove useful in the establishment of clinical cut-points for the identification of thresholds before progression to pathology, for tracking recovery from dysfunction, determining vocal fitness for performance requirements and for the identification of vocal disorder. At this stage, however, the clinical utility of EASE remains speculative. In addition, the cross validation of EASE using separate datasets and exploration of test-retest reliability are recommended to ensure the scale fully meets psychometric standards for a patient-related outcome measure [40, 41].

The current study focused on professional MTS and it is unclear how well the findings generalize to other singer groups. It would be of great interest to explore the potential usefulness of EASE for other genres such as those performing opera, contemporary pop/rock or jazz styles. In addition, the collection of age data in our study was limited and it is recommended that a more rigorous evaluation of the effect of age, vocal experience and

training on EASE responses be undertaken in the future. The vocal health findings for the surveyed MTS in this study relied on self-report data only. Little is yet known about the relevance of these findings to the development and prevalence of voice disorders among MTS and the relationship of EASE to medical, clinical and instrumental assessment of vocal function. Exploration of the predictive validity of EASE and subscales is therefore recommended to determine whether this tool has value as a vocal health screen, clinical outcome measure and predictor of vocal pathology among singers.

Summary

The present study represents an important step in the ongoing validation of EASE and has also yielded novel findings for a large group of professional MTS. Significant differences in EASE performance according to whether or not singers are currently performing in a music theater production were shown. For those currently involved in a music theater production, several inter-related factors such as role, gender and load were demonstrated to be associated with perceived current vocal function and to differentiating vocal fatigue and pathology-risk indicator subscales, thereby enhancing our understanding of the vocal health of this unique voice-user population.

It is now a priority to determine the potential usefulness of EASE as a tool to measure self-reported physical changes in vocal function among performers across time. Research to date supports the internal consistency of the scale but further research is required to evaluate its test-retest reliability. EASE shows promise for tracking the perceived immediate, short-term and long-term effects of working as a music theater performer and thereby contributing to our knowledge of the impact of heavy load, vocal dose thresholds and recovery periods for this singer population. This study has shown EASE is potentially clinically useful as a singing

voice outcome measure and as a sentinel for further investigation of vocal health among working singers.

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Chapter 6

INTEGRATIVE DISCUSSION

The perceived status of vocal function among working music theatre singers has not been previously determined, despite the common belief that these singers have a heavy vocal load and therefore may be at higher risk of developing voice problems than other voice users. In addition, there is a conspicuous lack of research addressing whether the status of physical functioning of the vocal instrument for singing fluctuates within the occupational environment, whether or at what stage these fluctuations are perceived to be normal or disordered sequelae of 'work', and whether there are inter-individual differences among singers in the nature and extent of these fluctuations.

The research described in the three previous papers offers a novel investigation into the perceived impact of vocal performance on the physical aspects of vocal function in one group of professional voice-users: music theatre performers. The majority of past literature concerned with singers' vocal health has focused on disorders of the singing voice, on the treatment-seeking singer population particularly classical singers, has provided inconsistent information and suffered from a lack of methodological rigour. In addition, the influence of factors such as singing genre, which can account for significant differences among singers in their voice use in terms of vocal characteristics and vocal demands, has received little attention to date. In an attempt to advance our understanding of the nature of vocal health among one singer subgroup, namely music theatre, the present studies diverged from

methodologies employed by previous research. In particular, the interviews, online survey approach and use of the newly developed scale (EASE) enabled a comprehensive and sensitive exploration of the music theatre singers' voices from their own viewpoint and from a health rather than disease perspective.

6.1 EASE as a new measurement tool

The previous three papers describe the genesis of EASE as a new unidimensional measure of perceived singing voice function specifically designed for occupational use among singers. It is short, easy to administer, comprises both positive and negative descriptors and the response format profiles a singer's perception of current physical functioning, rather than being reliant on retrospective recall. Development involved a rigorous process of item generation and testing and the results confirm the high level of unidimensionality and discriminability of the EASE. Content was derived from singer interviews, expert opinion, and refinement using a consensus approach. The person-derived item generation and item reduction processes used in this study conform to the recommendations made by Branski et al. for instrument development (Branski et al., 2010). In addition, EASE appears to be one of the first scales developed within the voice field to use Rasch analysis as part of the evaluation process.

Although EASE may also prove a valuable clinical outcome measure for symptomatic aspects of compromised vocal health, the tool is not primarily designed to be a disease-specific instrument. It aims to profile a singer's perception of the physical functioning of their voice using language and terminology that does not assume disorder and therefore can capture the nuances of the healthy singer as well as those

with impairment. In this way, it may potentially predict or screen for singers ‘‘at risk’’ of developing voice disorders but whether the EASE can be used clinically to differentiate vocal impairment from ‘‘normal’’ vocal impairment has yet to be determined.

The findings that the two EASE subscales Vocal Fatigue (VF) and Pathological Risk Indicators (PRI) performed differently on certain voice-use variables suggest that they may be measuring different components of vocal function and therefore should be scored and used separately. The labeling of the two subscales according to these precepts is however speculative. Whether the two subscales are clinically distinguishable and therefore differentially predictive of vocal fatigue and/or specific vocal conditions (such as oedema) will require further investigation. Validation of the scale with voice-disordered singers is also necessary, and, until then, the potential independence of the two components is speculative. Further testing of the predictive or criterion validity of EASE with instrumental assessments (for eg., videostrobocopy, acoustic or aerodynamic measures such as phonation threshold pressure) is therefore strongly recommended to determine whether the total EASE or the Pathological Risk Indicator (PRI) subscale is predictive of pathology. This may prove useful in the establishment of clinical cut-points for the identification of thresholds before progression to pathology, for tracking recovery from dysfunction, determining vocal fitness for performance requirements and for the identification of vocal disorder.

At this stage the clinical utility of EASE therefore remains speculative. In addition, the cross-validation of EASE using separate datasets and exploration of test-retest

reliability are recommended to ensure the scale fully meets psychometric standards for a patient-related outcome measure.

In singing pedagogy, there is an obvious benefit for tracking change or improvement in physical functioning of the singing voice and, although not investigated in this thesis, EASE may also prove useful for this purpose. Evaluations of improvement in vocal capacity and vocal function as a direct outcome of vocal training and practice rely mostly on singers' and singing teachers' subjective impressions (Lamarche, Ternström, & Hertegård, 2009a; Lamarche et al., 2009b; Oates et al., 2006; Schewell, 2010). Another method for the evaluation of improvement in voice quality and loudness and pitch ranges in singing is afforded by phonetograms but these tend to be time consuming and are used more readily for clinical than pedagogical assessment tools (Lamarche, 2009; Leino et al., 2008). These current methods and the singing teacher evaluations may be well supplemented by a scale such as EASE that offers a self-appraisal of physical functioning of the singing voice and a potential means of quantifying improved singing voice performance.

6.2 Singers' perceived vocal function

The interview data (described in Paper One) revealed many themes of singers' experiences of changes to the physical vocal mechanism secondary to both singing and performing. Most of the singers interviewed in this study reported regular experience of vocal status shifts and variability in vocal abilities after a show and over a given performance week, particularly those with a heavy vocal load. Singers reported that the vocal demands of the show and the role they played created specific

challenges to their vocal stamina, technique, fitness and recovery from performing. Specific factors that were considered by the singers to influence vocal status were the repertoire demands (intensity, pitch, singing style, duration of singing), the role responsibility (for e.g., whether playing a principal or ensemble role), emotional and dramatic demands of the role, adrenalin of performance, day of the performance week, number of performances and length of performance season.

Several of the factors suggested by the singers in the interviews to influence the physical functioning of the voice were also shown to be important predictors of performance on the EASE scale (Paper Three). The findings that higher total EASE and Vocal Fatigue subscale scores were reported for singers currently performing in a show, for certain roles and for those with a perceived high vocal load lend further support for singers' impressions that such factors, typically associated with vocal load, can have a significant impact on the physical aspect of vocal function.

In the interviews, the descriptors used by the singers to detail the nature of vocal function fluctuations were varied and included both positive and negative perceptions. They could be loosely ascribed to the categories of vocal quality, pitch, loudness, resonance, sensation, effort, and consistency. There were marked individual differences in the importance attached to these descriptors with approximately two-thirds of the performers perceiving them to be normal, whereas others perceived some negative descriptors to be symptomatic of impairment and/or to be concerning. This lack of consensus as to what constitutes normal vocal function among singers is in concordance with the literature reviewed in Chapter One and highlights the multidimensional nature of voice and, conversely, the inherent complexity of voice

disorders. In addition, the findings in Studies Two and Three, that performers who did not report current experience of a voice problem could still score high on the EASE Vocal Fatigue subscale, provides further evidence that singers can perceive the experience of negative physical changes to vocal function as normal occurrences. However whether, and if so at what level, thresholds exist before these changes become symptoms of impairment is unclear and merits further exploration.

Although individual variability in the extent and experience of these changes was common, many performers described definite trends across a working week with the first and last day of the week commonly perceived to be more vocally difficult than the midweek performance days. Although some research has been conducted investigating the measurement and signs of vocal fatigue in singers after specific loading tasks (Carroll et al., 2006; Stemple et al., 1995), fluctuations in vocal status across a working week among singers have not been previously reported. It has been proposed however that other voice-user populations experience variability in vocal function according to vocal doses, recovery times and cumulative effects of loading (Chen, Chiang, Chung, Hsiao, & Hsiao, 2010; Hunter & Titze, 2009; Hunter & Titze, 2010; Nanjundeswaran, 2013; Remacle, Morsomme, & Finck, 2014).

In a study of 87 teachers, Titze and Hunter (2009) evaluated the impact of vocal loading exercises according to teachers' self-ratings of speaking effort level and ability to achieve soft voice. They suggested that on average 50% of tissue recovery from loading was achieved within 4 hours and 90% within 12-18 hours post-loading hypothesising that vocal fatigue can be best described in the context of wound healing, with occupational voice users perceiving fatigue and recovery as an

integrated continuum. However, Titze and Hunter did not identify the confounding effects of loading on laryngeal musculature or whether recovery comprised other aspects of the vocal mechanisms. Therefore whether efficiency of vocal functioning is confounded by changes in vocal fold tissue (lamina propria), laryngeal muscles or other potentially fatiguable voicing components is difficult to determine due to the potential interplay of all these factors and a lack of appropriate measurement tools. In addition, the generalisability of these findings to the singer population has not been established.

Global change in singing voice status across the production season was also described by the performers in the interviews. Some performers described a sense of becoming vocally stronger and fitter as the season progressed whereas others reported a decline in vocal flexibility and stamina. Concern regarding long-term vocal health and resilience after long performance seasons was also discussed with many performers reporting that they needed partial or complete voice rest at the conclusion of a performance season. There was also much variability among performers in the observance, regularity, duration, timing and value of voice rest across performance weeks.

The concepts of improving fitness or conditioning and of regular self-imposed voice rest for performers as a means of vocal maintenance is of interest. A commonly accepted principle of physical training is that a period of loading followed by adequate rest results in improved performance (Cormack, 2010). Whether the same principle applies to singers has not been well investigated and what amount of time constitutes adequate rest for maximum recovery is therefore unknown. Vocal rest is regularly advocated for the remediation of acute vocal fold tissue injuries and

resolution of vocal fatigue symptoms (Behlau & Oliveira, 2009; Carding & Wade, 2000; Klein & Johns III, 2007; Sataloff & Cline, 1997; Timmermans, Vanderwegen, & De Bodt, 2005; Wingate, Brown, Shrivastav, Davenport, & Sapienza, 2007). However, further evidence and research into the role of voice rest for the prevention or recovery from vocal injury and for the optimisation of performance is required. Also, although the notion of improved vocal fitness among singers with specific exercises and strengthening has been demonstrated (Patel, Bless, & Thibeault, 2011; Sandage & Pascoe, 2010; Saxon & Berry, 2009; Schneider, Dennehy, & Saxon, 1997; Stemple & Dietrich, 2011; Wrycza Sabol et al., 1995), the potential value of regular and repeated performances to vocal fitness (as reported by the working singers in Study One) requires further investigation.

In sport, the development of optimal training programmes relies on quantification of training programmes and measurement of their specific effects on physiological adaptation and subsequent performance. Several methods are regularly used to quantify training load, including questionnaires, diaries, physiological monitoring and direct observation. Self-reporting questionnaires or perceived exertion scales have been used as indices of physical stress or to monitor the physical aspects of fatigue and overreaching and overtraining responses to training or exercise (Borresen & Lambert, 2008). Such scales are considered highly valuable for quantifying perceived changes in performance and measuring functional outcomes of training and loading.

Researchers have similarly attempted to quantify vocal load effects by measuring physical impact stress on the vocal folds (Verdolini et al., 1999), self-reported perceived exertion using visual analogue or direct magnitude estimation measures

(Carroll et al., 2006; Chang & Karnell, 2004; Hunter & Titze, 2009) and/or clinical evaluation of physiologic, acoustic or perceptual changes (Buekers, 1998; Eustace et al., 1996; Gelfer et al., 1996; Gelfer, 1991; Lamarche et al., 2009a; Lamarche et al., 2009b; Laukkanen, 2006; Laukkanen, Ilomäki, Leppänen, & Vilkman, 2008; Laukkanen, Järvinen, Artkoski, Waaramaa-Mäki-Kulmala, Kankare, Sippola, & Salo, 2004; Laukkanen et al., 1998; Leino et al., 2008; Remacle, Finck, Roche, & Morsomme, 2012; Remacle, Schoentgen, Finck, Bodson, & Morsomme, 2014; Stemple et al., 1995). Although these studies have provided valuable information regarding the potential impact of load including fatigue and positive changes, the development of these tools is in its infancy and none have offered a standardised or validated scale for clinical or occupational use. There is therefore currently no commonly accepted or known validated scale for self-evaluation of loading effects on vocal function related to speaking or singing, other than the newly developed EASE.

6.3 Limitations and recommendations for future research

As previously discussed, although the internal validity of the EASE scale has been evaluated, further testing of the test-retest reliability and of construct and predictive validity of EASE is recommended. Specifically, the ability of EASE to predict findings on instrumental assessment of vocal function requires future investigation and will be of great interest to the determination of the clinical usefulness of EASE.

The insights gained from singers' perspectives on the impact of performing and the supportive EASE data will be of particular value to the design of future prospective or longitudinal studies on occupational health among music theatre singers. Whether

there are short or long-term changes in the physical aspects of vocal function as a consequence of singing and/or performing has not been investigated by the three studies described in this dissertation. The EASE does however show promise as a self-measurement tool for the quantification of potential physical changes in vocal function across time. Although the sensitivity of EASE to intra-individual changes across time has not yet been shown, an obvious opportunity exists to use the scale to further explore the singers' contentions that they experience significant changes in physical functioning across days, weeks and months according to vocal load and also several other factors. For example, daily fluctuations in vocal status independent of loading have been previously reported (Artkoski et al., 2002). In order to enhance our understanding of vocal function among singers and recovery from loading, it is of importance to determine the extent of these changes and whether EASE is able to capture and measure singers' perceived variability in physical functioning across time.

Our studies have suggested that singers can differ from one another in the perception of physical aspects of vocal function and that these differences may be influenced by many factors, such as gender, age, whether or not currently performing, performance role, experience of a voice disorder, genre of singing and perceived vocal load. Other factors which bear consideration in future studies may include style of singing, vocal training, singing experience, performance environment, speaking voice demands, lifestyle and psychosocial domains. The research described here focused on professional music theatre singers and it would be of great interest to explore the potential usefulness of EASE for other genres such as those performing opera, contemporary pop/rock or jazz styles. In addition, the collection of age data in our

study was limited and it is recommended that a more rigorous evaluation of the effect of age, vocal experience and training on EASE responses be undertaken in the future.

An inherent difficulty in research addressing potential vocal load effects is the method for quantification of vocal load. In our studies, singers were asked to judge their perceived vocal load over the past 24 hours. This was a subjective global measure, arguably of perceived vocal exertion, and therefore may not be an accurate calculation of load in terms of amount and type of voicing. In addition, potentially cumulative load or recovery effects were not captured by the use of a 24 hours period of measurement only. It is therefore recommended that future studies regarding singers employ objective measures of vocal load (for example, using dosimetry or equivalent methods) and/or provide more robust definitions of vocal load for singer estimations.

The vocal health findings for the surveyed music theatre singers in this study relied on self-report data only. Little is yet known about the relevance of these findings to the development and prevalence of voice disorders among music theatre singers and the relationship of EASE to medical, clinical and instrumental assessment of vocal function. Exploration of the predictive validity of EASE and subscales is therefore recommended to determine whether this tool has value as a vocal health screen, performance fitness or clinical outcome measure and predictor of vocal pathology among singers.

Finally, although the physical impact of vocal load on vocal function among singers across time has not been measured, an obvious opportunity now exists to use EASE to measure potential changes and thereby contribute to our knowledge of the impact of

heavy and cumulative loading and phases of recovery.

Chapter Seven

CONCLUSION

The research presented in this thesis represents important steps in the ongoing validation of EASE and has also yielded novel findings for a large group of professional music theatre singers. Significant differences in EASE performance according to whether or not singers are currently performing in a music theatre production were shown. For those currently involved in a music theatre production, several interrelated factors such as role, gender and load were demonstrated to be associated with perceived current vocal function and to differentiating Vocal Fatigue and Pathologic Risk Indicator subscales, thereby enhancing our understanding of the vocal health of this unique voice-user population. It is now a priority to determine the potential usefulness of EASE as a tool to measure self-reported physical changes in vocal function among performers across time. Research to date supports the internal consistency of the scale but further research is required to evaluate its test-retest reliability.

The EASE shows marked promise for tracking the perceived immediate, short-term and long-term effects of working as a music theatre performer, for ascertaining performance fitness and for clinical and pedagogical use as a singing voice outcome measure. EASE scores may also prove useful as a sentinel for further investigation of vocal health among working singers. The information yielded from future studies

regarding singers' perceptions of the physical functioning of their voices may further enhance our understanding of the complex mechanisms of vocal fatigue, repair and recovery or progression to pathology. A better understanding of these processes will be invaluable to the prevention of occupational voice disorders among singers, to vocal longevity and to optimal artistic performance.

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Appendix 1

Evaluation of Ability to Sing Easily (EASE)

Today…..	Not at all	Mildly	Moderately	Extremely
1. My voice is husky	1	2	3	4
2. My voice is dry/scratchy	1	2	3	4
3. My voice cracks and breaks	1	2	3	4
4. My throat muscles are feeling overworked	1	2	3	4
5. My voice is breathy	1	2	3	4
6. My singing voice feels good*	4	3	2	1
7. The onsets of my notes are delayed or breathy	1	2	3	4
8. My voice feels strained	1	2	3	4
9. I am worried about my voice	1	2	3	4
10. I am having difficulty with my breath for long phrases	1	2	3	4
11. My top notes are breathy	1	2	3	4
12. My voice sounds rich and resonant*	4	3	2	1
13. My voice is cutting out on some notes	1	2	3	4
14. I am having difficulty singing softly	1	2	3	4
15. My voice is tired	1	2	3	4
16. I am having difficulty changing registers	1	2	3	4
17. I am having difficulty with my high notes	1	2	3	4
18. Singing feels like hard work	1	2	3	4
19. I am having difficulty projecting my voice	1	2	3	4
20. I am concerned about my voice	1	2	3	4
21. My voice feels ready for performance if required*	4	3	2	1
22. I am having difficulty sustaining long notes	1	2	3	4

*reverse scored

Score Sheet

VF score	PRI score	VC score
/40	/40	/8