

BMPF7013 Independent Study
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BMPF7013: Independent Study

A Critical Interpretive Synthesis of Voice Acoustics in Belting

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Component 1: Portfolio

[4,608 words]

Introduction

As an early-career singing teacher working with students in popular genres, pedagogical resources to support me in teaching the belt quality of singing to my students was the subject of a previous assignment (O'Reilly, 2022). Many of the strategies to support students found during that study were technical exercises where specific vowel sounds were recommended. While I have found these strategies to be relatively effective, I have not understood why specific vowels are better than others in terms of achieving the belting sound. My previous study alerted me to the complex area of vocal acoustics, which was entirely new to me, but seemed to discuss vowels and how they are shaped in a more concrete manner. As singing exercises are never quite the same for each student, I determined that it was necessary for me to understand the underlying principles underpinning the exercises I have been using. In a qualitative study about belting for singers, five expert teachers were shown unanimously to use specific vowel sounds like /e/ and /ei/ in exercises to illicit the belt vocal quality with maximum efficiency (Roll, 2016). Having experimented with different vowel qualities for my own singing and with students, I understand the use of specific vowel qualities can be very effective, but I do not understand why. On the surface, a vowel based exercise may work well for many of my students, but without understanding what underpins its efficacy, I cannot make adaptations to exercises when a student is not able to produce a specific quality from imitation alone. Neither am I able to help them create appropriate strategies for how this quality will carry over into particular pieces of repertoire. It seems that a deeper understanding of what underpins the creation of a vowel - and specifically, vowels for belting - would be highly relevant to my practice.

Rationale

As a singing teacher, it is important that I am able to select and adapt the best exercises to support my students in creating their target sound, and belt is a popular technique that almost all of my students wish to use. I currently have very minimal knowledge about how vowels are created, and why certain vowels support the generation of a belt timbre. The field of Vocal acoustics explores some of these questions. Concepts like resonances, formants, and harmonics help us to explore

the different components of a single sound, and understand how to increase or suppress the presence of these components using vocal tract shaping to produce a specific timbre (Bozeman, 2013). Exploring this information with respect to a specific style (belting) will help to narrow down relevant material and understand how this information might be applied in the studio to enhance teaching and learning. Developmentally, I believe this study will enable me to:

- Understand and apply the terminology used within the field of vocal acoustics to describe sonic phenomena
- Improve my perception of the components of sound
- Understand how shaping in the vocal tract can encourage or suppress certain components of sound.
- Continue to develop rigour and criticality when learning about complex subjects and their application to practice.

While this study is unlikely to make a significant contribution to the wider field of literature in terms of practical acoustics with respect to singing, it will help me to further develop my criticality, and lay the foundations of future expertise that may result in such a contribution in the future. The current parameters of this study is more likely to serve as a contribution to practitioner voice with respect to continued professional development in the field of voice studies.

Programme of Study

Aims and Outcomes

This study aims to facilitate the acquisition of advanced knowledge of vocal acoustics with respect to belting by engaging in a literature review. It is likely that this knowledge will be gained through peer reviewed literature, with support from grey literature where entry level explanations are required to support more advanced understanding. The development of this knowledge will facilitate a critical exploration of existing resources for application of vocal acoustics in the teaching studio. It is expected that undertaking the review will result in:

- The production of a rigorous literature review
- The compilation of resources to support my application of this knowledge with students (likely in the form of suggested exercises, prompts, and software)
- A greater awareness of the components of vowel sounds, making it easier for me to assess my student's singing and offer supportive information and exercises.

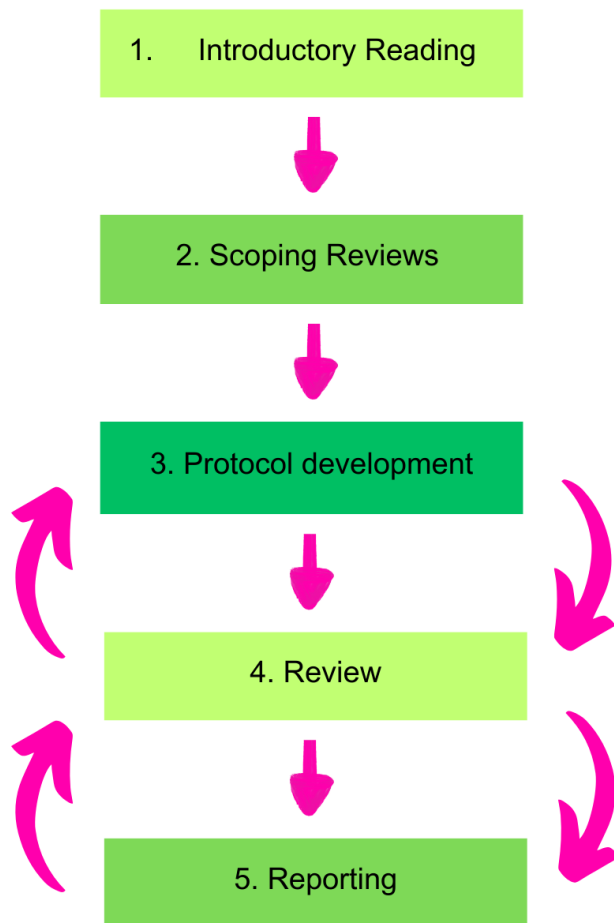
- Understand any ways in which I can encourage students to create a belting sound that is healthy and sustainable.

Methodology

Selecting a methodology

This study takes the form of a literature review with a focus on understanding a complex topic through the lens of practical application in the voice studio. Several types of review were considered in light of the context and aims of the study. Systematic reviews (SRs), largely concerned with quantitative data derived from clinical trials in the field of healthcare, were initially developed to be exhaustive reviews that aggregate statistical information about healthcare interventions to aid decision makers and practitioners in their work (Higgins et al., 2022). While a systematic review is the gold standard for reviews, this study is not intended to provide an exhaustive review or synthesis of the subject (Grant and Booth, 2009). *The Cochrane Handbook for Systematic Reviews of Interventions* further recommends that systematic reviews be carried out by a team of experts over an ample period of time - working as an individual with little prior knowledge of the topic in the context of academic timelines then precludes the execution of a true systemic review (Higgins et al., 2022). A qualitative evidence synthesis (QES) was also considered. These are concerned with exploring complexity, perception, and the voices of stakeholders in relation to a healthcare interventions, and it is often recommended that they either be linked to a specific clinical trial, or that a review should not attempt to be exhaustive given the rich data and time-consuming nature of qualitative analysis (Higgins et al., 2022). A strict application of QES methods could mean excluding quantitative literature, which may not be conducive to the evidence-informed approach that I hope to use in my teaching (Grant and Booth, 2009). Narrative reviews, popular in dissertations and assignments of this nature, often provide a flexible structure to identify and analyse issues central to the subject of study, but such reviews often suffer from a lack of structural rigour or transparent reporting that damages their credibility, as their findings cannot be meaningfully compared to other studies, or used to add value to a particular field of work (Grant and Booth, 2009; Snyder, 2019). The aims of this study are complex, and meeting them will not fit neatly into the methodologies outlined above, or necessarily be bound by a single type of literature. Thus, deeper research was conducted into SR, QES and a range of research designs and tools to enable the selection of an appropriate framework for study.

This study proposes to use peer-reviewed literature, pedagogical literature and grey literature; the exploratory nature of the research aims also suggests that creating a specific research question or protocol in advance is impractical. As the guiding principles for this study are the research aims



themselves, rather than strict adherence to a particular ontological, epistemological or axiological underpinning, a pragmatic, constructivist approach that allows key concepts and themes to emerge from the research process will be adopted. It is anticipated that this process will be iterative, but growing in specificity as the research progresses. Although quantitative literature will not be excluded from this study, the methods and methodology used to govern the structure and synthesis of evidence will be more qualitative in style. My initial approach will be that of a Critical interpretative syntheses (Dixon-Woods et al., 2006, Lakin and Kane, 2023).

Proposed structure and methods of this review

Researching suitable models for the present study was undertaken in a somewhat informal manner, but generally evolved from forward-chaining from Higgins et al., (2022). Different methods of analysis and synthesis were also explored, like Thematic analysis (Thomas and Harden, 2008), Meta-ethnography (Doyle, 2003), Meta-narrative reviews (Greenhalgh et al., 2005) and Critical Interpretive Synthesis (CIS) (Dixon-Woods et al, 2006). This process was iterative, with a compilation of a method evolving gradually. The following appendices provide an insight into this process:

- **Appendix 2: Methodology comparison (p.33)** - SR and QES reviews are compared in terms of structure and purpose of each step, with a comment on the relevance of each step to the present study.
- **Appendix 3: Comparing literature type (p.37)** - Consideration was given to the benefits and threats posed by each kind of literature being considered for inclusion.
- **Appendix 4: RETREAT framework (p.39)**

- **Appendix 5: PRISMA resources (p.40)** - see in particular 5.2, a spreadsheet that displays relevant sections of the PRISMA (2023) checklist, where each point is assessed pre-scoping review and post scoping review to showcase the development of the protocol structure for the formal review. This also contains resources for creating a flow chart for reporting on the search.
- **Appendix 6: Search strategy and Selection information (p.41)** - Records kept of the search process

Figure 1: Review Structure flowchart

1. Introductory Reading: Both SR and QES advocate for experts to carry out reviews (Higgins et al., 2022), this implies that some prior level of knowledge is required in advance of commencing the study proper. In some qualitative reviews, the initial stages of study are somewhat less formal, as in CIS (Greenhalgh et al., 2005; Dixon-Woods et al., 2006; Lakin and Kane, 2023).

2. Scoping Reviews: Harris et al. (2018) suggest the method of using multiple lines of enquiry to identify the different perspectives involved in a field, and understand the scope and feasibility of a potential refinement for a research question. This further supports the exploratory function of this study and allowing questions to develop from data available within the field itself.

3. Protocol development:

It is anticipated that this will be qualitative and follow the structure of a CIS, utilising the PRISMA (2023) checklist. Dixon-woods et al. (2006) and Lakin and Kane (2023) will serve as reference points (the structure of which is outlined in Appendix 7, p. 42). This will not be determined with certainty until after the scoping review, as the line of enquiry chosen may impact on the appropriateness of the methods outlined here. Any changes in advance of creating the review protocol be documented via the Appendix 5.2 (p.40).

3.1 Search Purposive sampling will be used in line with the pragmatic approach to this study (Thomas and Harden, 2008). This will be documented in Appendix 6 and in a flowchart format in Component 2 of this assignment (p.18).

3.2 Quality assessment and Inclusion/exclusion criteria: In addition to the research aims, the concept of Signal (information pertinent to the research question) to Noise (quality of study design) as per Edwards et al.(2000) will be used to screen for suitable studies. It is anticipated that the margin for exclusion will be low given the interpretive nature of the research aims. These records can be accessed in Appendix 6, Tab 3c. (p.41).

3.3 Data extraction: A template will be used for each study as per Lakin and Kane (2023). These records can be accessed in Appendix 6, Tab 3d. (p.41).

3.4 Synthesis: The process of synthesis is continual in CIS; each choice made about what to include constitutes a subjective judgement, and thus a step towards synthesis (Dixon-Woods et al., 2006). The products of synthesis in CIS are several critiques of the literature in question, and a synthesising argument - a concept that can speak to the issues that have arisen in the literature (Dixon-Woods et al., 2006; Lakin and Kane, 2023). Given the exploratory nature of this work, the products of this synthesis may differ.

4. Review: The methods and structure above will be applied. This may need to be adapted as the research deepens as per Dixon-Woods et al., (2006) but such decisions will be clearly documented in Appendix 8 (p.43).

5. Reporting: As per PRISMA (2023), The results of the search and selection process will be described, and critiqued. The likely format for results will be interpretive text, such as applications of knowledge to singing teaching, alongside some creation of resources. Some data may be presented as infographics.

Timescales and review dates

The timescale of this project is between 22nd January 2023 and 6th June, 2023 (a little over four months). Timescales are an important part of a reader's ability to determine the quality of the review (Grant and Booth, 2009). The anticipated timeline will be broad to as to leave scope for adaptation and reflection.

22nd January - 22nd February (four weeks): Literature review

This time will be spent researching and ensuring I have developed a clear understanding of the kinds of literature review available to me.

22nd February - 5th April (four weeks): Vocal Acoustics

This will constitute the main period of research where a clear understanding of vocal acoustics will be developed. This will also influence further reading in the next phase.

5th April - 26th April (three weeks): Belting

During this time the reading will shift to a more specific focus on belting.

26th April - 24th May (four weeks): Writing and reading about critical reflection

Draft Deadline: Tuesday 16th May

This portion of the study programme will be reserved for writing, and developing a critical model for reflection. During this time I will submit a draft to my tutor for feedback.

24th May - 5th June (just under two weeks): Editing and proof reading

This period will be for final editing and proof-reading of the work.

6th June - Submission Deadline

Context: Vocal Acoustics and Singing

Resonance is an important concept in singing. My received understanding of the concept prior to this study was that it related to finding the correct kinaesthetic sensation in the head and neck while utilise the correct vowel so that the sound would be sufficiently loud. "Placement" - a manner of linking certain configurations of the singer's anatomy to a particular vibratory sensation in their body (generally in the neck, mouth or head) is often enlisted to promote kinematic discrimination and learning to achieve and replicate the target sound (Sundberg, 1974, Chapman, 2017). Vowels and articulatory gestures in the lips, tongue, velum, pharynx, and larynx can be used in service of finding this placement or resonance (Titze and Worley, 2009). While imagery can indeed be very helpful from a student-facing perspective (Foulds-Elliott et al., 2000), it may not lead to a deeper understanding of the mechanisms that underpin these sensations and strategies for evidence-informed teaching. This section aims to outline some of the key considerations and terminology that will be considered in more depth with respect to belting in component 2.

Students of singing must master many skills to achieve their target sound throughout their register, across varied pitches, musical phrases and texts. In this context, the way in which the singer manages resonance can be like a sonic fingerprint that both gives the singer their unique sound and imparts information about text and genre. For example, classical singers prize a rich, warm sound with a very smooth, imperceptible transition from their chest voice to their head voice (these transitions between registers is called the *passaggio*). Contemporary Commercial Music (CCM) such as musical theatre or pop often calls for a brighter tone, a more speech-like in quality through as much of the range as possible, and the ability to maintain the chest voice beyond the area

where a classical singer would transition into their head voice (Bozeman, 2013). In order to highlight and train for these distinctions, teachers often use vowels in different patterns across the singer's range, modifying the shaping of the vowel according to style, area of registration, and target sounds of the singer. Initially, this study was born of a desire to understand how, why, and when alterations in shaping of the vowel are appropriate, and it is in learning more about vowels where the role of vocal acoustics - that a more specific usage of the term "resonance" will be found.

Vowels, their components and their articulation, have been the subject of studies for more than a century; theories about voice production date even earlier to at least a century before (Vilain et al., 2015; Chen, 2016). To understand how vowels are produced, it is useful to first look at some of the current understandings of voice production. The vocal tract - the space in the mouth, throat and nose - is the environment in which sound is created and shaped (Malde et al., 2020; Chen, 2016). It can be viewed as two interconnected acoustical tubes (Sundberg, 1974). A simple acoustical tube has its own resonant frequency which will considerably boost the dB level of a matching frequency that enters it (Chen, 2016). The vocal tract however, comprises two tubes - the pharynx and the epilaryngeal tube. Crucially, the pharynx can change in length (when the larynx is lowered, according to the shape of the mouth, lips, or the position of the tongue) and both the pharynx and the epilarynx can change in diameter through muscular contraction or relaxation (Sundberg, 1974). This complex relationship between acoustical tubes means that the vocal tract is thought to have three to five resonant frequencies within hearing range, and these five frequencies change according to how it is shaped (Bozeman, 2013). These resonant frequencies boost the frequencies that match the acoustical properties of its own geography (Chen, 2016). The shape of the vocal tract and the position of our articulators change in order to create distinct and separate vowel sounds and timbres, which changes the acoustical properties of the vocal tract, generating a different configuration of peaks for different vowels (See Fig 1 for an example of these peaks displayed for a sung vowel on /u/).

Each vowel has a characteristic distance between these peaks that make it discernible and distinct from other vowels (Howell, 2017). Introductory reading for this topic revealed two key terms for referencing these peaks: "resonances" which refer to the

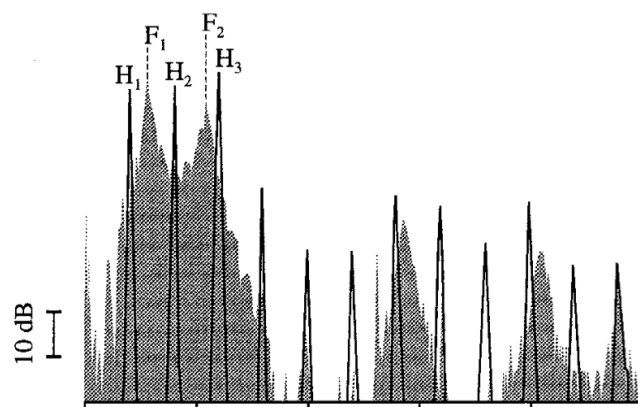


Figure 1:
/u/ sung on G4, from Bestebreurje and Schutte, (2000), p.197

shapes, or “caricatures” of the vocal tract that give rise to these peaks, and “formants” are the resultant radiated sounds of these (Bozeman, 2019a). The resonances can be labelled as fR_1 , the first resonance of the vocal tract (which radiates as the first formant of the vocal tract), fR_2 , for the second resonance (which radiates as the second formant of the vocal tract), and so on through to fR_5 . In speech, it is generally the distance between fR_1 , fR_2 and fR_3 that dictates the vowel sound (Joliveau et al., 2004).

Figure 1: Taken from Bestebreurtje and Schutte, 2000, p.197

Pitch is the sound generated in the vocal tract in response to vocal fold vibration (Bozeman, 2013). Each pitch we hear is a composite of many harmonics - these are different frequencies that resonate in response to the perceived pitch (or fundamental frequency), and they relate to the perceived pitch logarithmically in a predictable, stable pattern (Bozeman, 2013). The pitch that we perceive can be referred to as the fundamental frequency, or F_0 . If any of the harmonics radiated by a pitch falls close to a resonance in the vocal tract, that harmonic will receive a boost in signal, which will impact the intensity of the sound (Bestebreurtje and Schutte, 2000). If a harmonic is further away from a resonance of the vocal tract, it will only provide a weak signal. For a singer producing both melody and text simultaneously, negotiating the shifting relationships between resonances and harmonics is a constant process as they move from pitch to pitch and vowel to vowel. The harmonics can be referred to as fF_0 , for the first harmonic (also known as the fundamental frequency), fF_2 , for the second harmonic, and from a theoretical perspective, this carries on infinitely.

A critical reflection on the learning experience

In reflecting on the process of this study, I employed the use of a model developed by Rolfe et al. (2000) which is often utilised in healthcare settings (University of Hull, 2022). It follows a very clear structure of three core questions (What? So What? Now What?) And includes some prompts for each to facilitate a clear discussion of an experience, the relating of that experience to a broader context, and implications for future practice (University of Hull, 2022). In previous essays I have struggled to create an appropriate critical reflection, so having a clear structure with some supportive guidance was useful for me to ensure a structure and tone appropriate for academic reflection. In addition to the reflections below, a full report on changes made to the review protocol are included in Appendix 8 (p.43).

1. The literature review

What?

As the author of a study on a complex topic at masters level, and having received feedback previously prompting more specificity and rigour in my literature review process, I was afraid to use a narrative review for this work, as they are often criticised for lacking in rigour or structure (Grant and Booth, 2009). For this reason I wanted to draw on the methodologies of systematic reviews as outlined in Higgins et al (2022). I believe this led to a “mechanistic approach” that shifted my attention “away from the content and toward the procedural aspects of the review” (Flemming et al, 2017, p.1).

So What?

While research on the methodology was planned to take place over four weeks, this study time was spread out over a period of three months due to professional deadlines. It also led to a form of record keeping and reporting that was extremely labour intensive. This left very little time to actually engage with the literature and develop my understanding of the research topic. Higgins et al, (2022) does warn that the most important factor of a systematic review is the time it takes; I believe this was true in my case, especially when using a framework designed to be carried out by a team of researchers who are experienced in the topic and not by a sole author. The result was that proposed timescale was not adhered to, important parts of the study were rushed (particularly writing and reading eligible studies) and even with an extension, there was not enough time for me to achieve several of my objectives.

I did not have the experience with this model to realise that I had not made necessary adjustments to the review protocol to make it feasible for one person. This was also underpinned by a worry that deviating from the review protocol would become too interpretive to be regarded as sufficiently rigorous. While my new understanding of systematic reviews may save me weeks of research time should I choose to use it again, from the perspective of utility to my practice, the time spent engaging in procedural aspects of the review may not be worth the time it costs me in reading material relevant to the research topic and developing as a practitioner, not just a researcher. As I feel burnt out and somewhat demoralised from the process of this review, entertaining the idea of researching an entirely different kind of review feels just as daunting as using the model in the present study again.

Now what?

As this is an academic context, I do have support available to me in the form of feedback on the present work, and discussions with my tutor. This will be very important for my progression given my inexperience. I also believe taking some time away from the work to reflect will provide me with critical distance and support me in re-assessing before commencing the next module. I do believe rigour still needs to be planned for in my next review: perhaps some further research into the concept of rigour itself and how it presents in literature reviews may provide me with a fresh perspective.

2. Meeting my objectives

What?

Some objectives for this study were met, others were not. While I did greatly advance my knowledge of vocal acoustics with respect to belting through a literature review, I engaged with far fewer pedagogical resources than expected, I did not develop my aural awareness, and I did not accumulate as many strategies for practical use in teaching as I had hoped.

So What?

The level of new knowledge accumulated from this study was quite high. My understanding of systematic literature reviews has greatly improved. I have gone from having little understanding of vocal acoustics to having quite a detailed level of knowledge (more than I was able to express in this work, as the synthesis of resources was the main concern of the framework and time constraints were pressing). Reflecting on the process, I believe that it may not have been possible to develop advanced knowledge of this complex topic for a specific style, with this labour intensive methodology, and also engage in ear training, the assessment of available softwares for use, and substantial reading about pedagogical approaches. I believe this relates strongly to the tension of being a practitioner-researcher, where baseline knowledge must first be developed before it can be appraised more critically and applied practically.

Now what?

I believe a strong foundation has been established in this field, and perhaps the aims that were not achieved in this study could be carried forward to another with a focus on pedagogical strategies and resources.

3. Ethical considerations

What?

Ethical considerations could have been better integrated into the fabric of this study. Reflecting on my conduct as I carried out the review, transparency of reporting and the truthful presentation and representation of results was at the forefront of my mind, but I attributed this to rigour rather than to ethical treatment of an author's work (Robson and McCartan, 2011). I did consider ethics when reporting findings based on gender, using inclusive language both in my own notes and in the reporting. However, reflecting on the language of my writing, I may also have presented my findings in a universal light, even though none of the studies included showed any evidence of attempt to include diverse populations, and few records from non-western backgrounds were included.

So What?

Both racial disparities and white supremacy are sometimes made invisible by simple omission in research (Mowrey, 2015). While it may not have been possible to plan my work around these factors, or to include studies from other cultures and in other languages without misrepresenting them, this is still something that could have been raised in the form of clear signposting in my review protocol, or in my inclusion criteria. Even though I included gender inclusive language, the studies reviewed were not inclusive in and of themselves, and this could have been noted more clearly. Generally, more consideration could have been given to the ethics of how participants in studies were considered.

Now What?

In future studies I can be more committed to highlighting inequalities by including an ethical section in my inclusion/exclusion criteria, or simply by noting it in any data extraction tables.

Conclusion

LoVetri et al (1999) highlight that many teachers need to improve their knowledge of belting, a challenging and powerful style of singing. This study succeeded in developing a detailed knowledge of vocal tract acoustics and considerably deepened my knowledge of Belting. While this study did not lead to the expected outcomes of improved aural recognition of acoustical properties

of the voice, some insights into the teaching of this style were gained, and this information will provide a solid grounding for future studies in the work. While methodologies and ethical considerations do leave room for improvement, the process constitutes a commitment to rigour and to improving ethical reporting.

Component 2: Written Assessment

[4,861 words]

Introduction

As a singing teacher, my primary goal is to help my students achieve their target sound. When I search for resources to support a student in achieving a particular timbre, many exercises offered, often from expert teachers in studies like Roll (2016). They are often based on vowels and how they are shaped in the vocal tract. The present study seeks to understand the mechanisms that underly these strategies through the lens of vocal acoustics with respect to belting. Belting is in high demand, from stage schools to casting notices, so it is imperative that I have the skill set to offer students a range of options for acquiring the technique safely, as belting incorrectly can affect the health of the singer's vocal folds (LoVetri, 1999; McCoy, 2007). The complex interactions between voice production, harmonics, resonances, and the belting technique have been researched using the frame work of a Critical Interpretive Synthesis (CIS) (Dixon-Woods et al, 2006; Lakin and Kane 2023), underpinned with structures recommended for systematic reviews as collated in the PRISMA checklist (PRISMA, 2023). The CIS framework begins with a broad focus that becomes more refined as the search is carried out using rigorous, systematic search methods (Lakin and Kane, 2023). Within CIS, critiques of the literature are offered, and a synthesising argument presented, which draws together and synthesises findings to into a coherent framework that illuminates the relationships between different studies (Dixon-Woods et al, 2006). In the case of this study, the review of the literature constitutes the synthesis, and the critiques are presented after. While I have studied belting in a previous essay from the standpoint of understanding the features of the technique, the study was more focused on comparing peer-reviewed scientific literature with popular teaching models like CVT, Estill, and Voiceworks; this work departs from my previous writing in that it investigates belting much more deeply through the lens of vocal acoustics (O'Reilly, 2022). While the search process for that study does have some records in common with

the present work, the following discussion of belting will draw on records retrieved during this search process only.

Literature Review

The review commenced with a broad topic of interest - vocal acoustics - and a stage of introductory reading, as some pre-existing knowledge of a topic is required before commencing a systematic review (Higgins et al., 2022). Through two separate scoping reviews, the feasibility of two topics were assessed, the search protocol was created (housed in Appendix 6, tab 3a. Review Protocol: Structure). The topic was refined and selections were made as the literature was screened through various different phases. See Figure 2 for the PRISMA flow diagram on p.18 (PRISMA 2020 checklist, 2020). While the overall structure of the protocol was enacted, several adjustments were made to accommodate the research as it unfolded, such as including a keyword trial in the introductory reading. Limitations, such as limited availability of full search results when using Google Scholar were also noted, and these changes and adaptations to protocol can be reviewed in detail in Appendix 8 (p.43). All of the literature included in this study can be reviewed in Appendix 6 alongside inclusion criteria and quality assessment (Tab 3c) and data extraction (tab 3d). In a limited number of cases, entries in Tab 3c of Appendix 6 are not fully complete. Additionally, not all eligible literature was reviewed, a focus was placed on peer-reviewed studies that examined belting and acoustic resonances of the vocal tract due to time constraints.

Belting and vocal acoustics in the selected literature

Belting does not currently have a concrete definition within scientific literature, nor is there consensus among singing teachers about this vocal quality and how it is produced (Echternach et al., 2014b; McGlashan et al., 2017). Nevertheless, the style is in high demand, from young students in musical theatre programmes, to casting directors in Broadway (LoVetri et al, 1999). Coupled with the potential risk of vocal damage if executed poorly, it becomes even more crucial that teachers do their best to engage with existing knowledge about belting, even if a concrete definition does not yet exist (LoVetri et al., 1999; McCoy, 2007; Lebowitz and Baken, 2010; Gunjawate et al., 2017; Caffier et al., 2018). Although this study began with a desire to understand the utility of vowels from the perspective of vocal tract resonances, the physiological aspects of belting are inextricably interconnected with the vocal tract resonances and strategies used, and so will be discussed in tandem. References to resonances and harmonics will be updated as per recommendations made by Bozeman (2013;2019a; 2019b). Inclusive terms will be used to discuss the sex of participants where necessary, namely Assigned Female at Birth (AFAB) and Assigned Male at Birth (AMAB).

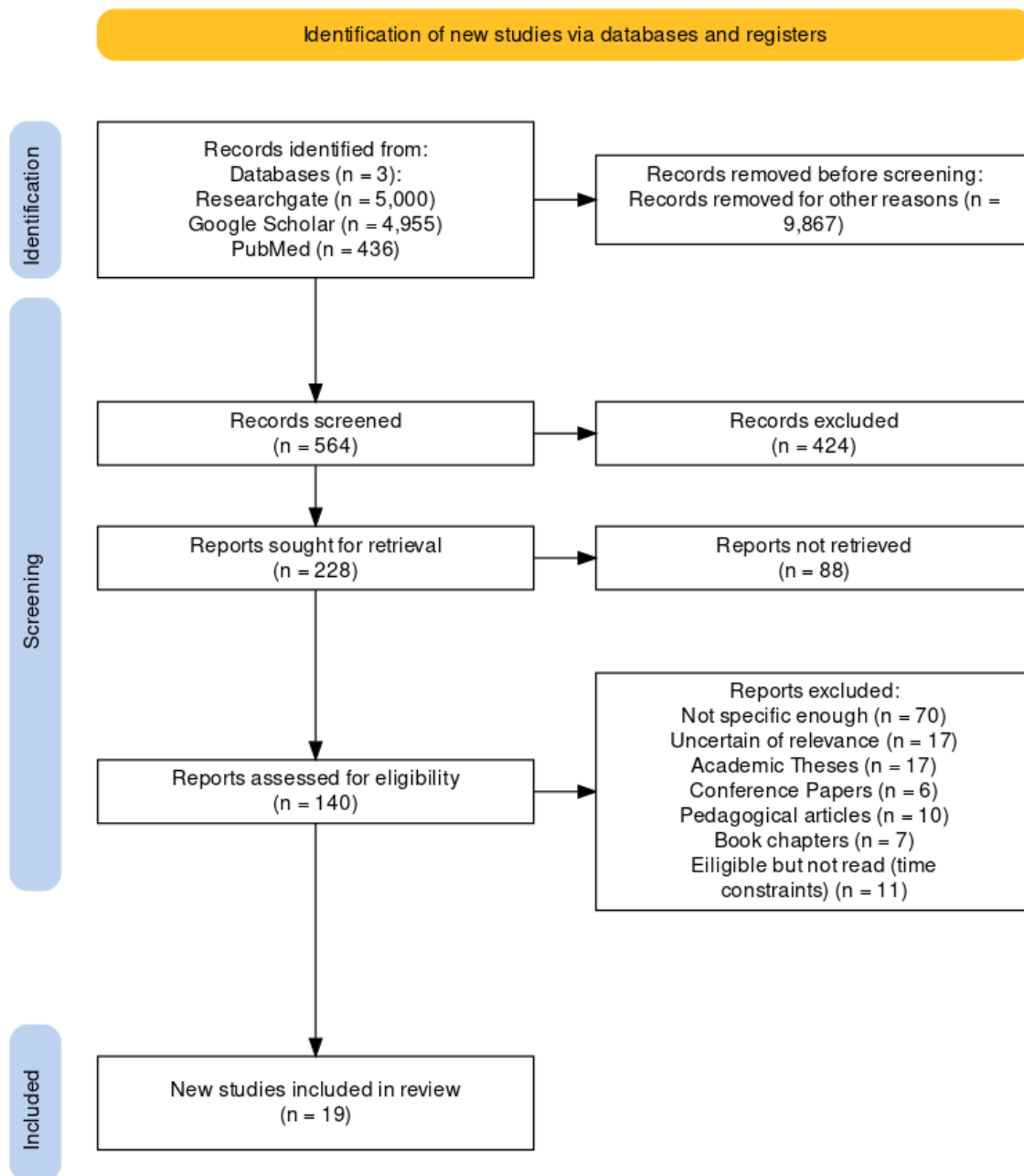


Figure 2: PRISMA flowchart (Haddaway et al., 2022).

Belting is sometimes described as bright (LoVetri et al, 1999; McCoy, 2007; Addison et al, 2008), loud, (Bestebreurjte and Schutte, 2000, Sundberg et al, 2012) yell-like (Sundberg et al, 2012; McGlashan et al., 2017;), and speech like (Bestebreurjte and Schutte, 2000; McCoy, 2007; Addison et al, 2008; Sundberg et al, 2012;). Some of these attributes can be linked to the acoustical profile generated by different vocal tract strategies. Brightness may stem from the fact that relative to other styles (like classical singing), belting exhibits the enhancement of higher harmonics across a much broader frequency range (Bestebreurjte and Schutte, 2000; McCoy, 2007; Barlow and LoVetri, 2010). Howell (2017) notes the frequencies between 5 kHz - 8 kHz by 18

be irrelevant in the context of speech, but may impact significantly on the quality of a sung sound. A stronger maximum flow declination rate (MDFR) was observed in belt versus legit or head voice qualities, indicating a faster closure of the vocal folds, which leads to create excitation of the vocal tract, thus energising the harmonics (Sundberg et al, 2012; Sundberg and Thalén, 2015; Bozeman, 2019b). Caffier et al. (2018) found that higher styles of belting had more even distribution of harmonics. Brightness of sound may also be linked to loudness, as Titze (2021a) notes that distributing acoustic energy across a broad range of harmonics is more effective in generating loudness than directing all the energy towards a single harmonic. Loudness is not found in all productions of belt (McCoy, 2007), but it does seem to be significantly louder than classical or neutral styles of production (Bourne and Garnier, 2012; by 8.5db average, Sundberg and Thalén, 2015; Titze, 2021a). As for belt as a speech-like quality, it is certainly the case that some singers view belting as linked to speech (Caffier et al, 2018). The intelligibility of text is greater in belting (Bestebreurjte and Schutte, 2000). However, speech exists in a more limited pitch range and exhibits shorter phonation periods than singing a piece of music (Howell, 2017). Herbst et al. (2023) found that speech-like vowels (and their accompanying vocal tract strategies) cannot truly be maintained over a singer's entire range. Indeed, elite Broadway singers have reported that as belting is different as it moves above C5, although there were different perceptions among participants about what those changes were (Flynn et al, 2020).

Belt is said to take place in the chest or modal register (LoVetri et al., 1999, Addison et al, 2008, Sundberg et al, 2012) with a high laryngeal position (Bourne and Garnier, 2012; McGlashan et al., 2017), high closed quotient (CQ), and featuring nasality (Addison et al., 2008; Sundberg et al, 2012,). Belting, however, is called for in increasingly high regions of the voice in modern music, and so belting may not always be in chest voice above the first *passaggio* (Echternach et al, 2014b). It seems that laryngeal position varies, with observations of low larynx for belting found by LoVetri et al (1999), and relative to control conditions, observations of no change in height (McCoy, 2007), or a higher relative position (Echternach, 2014b; Caffier et al., 2018). A high larynx would seem to be a strategy that is not universally applied. High CQ is similarly variable. An oft cited study by Schutte and Miller (1993) posits that belting requires a CQ of 50% (cited in Bestebreurjte and Schutte, 2000). While it is often higher than in classical singing (Barlow and LoVetri, 2010, Bourne and Garnier, 2012; Sundberg and Thalén, 2015), CQs at or below 50% were observed by Lebowitz and Baken (2010), while some 75% of singers in one study belted with a CQ comparable to the classical style (McCoy, 2007). With respect to nasality, a closed velum was observed by Echternach et al, (2014b) in belting tasks. Additionally, belt is often discussed as a technique for AFAB singers; in the selected studies a total 199 human participants took part, of which 44 were AMAB singers (22.1% of participants). Other observations of belt arose in the literature, but did not yield as much information for comparison within the selected studies. Medium levels of subglottal pressure were observed for belting by Sundberg et al (2012), but high subglottal pressures were found by Sundberg and Thalén, 2015). Lower levels of Normalised Amplitude Quotient (NAQ),

used to measure the differences in vocal qualities, but this is not elaborated on (Sundberg and Thalén, 2015). Higher speed quotients (SQ) were found for belt than for other styles, indicating asymmetrical movement of the vocal folds (Lebowitz and Baken, 2010; Bourne and Garnier, 2012). Sparing use of vibrato was noted in two studies, (Addison et al., 2008; Echternach et al, 2014b), A strong separation between registers (Addison et al., 2008) and Higher pulse amplitude (Sundberg and Thalén, 2015, but it is not explained what the latter suggests.

Vocal tract resonances and harmonics for belting often have a weaker fundamental frequency (F_0) relative to other harmonics (Barlow and LoVetri, 2010; Flynn et al, 2020). In belting, F_0 appears to be weaker than in other styles, like classical singing (Sundberg et al, 2012; Sundberg and Thalén, 2015), although this has not been observed in all cases (Lebowitz and Baken, 2010). The dominance of other harmonics in the spectrum is thought to be related to vocal tract strategies (or shaping) that brings the harmonics into range of a natural resonance of the vocal tract, thereby receiving a boost in intensity (Bozeman, 2013). This is sometimes referred to as “formant tuning”, even though a note need not precisely match the frequency of a vocal tract resonance to be boosted (Titze and Worley, 2009). A dominant second harmonic is often observed for belting (Titze and Worley, 2009; McGlashan et al., 2017; Titze et al., 2017). While it has been posited that the first resonance of the vocal tract (fR_1) must be coupled with (or “tuned to”) the second harmonic ($^2F_0$) to boost the second harmonic and produce a belt, this is another feature of belting that is not universal (Schutte and Miller, 1993; cited in Bestebreurje and Schutte, 2000). While studies in this review have contained examples of participants using fR_1 : $^2F_0$ coupling (Bourne and Garnier, 2012), this is not always the case (Lebotwitz and Baken, 2010; Sundberg et al, 2012; Sundberg and Thalén, 2015). In some instances of belting, fR_1 was tuned to a harmonic by participants; just not $^2F_0$. In Bourne and Garnier (2012), it was noted that singers can move the position of the natural vocal tract resonance to facilitate couplings; participants were observed to have higher frequencies for fR_1 in belting (no strategies for fR_2 , were observed, although it was higher in belt than it was in a classical style). Herbst et al (2023) found from computational models that certain vowels were more likely to result in an fR_1 : $^2F_0$ coupling, with the highest incidence occurring between A3-E4. In this model, voice source strength helps to create the conditions for the dominance of harmonics above F_0 , suggesting that moderate-strong voice source creates the best conditions (Herbst et al, 2023). This agrees with Titze (2021b), which states that the manner in which the vocal tract reacts to stimulus from the movement of air through vocal folds can create a favourable environment for vocal fold oscillation. If the response above the glottis is inertive (delayed), this can reduce the air pressure required for phonation, increasing the amplitude of vocal fold oscillation, and creating a higher probability of a dominant $^2F_0$, a condition known as “supraglottal inertive reactance” (Titze, 2021a). Several studies suggest that a divergent resonator (or a “megaphone” configuration of the vocal tract) also supports the creation of belt (Titze and Worley, 2009; Bourne and Garnier, 2012; Titze et al., 2017). High belting, however, appears to

have more even distribution of energy across harmonics, with a relatively stronger F_0 (Caffier et al., 2018).

Vocal tract strategies for belting

Singers modify the dimensions of the vocal tract to change the position of fR_1 and fR_2 in order to boost select harmonics (Bestebreurjte and Schutte, 2000; Bourne and Garnier, 2012; Howell, 2017). This change is referred to as a resonance strategy (Bestebreurjte and Schutte, 2000). Henrich-Bernardoni et al., (2011) demonstrated that participants could “tune” vocal tract resonances to harmonics with a precision of about 20 Hz. Titze and Worley (2009) hypothesise that such tuning can be used to both suppress and boost select harmonics by using favourable pitch-vowel combinations that generate the supraglottal inertive reactance discussed above, thus reinforcing vocal fold vibration. Although there is great heterogeneity in the resonance strategies adopted to create belt, studies have shown that singers do have consistent strategies for creating this sound at the individual level (Barlow and LoVetri, 2010; Lebowitz and Baken, 2010), with some studies even demonstrating significant parametric changes from one style of belting to another (McGlashan et al., 2017), or from one area of the singer’s pitch range to another when belting (Echternach et al., 2014b). Even in cases where singers report the same strategy, this did not result in the same acoustic profiles as per objective measurements (Lebowitz and Baken, 2010; Henrich-Bernardoni et al, 2011; Sundberg and Thalén, 2015; Caffier et al., 2018). The methodologies and methods used to assess these strategies are just as varied. This variety limits the credibility of any synthesis of information about belting or how it is achieved, but from a practical standpoint, students of singing will experiment with this style regardless, so it is important to attempt such a synthesis.

The utility of a divergent resonator (or megaphone shape) for belting is described both directly and indirectly across the literature reviewed. The characteristics of this strategy include a wide open mouth, a narrowed pharynx and epilarynx, and a high tongue dorsum. The degree of mouth opening is thought to shift the frequency range of fR_1 and fR_2 upwards (Titze and Worley, 2009; Jeanneteau et al., 2020, Bourne and Garnier, 2012; Echternach et al, 2014b). This may allow for fR_1 to couple with and boost $^2F_0$ (which lies an octave above the intended sung pitch), or perhaps to position F_0 in a range where it will not be boosted acoustically, allowing other harmonics to dominate the sound. Tongue placement has been observed to be high in some studies, and this impacts on the second vocal tract resonance fR_2 . A high tongue dorsum has been observed in several studies (Echternach et al, 2014b; Caffier et al., 2018), but not all (LoVetri et al., 1999; Bourne and Garnier, 2012). This may relate to the vowel sounds being produced and the vowel strategy employed. Moving the tongue backwards lowers fR_2 , while bringing it forward raises fR_2

(Jeanneteau et al., 2018). A tongue further back in the mouth can also contribute to a reduction of the space in the back of the mouth, which was found to produce bright vowels by LoVetri et al (1999). A constriction of space by the pharynx and epilarynx also contributes to the creation of a divergent resonator (Bourne and Garnier, 2012; Echternach et al., 2014b). Titze and Worley (2009) found that a narrowed epilarynx was even more effective than overall pharyngeal constriction, as it increases the excitation of energy in the vocal tract because air must move more quickly in a narrow space. McGlashan et al (2017) also noted narrowed piriform sinuses and a tilted epiglottis in productions of belting - the piriform sinuses can be responsible for "dead" areas across the spectrum of a singer's radiated sound, which may not be desirable (Titze and Worley, 2009). In breathing for belting, Sundberg and Thalén (2015) reported a more expanded ribcage, but did not find a consistent strategy among participants. Titze (2021ba) notes that increased lung pressure can double the loudness of a sound. This may be pertinent as loudness is thought to be a feature of belting.

Pedagogical comparison: Kenneth Bozeman

It was anticipated that this study would rely much more on pedagogical literature, and while this was not the case, some reference to pedagogical approaches is warranted given that this study is designed to facilitate practical application of the information. The work of Kenneth Bozeman was a key element in the development of my understanding of vocal acoustics for this study; as a published author, researcher and international lecturer in this topic, it seems his approach is very well grounded in the literature. Physiologically, Bozeman defines belt as requiring a narrowed pharynx, a raised larynx, and an open/wide mouth shape (Bozeman, 2019d). Acoustically, maintaining $^2F_0$ at or above fR_1 is desirable for a passage of music requiring belting technique across different pitches and vowel sounds (Bozeman, 2013; 2019d). A divergent resonator shape is advocated to help raise fR_1 closer to $^2F_0$ (Bozeman, 2013). While chest register is extended within this technique, it can be done with different degrees of thickness at the vocal folds, while retaining the timbre of the chest voice (Bozeman, 2013). It calls for an open timbre naturally found in mid-open vowels (See: Interactive IPA chart (no date)). Regulation of breath pressure is regarded as important for the style to be sustainable, and a modified degree of larynx raising, pharynx narrowing, reduction of breath flow, and engagement of the aryepiglottic sphincter are important in achieving this (Bozeman, 2013). The quality can be produced with sustainable levels of glottal adduction when strategies that emphasise higher harmonics are employed (Bozeman, 2013). While Bozeman primarily discussed classical singing in the sources cited, having knowledge of how the style is created physiologically means we can infer pedagogical tools to support the creation of a belting sound.

In discussing resonator shape, Bozeman cautions that a singer's percept of the resonating space is often incorrect (2019a). The 'yawny' /a/ often coached with the intention of producing a convergent resonator (narrower in the mouth, more spacious in the pharynx) in fact produces a divergent resonator (open in the mouth, narrow in the pharynx), which is useful for belting (2019c). We can support singers in creating a belting sound in the following ways:

- Affect: Inhaling and creating a sense of "windchill" in the back of the throat leads to a narrowed pharynx. (Bozeman, 2019c)
- Using whispering as a practice tool creates more oral sensations for the singer, and thus a more open mouth shape. (Bozeman, 2019c)
- Coaching the singer to utilise reduced airflow (Bozeman, 2013). This may be consistent with the ribcage movement observed by Sundberg and Thalén (2015) which may have caused reduced subglottal pressure (Thorpe et al., 2001). This may also coincide with Titze (2021a); if the epilarynx is sufficiently narrowed, the movement of air through the narrow column should produce increased excitation of the vocal tract, creating more loudness and supporting vocal fold oscillation.
- The adduction of the false vocal folds can be inhibited by using Estill's affect of the suppressed laugh (Bozeman, 2013)
- According to Bozeman the best vowels for belting are /a/ and /ɛ/, so singers may benefit from exercises involving those vowels as an initial step (Bozeman, 2013).

It may also be useful to note that Bozeman's teaching he makes regular use of the *Madde* Voice Synthesiser to demonstrate the movement and interactions of formants and harmonics. It is unclear the extent to which (Bozeman, 2019a-d). In his discussion of imaging software, Bozeman advises that such software is there to compliment the ears of the teacher and the student, and can be used to "complete the picture" of any issues being addressed in the lesson (Bozeman, 2013).

Critique 1: Drawing the research together

In line with the CIS framework for literature reviews, critiques of the body of literature review must be presented. For a topic like belting, which is the subject of many different kinds of research questions, aggregation of objective information across studies would be quite difficult. Even among quantitative studies within the selected literature, the objective measurements and participants differ greatly from study to study. Reporting on equipment used to obtain measurements is sometimes lacking, and advancements in technology also mean that new parameters for assessment are still in development. For example, Titze (2023) re-examines how loudness is measured in singing, and while his results are of great interest to singing teachers who want to create more volume for less physical effort, the ability for these results to be meaningfully aggregated with other searches is limited. The variety of research questions applied to belt is also

reflected in the variety of methodologies found across these studies. Some use *in silico* computer modelling to assess voice quality, with a range of different kinds of simulated vocal tracts assessed. Others use subjects with variations in age, experience, and voice type and genre to assess different parameters, all heavily skewed towards AFAB singers. Subjective, unsubstantiated descriptions of belting in the literature feeds into the heterogeneity, and the literature therefore is difficult to organise and collate, because belting does not mean “the same thing to different people” (Lebowitz and Baken, 2010, p.165). Henrich-Bernardoni et al (2011) is a case in point, where unsubstantiated definitions and causal links are seen regularly throughout the paper. Neither are more recent studies taking full advantage of the digital age of publishing by linking to the qualities studied, as in McGlashan et al., (2017). It is also worth noting that where studies include such resources, these additional materials may not always be as accessible as the study itself, as is the case with McGlashan et al (2017) (Echternach et al., 2014b). This is difficult given the sonic nature of the topic at hand. Many of the issues that affect belting as a research topic also seem to impact vocal acoustics more generally (Gunjawate et al., 2017). The fragmentation of knowledge across the research on belting may be symptomatic of a developing field at large: with many facets of acoustics, physiology and practical application to address, it may simply be a matter of time and further study before consensus on any facet of belting is reached. Higgins et al (2022) advises that the best research questions “occur in the context of an already-formed body of knowledge” held by the researcher. Perhaps such a body of knowledge is also required on the level of a broader field before more unified approaches to researching belting will be developed.

Critique 2: Better integration of qualitative approaches.

Many of the descriptions of belting, even within quantitative studies, are subjective. This is not to say that relevant literature was not reviewed and discussed by authors, but rather that the subjective aspects of the study are not acknowledged openly, and there is little reflexivity offered on the part of the researcher for subjective aspects of the work, most typically found in the introduction and the discussion portions of the studies. This may be due to the fact that qualitative researchers are (in theory) more sensitised to their own subjectivity, and the need to offer a clear context for their interpretation, whereas Quantitative researchers may place more focus into ensuring that the methodology and methods chosen are valid for the question at hand. A more pragmatic approach to research questions might assist in the practical inclusion of Qualitative techniques to ensure greater transparency, and thus, less confusion among readers about the origin of certain definitions of belting. Qualitative methods were included in two studies in this review (Flynn et al, 2020; Jeanneteau et al, 2020), and the inclusion of participant voice greatly aided my understanding of how my students may relate to tasks in a lesson, and how they understand belting. Both studies could have gone further in including participant voice to support the continued development of definitions of belting and how students experience and interpret it. More formal information about the exact involvement of practitioner researchers as authors in

studies is an opportunity for reflexivity, but it would also be a useful qualitative resource for singing teachers, students and other researchers (LoVetri et al., 1999; Barlow and LoVetri, 2010; Jeanneteau et al, 2020) To an extent, studies like McCoy (2007) achieve this goal quite well; the practitioner's voice and context is clear, but this could be more transparently and intentionally integrated into research designs.

Impact

Possible Application to teaching: Imaging software

Within the literature various strategies were suggested or trialed for supporting the application of vocal tract acoustics to create specific timbres. This includes recommendations for the use of spectral imaging in the voice studio (Howell, 2017), and creating formant profiles for individual students to clarify the degree to which they can personally control the movements of formants across different vowels (Titze et al, 2017). In a study about training singers to use imaging to improve formant tuning, singers made progress on changing format tuning with visual imaging, but most did not use it spontaneously after, whereas more time (four months with 30 minutes of time with the imaging software daily) resulted the ability to change tunings at will and an increased range of a 5th (Jeanneteau et al., 2018). Singers reported an increased awareness of physical manoeuvres after this training, and it is thought that some of the difficulties experienced by participants in this study may be to do with the difficulty of changing already entrenched patterns of vocal production (Jeanneteau et al., 2018). Several eligible studies that addressed the use of spectral imaging in the studio were identified during the literature review, but due to time constraints, these could not be reviewed in detail. While the recommendations of the three studies cited here are compelling enough to me to explore spectral imaging as a tool for the purposes of teaching belting, this is a tentative, preliminary conclusion. The literature reviewed for this study contains some visual examples of different singers producing a belt quality across a range of vowels and musical phrases; it is instructive to use the graphs presented to create an idea of what might be seen or observed in software that can reproduce sound in terms of Long Term Average Spectrum graphs and spectrograms. Images of useful figures from the literature have been gathered and organised into their respective vowels with a view to creating a database of visual information for use alongside software (Bestebreurjte and Schutte, 2000; Titze and Worley, 2009; Addison et al., 2008; Barlow and LoVetri, 2010; Lebowitz and Baken, 2010; Bourne and Garnier, 2012; Sundberg et al, 2012; Sandberg and Thalén, 2015; Herbst et al., 2023). See Appendix 9 (p.46). These can be used alongside online resources for IPA pronunciation to facilitate personal experimentation before introducing this tool into my own teaching (Interactive IPA Chart (no date)).

Development of new knowledge: Preliminary foundations

My knowledge of systematic review methodologies, vocal tract acoustics, and belting have all been greatly enhanced by undertaking this review. Prior to the study I had virtually no knowledge of how a systematic review was carried out (and therefore, no experience of implementing one), and my level of understanding of vocal tract acoustics was minimal. While I had conducted one study in belting previously, it did not address vocal tract acoustics at any length; the present review was a much deeper engagement with topic than my previous study (O'Reilly, 2022). As eligible studies identified from a practitioners perspective were not reviewed for this study due to time constraints, I do not feel I have gained a concrete teaching strategy that is ready for use in the voice studio. However, I do feel that I have a solid foundation grounded in the literature about how vocal tract acoustics behave and how they can be influenced, which is a much better position to seek strategies from relative to where I started. This may lay the foundations for a future study where the main focus of the work is to assess pedagogical literature and build lesson plans for students who wish to belt.

Conclusion

The present study sought to synthesise and critically engage with literature to draw conclusions about the role of vocal acoustic within belting, and how this can be applied. Several suggestions from the work of Ken Bozeman were identified that appear to enjoy some support in the literature, and imaging software was identified as a potential tool for further examination (Bozeman, 2013; 2019a-d; Jeanneteau et al, 2020). While the literature on belting is somewhat fragmented because of a lack of consensus about how the term is used, and the need for further research to unify and verify healthy ranges for the technique, it was still possible to extract some information from the literature that may serve as a useful frame of reference within teaching.

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Appendices

Appendix 1: Glossary of terms

Amplitude -

Assigned Female at Birth (AFAB) - An inclusive term used to ensure that participants who may have a similar vocal fach to cis-gendered women are not misgendered.

Assigned Male at Birth (AMAB) - An inclusive term used to ensure that participants who may have a similar vocal fach to cis-gendered men are not misgendered.

Belting - A style of singing that does not have an agreed definition, but is frequently used in pop and musical theatre, informally said to have a bright, loud, speech-like quality.

Closed Quotient - The amount of time that the vocal folds remain closed per vibratory cycle.

Contemporary Commercial Music (CCM) - Coined by Jeanie LoVetri, this term is often used to reference nonclassical styles of singing.

Convergent resonator shape - Sometimes referred to as an "inverted megaphone" shape. A configuration of the vocal tract that is open in the back of the mouth, and narrower in the front. Associated with classical timbres.

Divergent resonator shape - Also known as a "megaphone" shape. A configuration of the vocal tract that is open towards the front of the mouth, and narrower in the back of the mouth. Associated with belt timbres.

Epilarynx - the area above the larynx.

Formant - a peak within radiated sound resulting from a natural resonances of the vocal tract.

fR_1 - The first natural resonance of the vocal tract for a given vowel or vocal tract configuration.

fR_2 - The second natural resonance of the vocal tract for a given vowel or vocal tract configuration.

Glottis - the space between the vocal folds.

Harmonic - a property of pitch: these are radiated at logarithmic regular intervals that are the same distance apart no matter the pitch. Often referred to as F_0 , $^2F_0$, $^3F_0$, and so on infinitely.

Inertive reactance - This is a condition where the response of the vocal tract (reactance) is said to be delayed (inertive). This is good for vocal fold vibration and thought to create ideal conditions for belting.

Legit - Terminology from musical theatre practitioners indicating a more neutral, rounded, or quasi-classical timbre of voice.

Percept - The manner in which we perceive a stimulus.

Pharynx - The walls of the throat, comprised of three areas; the naso-pharynx (located roughly behind the nose), the oro-pharynx (the back wall of the mouth) and the laryngo-pharynx (just above and around the larynx). These areas can contract or relax to create different conditions within the vocal tract.

Registers - Refer to different manners of vocal production in different areas of the voice. Chest voice (thick fold, M1, Modal register) is familiar to most, this is a thicker configuration of the vocal fold used in most speech. Head voice (thin fold, M2) is a thinner vocal fold configuration that exists higher in a singer's range. Other ranges exist but chest and head are most relevant for a discussion of belting.

Resonance - In the author's experience, this has been informally used to indicate kinaesthetic information about where the sensation of sound should be felt in order to generate the correct timbre with the correct level of projection. Within vocal acoustics, this is a specific term that alludes to frequency responses in the vocal tract owing to the properties of the space in any given moment.

Supraglottal - Above the glottis.

Subglottal - below the glottis.

Appendix 2: Methodology comparison

This table compares criteria for Cochrane Systematic reviews and Qualitative Evidence Syntheses in order to assess relevance to the present study. Centre for Reviews and Dissemination (2009) Higgins et al (2022) are the main sources unless otherwise stated.

Section	Systematic recommendation (SR)	Qualitative Evidence Synthesis (QES)	Relevance to current study
Planning			
Submit proposal for review	Create a proposal for the intended review (to avoid duplication of reviews)	No differences specified	N/A
Question development	- Determined at the outset of the review. - Topic should support decision making in clinical practice and policy. - FINER tool recommended for question formulation. (Cummings et al, 2007). - Topic should not replicate previous Cochrane reviews.	Questions develop as the research unfolds; generally after a scoping review. Multiple lines of inquiry can be pursued. (Harris et al., 2018)	QES framework more suitable given the nature of the enquiry and the standing and level of experience of the author.
Title formulation	Use a pre-existing protocol for creating a title (See table II.1.a of Higgins et al., 2022)	PICOC, SPICE or SPIDER formulations for questions recommended.(Harris et al., 2018)	Both studies use external frameworks to generate their title, to improve visibility of relevant studies in searches, and thus the usability of the research. (Higgins et al., 2022)
Protocol	A written protocol must be set out in advance, specifying both scope and methods intended to carry out the review. Changes to this protocol must be documented and reported.	Developed after a scoping review of each aspect of the phenomena. Protocol is flexible and iterative, can be based on a relevant theoretical model. Changes must be transparent, documented and justified. (Harris et al., 2018)	QES model is more appropriate for the purposes and context of this study.
Headings/ sections recommend	See Box II.1.a, Higgins et al., 2022.	No specific, distinct sections for QES headings found.	This goes against the assignment structure required by UWTSD for the present assignment. However, the headings recommended by Higgins et al., (2022) can be used to ensure that information is present in the assignment. UWTSD handbook is available in Appendix 10 (p.46)

Section	Systematic recommendation (SR)	Qualitative Evidence Synthesis (QES)	Relevance to current study
Planning			
Author team	Carried out by more than one person; The skills and expertise of the team across subject, methodological knowledge, and inclusion of user and practitioner voice are considered in whether a review will be accepted or not.	A review team carries out a QES (Harris et al., 2018)	This is a single author study in an academic context, so this criteria cannot be satisfied for this study.
Resources	Consider the availability of: - Time (workload, task management, scope of topic) - Training for team members - People to conduct searches - Access to libraries and databases - Equipment (hardware, software) - Facilities - supplies, office space - Funding for travel	QES share these considerations.	Planning for teams, funding, and larger scale facilities are not relevant to this study. Concerns related to time and planning, access to databases, and certain kinds of software and equipment will be given consideration.
Reporting of reviews			
Abstract	Include a brief abstract between 700-1000 words. Language should be accessible for general healthcare practitioners and avoid all but the most common abbreviations.	Could not find an approach to this section that was distinct from SR.	N/A

Section	SR	QES	Relevance?
Reporting of reviews			

Section	SR	QES	Relevance?
Plain language Summary	Use pre-defined guidance to create a summary of the review - these are often translated into different languages.	Could not find an approach to this section that was distinct from SR.	N/A
Background and Objectives	To include: - Description of the condition - Description of the intervention - How the intervention is thought to work - Why the questions within the review are relevant - The objectives of the study	- Explain why Qualitative evidence is needed (often linked to a specific Systematic review). (Harris et al., 2018) - Explain who stakeholders are, and the manner of involvement. - CICI Framework (Harris et al., 2018)	The structure can be modified and incorporated into the study, especially with modifications for QES recommended by Harris et al. (2018). - In my case, synchronous involvement (see ref from Harris et al., 2018)
Methods	- Discuss inclusion criteria for which studies are included (study design, method of measurement) - Comprehensive detail of Search methods used, with an appendix of the exact search strategy - Assessment of quality of studies included using GRADE or other models - Data collection and analysis - Assessment confidence	- SR principles adapted to place greater emphasis on context and phenomena - A wave of searches can be done based on increased understanding (Harris et al, 2018) - Quality assessment methods are reflective of the kind of data being analysed - GRADE-CERQual approach, for example (Harris et al., 2018; Noyes et al, 2018) - Data integration can be sequential or convergent (Harden et al., 2018)	The recommendations for SRs and QES can be taken together and applied to this study, with the exception of discussions about decision making within a team, as this is a single-author study, and the use of frameworks that best suit the kind of literature under review.
Results	- A summary of the results of the search - The risk of bias within the results - Efficacy of intervention(s) studied - Synthesised findings in tables or figures by intervention group	- A theory - participant quotations, researcher - interpretations of data - Can be displayed through narrative means, or in visual terms like infographics or tables (Noyes et al., 2018)	As this is an exploratory study of an area new to the researcher, information is more likely to be presented in the form of interpretations as might be found in a QES.

Section	SR	QES	Relevance?
Discussion	- Summary of main results - Assessment of how well the aims of the study were achieved - Reliability of evidence - Biases within the review process - How findings support or deviate from other reviews.	Could not find an approach to this section that was distinct from SR.	This is applicable and flexible enough that it can related to different kinds of source material and syntheses.
Conclusion	- Application to practice - Potential future research	Could not find an approach to this section that was distinct from SR.	The structure can be modified and incorporated into the study, with the addition of further context about the author and my practice.
Administrative information	- Author contributions - Declaration of conflicts or potential conflicts of interest - Acknowledgement of team members who may not be credited as authors - Deviations from initial protocol to final review - Other support and awards that assisted the review	Could not find an approach to this section that was distinct from SR.	Deviations from initial review will be discussed in the reflection section of the work. Otherwise, N/A

Appendix 3: Comparing literature type

Type of literature	Paradigm & Presentation of findings	Advantage	Disadvantage
Peer-reviewed: Quantitative studies	Positivist, findings presented in terms of statistical analysis	- Clearer information for reader to assess the quality of the study. - Facilitates statistical aggregation of findings. - More concrete information to facilitate evidence-informed teaching. - Clearer objectivity	- Comparatively small number of studies available in this manner specifically addressing singing. - Can take a lot of additional research to understand if not already trained in this area. - Findings do not always hold clear implications for practice in the studio.
Peer-reviewed: Qualitative studies	Constructivist, findings are interpretations in the format of themes, infographics, or theories.	- Understanding the perceptions of the singer is important for a singing teacher. - Can help with locating one's practice within the broader field - Accessible - Research questions can be based on practice. - Can facilitate more than one kind of literature. - Important to provide context and complexity (often used to supplement Randomised Control Trials).	- Subjectivity of researcher is inherent in the findings. - The specificity of these studies can affect their generalisability. - Findings may not be concrete enough to apply to practice. - Variety of Methodologies and methods can mean aggregation of data is itself interpretive rather than statistical - Comparatively small number of studies that specifically examine singing.

Pedagogical literature	Paradigm can depend on the writer. Findings are often based on informal trial and error about application of the knowledge in question, and presented as exercises for use in teaching.	- Often provides brief reviews of the field in advance of providing instruction. - Useful for back-chaining or snowballing search techniques - Designed to facilitate practice - Useful for building confidence and understanding in the studio - Key texts within literature dedicated to singing have been eager to incorporate the findings of peer-reviewed research, arguably as far back as the Garcias in 1700s. - Many texts have been authored by singing teachers who themselves have participated in and contributed to primary research on the voice. - Provides a "stakeholder" perspective (Harris et al., 2018)	- The exercises included in texts are rarely the subjects of peer-reviewed studies. - Peer-reviewed base of evidence for singing specifically is generally small, casting their findings into doubt. - Practitioners often draw on studies not designed for singing to arrive at their conclusions. - Subjectivity: Many recommendations in these texts are on the basis of the author's experience - while this can be helpful it is not peer-reviewed. - Not all authors make an effort to their their understanding back to literature, thus proliferating myths about singing.
Other grey literature (lectures, workbooks, YouTube videos)	Often lacking in a clear paradigm of origin. Findings can be practical demonstrations through audio and video.	- Can provided audio-visual information to help the teacher and singer discriminate between different conditions of the voice, essential for singing teaching. - Demonstrations of exercises and scientific principles can be more readily understood for a novice from audio-visual formats rather than descriptive text. - Information can be more quickly understood. - Tutorials and instruction in the usage of software is important in this area of study to be able to discuss and demonstrate the principles in question. - The authors of these resources can be singing teachers who have authored or contributed to primary research on the voice. - Easily accessible and created to support teachers and students.	- Can be under-researched and completely unsubstantiated. - Is considered a literature of last resort in academic communities. - Novices with little understanding in a topic may not be able to discern the quality of these resources. - Often highly subjective.

Appendix 4: RETREAT

Applied as per Booth et al. (2018).

R	Review Question	No specific question: An aim to understand and apply information about vocal acoustics to my singing practice
E	Epistemology	Pragmatic - guided by the question, Constructivist - data can be analysed thematically or interpretively
T	Time	5 months (but a considerable amount of this time will be taken up studying methodology, and gaining an understanding of a complex subject)
R	Resources	Previous knowledge and experience of teaching singing and of singing, Lecturers, Voice Study Centre Library, access to electronic databases, Laptop. Single author study. One draft can be reviewed in advance of submission.
E	Expertise	Previous experience of reading scientific literature through previous three modules of study, but apart from this, only very general awareness of the subject, working alone to find and analyse resources.
A	Audience/Purpose	Singing teachers and students with an academic background.
T	Type of data	Quantitative, Qualitative, pedagogical

Appendix 5: PRISMA resources

(Source: Page et al., 2021)

5.1 Original PRISMA 2020 checklist

For traditional systematic reviews, a checklist has been created to guide reviewers to include the correct information. Available at: <https://prisma.shinyapps.io/checklist/>

5.2 Adapted checklist for protocol development and planning

Planning the review protocol was supported by using an adapted version of the PRISMA checklist. This adapted list and reporting on the rationale for excluding and including certain steps is linked here: https://docs.google.com/spreadsheets/d/1NDx98ET_SquPip92mUIKkoAHofYxYowmxl5JR4zvHb_Q/edit?usp=sharing

5.3 PRISMA 2020 flowchart creation tool by Haddaway, et al, 2022.

This tool enables you to input figures from a review and it generates a PRISMA flowchart to aid in the reporting of findings. Accessible at https://estech.shinyapps.io/prisma_flowdiagram/.

Appendix 6: Search Strategy and Selection information

This includes individual tabs with information about the introductory reading, the scoping reviews and the review for the main topic. Please use the tabs to navigate.

https://docs.google.com/spreadsheets/d/19tOScY3D0GzkPXFACZGLYneKfilZkxmq6dWADs8cgv8/edit?usp=share_link

Appendix 7: Critical Interpretive Synthesis Structure

Source: Table 2, Dixon-Woods et al (2006).

“Table 2: Key Processes in critical interpretive synthesis

- A review question should be formulated at the outset, but should remain open to modification. Precise definitions of many constructs may be deferred until late in the review and may be a product of the review itself.
- Searching, sampling, critique and analysis proceed hand in hand, and should be seen as dynamic and mutually informative processes.
- Searching initially should use a broadly defined strategy, including purposive selection of material likely or known to be relevant.
- The analysis should be aimed towards the development of a synthesising argument: a critically informed integration of evidence from across the studies in the review. The synthesising argument takes the form of a coherent theoretical framework comprising a network of constructs and the relationships between them. The synthesising argument links synthetic constructs (new constructs generated through synthesis) and existing constructs in the literature.
- There is a need for constant reflexivity to inform the emerging theoretical notions, as these guide the other processes.
- Ongoing selection of potentially relevant literature should be informed by the emerging theoretical framework. Literatures not directly or obviously relevant to the question under review may be accessed as part of this process.
- CIS encourages an ongoing critical orientation to the material to be included in the review. Some limited formal appraisal of methodological quality of individual papers is likely to be appropriate. Generally the aim will be to maximise relevance and theoretical contribution of the included papers.
- Formal data extraction procedures may be helpful, particularly at the outset of the review, but are unlikely to be an essential feature of the approach.
- CIS does not offer aim to offer a series of pre-specified procedures for the conduct of review. It explicitly acknowledges the "authorial voice"; that some aspects of its production of the account of the evidence will not be visible or auditable; and that its account may not be strictly reproducible. Its aim is to offer a theoretically sound and useful account that is demonstrably grounded in the evidence.
- CIS demands constant reflexivity on the part of authors of reviews. Authors are charged with making conscientious and thorough searches, with making fair and appropriate selections of materials, with seeking disconfirming evidence and other challenges to the emergent theory, and with ensuring that the theory they generate is, while critically informed, plausible given the available evidence."

Appendix 8: Completed Search Process

This appendix illuminates the difference between the planned schedule and how the process actually unfolded. A project journal has been kept throughout the process, and dates and details from those entries and their titles have been used to promote accuracy of reporting. Appendix 6 (p.41) and its tabs will be referenced frequently.

1. Introductory Reading:

This period took place over the course of roughly 5 weeks (interspersed with approximately 4 weeks dedicated to studying an appropriate methodology), which roughly correlates to what was planned. Texts were selected based on recommendations made by lecturers and by the content of the Voice Study Centre library. The UWTSD library was not used. This stage of the search was supplemented by some Google searches to find literature that would clarify certain concepts that had arisen in the reading. One podcast was used to provide an accessible introduction to the topic and a primer for further reading. There were many points during this phase where Google was used briefly to look up definitions of certain terms.

It became apparent as I began to write that I was unsure how writers in this area of study refer to their field - this was a potential issue for both my writing and my generation of keywords for the scoping reviews. To address this some preliminary, tentative keywords were tested, restricted to the Researchgate database. These tentative keywords have been logged and a very brief summary of nature of the results given in the Introductory reading tab of appendix 6, which documents the texts, papers and other resources that were used during this stage.

2. Scoping Review:

This process took place over the course of just over a week, and is documented on the Scoping review tab of appendix 6. Some adjustments were made to the initial plan for this review as it unfolded:

- **Quantity of databases searched:** It was initially planned that several databases would be searched for the scoping review - but given the time constraints this was reduced in order to make the search process more manageable. This is documented clearly in Appendix 6 at the outset of the records, and visually represented by greying out databases that were not ultimately used.
- **Quantity of keywords searched:** Similarly, given the volume of search results a more limited number of keywords were explored. In some cases, keywords were adjusted and searched again in an attempt to get more relevant results, and also to ensure results that would be relevant to my own practice. This is noted in the relevant sheet for each topic in Appendix 6.
- **Number of topics:** After pursuing two separate topics for the scoping review, I decided not to carry out further reviews. The potential topics for further review were under-vowels and over-vowels, and strategies for passagio in the lower voice). With respect to under-vowels and over-vowels, I felt on reflection that work by Bozeman (2013; 2019a-d) and Howell (2017) from the introductory reading provided sufficient context on this to facilitate application, and further research into it may take the study in a more deeply conceptual direction, away from application. Within my practice, I teach students in the category of both upper voices and lower voices, so I felt that restricting the searches based on that might deprive the study of useful information. I also noted an overlap in studies between the first two topics of the scoping review (Vocal tract acoustics in belting and Spectrograms in singing), and felt that this indicated that a combination of the topics may be feasible.

Several aspects of the scoping review limit the credibility of the findings:

- **Incomplete displays of search results:** Google scholar only offers the first 100 pages of search results, and in some instances it was not possible to load the last two pages of results.

The discrepancy of the results found and the results displayed can be seen in the tab for each topic in Appendix 6. Researchgate offered 100 pages of results for every keyword searched, which may indicate that it operates in a similar way, but without reporting of the number of results actually found.

- **Inclusion criteria:** The relevance of articles was roughly determined by the titles and brief descriptions given in the search results - studies that looked specifically at acoustical properties, or seemed like they might give practical information or context about application or perception of the topic were selected. It was sometimes difficult to discriminate how specifically these results would contribute to a review on that topic, as for expediency materials were not screened in any other way at this stage.
- **Sole reviewer:** As this work was necessarily limited to one reviewer, there was no scope for collaborative discussion and challenges about what constituted specific or general relevance.

3. Review

Search

Appendix 6, Tab 3b. Review Protocol: search

The initial search, as documented in Tab 2a and 2b of Appendix 6 during review generated 10,431 records, of which 564 search results were selected for screening. Of this number 126 were duplicates, for a total of 438 results assessed for this stage (abstracts read, alongside articles and chapters scanned for relevant information). 140 articles were selected for relevance to the subject of resonance relative to belting - this included articles relevant to teaching belting more generally, and the use of spectrograms more generally. While 140 articles may be small by the standards of a full systematic review, there were too many resources to read thoroughly and assess for the purposes of this study, and so decisions about relevance and the refining of the topic was occurring as themes and patterns were becoming evident in the literature.

Inclusion Criteria & Quality

Appendix 6, Tab 3c. Review Protocol: Inclusion Criteria & Quality

At this stage abstracts for all articles were read, or documents were scanned through where abstracts were not available. At this point, rather than just using Tab 3c of Appendix 6 as a way to record assessments for signal and noise, it was necessary to use it as a tool to categorise and make groupings of studies to refine the focus of the study. This process took a week.

Inclusion Criteria & Quality

Appendix 6, Tab 3c. Review Protocol: Inclusion Criteria & Quality

This stage took four days. Some studies were scanned through in more detail (which can be seen by comparing the "Notes from search (3a)" cells against "Updated summary" cells). The type of literature was categorised for each record. After an initial round of sorting records for relevance (including some 89 records), I began to add tentative codes to each entry to allow a fuller idea of what information was available to support in the refinement of the topic and the creation of critiques in line with the CIS methodology. The first phase of refinement left a total of 83 records (Coloured in green), with 53 records excluded (coloured in red). Records were grouped by literature type during the selection process (namely Peer-reviewed, Articles, Conference Papers, Books, and Unclear). As 83 records was still a substantial number for a sole reviewer with significant time constraints, a further refinement was necessary. Records in the Peer-reviewed category were subject to further refinement, resulting in 30 records eligible for review. As this was still a substantial number, it was determined that some categories of literature should be omitted, namely thesis papers (16 records) and conference papers (7 records) and the "Unclear" study (1 record) as they are not peer-reviewed. Somewhat more difficult to exclude were Articles for practitioners, mostly from the Journal of Singing (9 records), and book chapters penned by researchers like

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Sundberg and practitioner-researchers (7 records). It was determined that these latter two categories would be revisited in a purposive manner in the next stage. This effectively meant that 30 records were carried on for data extraction, with a further 16 records available for purposive sampling.

Data Extraction

Appendix 6, Tab 3d. Review Protocol: Inclusion Criteria & Quality

As peer-reviewed literature is considered the highest standard possible for a study, this phase began by reading the peer-reviewed articles included in the previous stage, with priority given to articles that directly discussed either acoustics, belting, or (preferably) both. 19 studies of the 30 included in this stage met this criteria. As the data extraction phase was begun very close to the deadline for this work, once these 19 studies were read, all further literature was sampled purposively (highlighted in yellow in the data extraction sheet). This phase of reading took four days. Critiques were developed based on these studies. It was hoped that more studies could be read for inclusion but it was not possible.

Appendix 9: Imagery for belting

The link below represents an early stage of developing further resources for use in the singing studio, allowing me to learn how to compare live feedback from imaging software with reference images of belting. The images are taken from eligible studies in this work and categories by vowel, or as a generally useful image ((Bestebreurtje and Schutte, 2000; Titze and Worley, 2009; Addison et al., 2008; Barlow and LoVetri, 2010; Lebowitz and Baken, 2010; Bourne and Garnier, 2012; Sundberg et al, 2012; Sandberg and Thalén, 2015; Herbst et al., 2023).

https://drive.google.com/drive/folders/1WhsUZJI7mL3uEWp40_S34oYKmYCB0quP?usp=sharing

Appendix 10: UWTSD Guidance for Module BMPF7013

Guidance and criteria for the present study is available here.

https://docs.google.com/document/d/1yqsbRrflQU_9LNf0YhgcmiPSePu3JUUh5/edit?usp=sharing&oid=105415530379979752983&rtpof=true&sd=true