ALL TIED UP: THE EFFECT OF WEARING A NECKTIE ON ACOUSTIC AND

PERCEPTUAL MEASURES OF MALE CHORAL AND SOLO SINGING

By

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Chairperson, Dr. James F. Daugherty

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Abstract

The purpose of this study was to assess acoustically (long-term average spectra and multi-dimensional voice profile) and perceptually (participant perceived phonatory ease and expert listening panel) the effect of wearing a necktie on male singing in choral (Experiment 1) and solo (Experiment 2) settings. No study to date has assessed the potential effects of wearing neckties in both choral and solo vocal settings. Among primary results: (a) statistically significant differences in spectral energy between performances with and without a necktie in both the choral (2-4 kHz) and solo (0-10 kHz) settings, (b) increases in mean jitter and shimmer percentage measurements of solo singers with necktie, (c) significant reduction in perceived phonatory ease when singing while wearing a necktie in choral and solo settings, and (d) listener preferences for singing without a necktie in solo and homophonic choral settings. Results were discussed in terms of limitations of the study, suggestions for future research, and implications for voice pedagogy.

Keywords: necktie, choral singing, solo singing, long-term average spectra, multi-dimensional voice profile, perceived phonatory ease, expert listening panel

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Table of Contents

List of Figures

List of Tables

CHAPTER ONE

Introduction

Men wearing neckties is today an accepted, occasionally even expected, custom in various social and cultural circumstances. In the social and cultural contexts of singing performance, some male singers and some male ensembles wear neckties. Others do not.

As a matter of fashion, male necktie wear largely remains a matter of preference and choice. Aside from fashion considerations, however, males who don neckties to sing typically wrap and tie them around the neck near the larynx. To date, no controlled research study investigates if this custom potentially may have acoustical and perceived vocal efficiency consequences.

Historical Overview

Historians (e.g., Gibbings, 19990) identify emperor Shih Huang Ti (259-210 B.C.), the Chinese warlord responsible for establishing the Qin dynasty by uniting China in 221 B.C., as the possible inventor of fashionable cloth neckwear for men. As an alternative to sacrificing an entire army to accompany him in the afterlife, Shih Huang Ti commissions artisans from around his empire to craft a 7,500-piece legion of archers, foot-soldiers, cavalry, and officers from terracotta. Each unique, life-sized soldier wears a neckcloth (see Figure 1), the earliest evidence to date of male neckwear as a fashionable accessory.

Figure 1. Third century B.C. terracotta soldiers from Shih Huang Ti's terracotta army. The sculptures feature silk carefully wrapped around the necks of the soldiers.

Historians do not find evidence of another neckcloth until three centuries later when Roman emperor Marcus Ulpius Trajanus (53-117 A.D) erects his famous Column of Trajan depicting key military victories against the Dacians. Some soldiers on the engraved column wear neckcloths tied in an assortment of ways (Gibbings, 1990).

The extent of neckcloth wear in the ancient world, however, remains a slightly perplexing topic. No other Chinese art from the Qin dynasty portray soldiers wearing a neckcloth, and according to some Roman writers and 19th century historians, only the sickly or effeminate men wore neckcloths (Le Blanc, 1828). Gibbings (1990) speculates as to why emperors would want to depict their soldiers with neckcloths: to tell the world how special they are. The neckcloth embodies the glory of being the emperor's guard in death and thus a badge of honor in life. However, soon after Trajan, the tradition of neckwear as a mark of distinction appears to continue only in the religious orders of Asia and Europe until its resurfacing in the common fashion of 16th and 17th century Europe.

The wealth of Renaissance European fashion brings with it a juxtaposition of extravagance and rigid conservatism. Brilliant colors, jewelry, and feather hats become commonplace among the gentry while the Puritans and others condemn such excess (Le Blanc, 1828). As a result, gentlemen find an alternative in neckwear. Fine linens and laces (particularly from Flanders and Venice) worn around the neck portray a man's wealth, but do not advertise it so flamboyantly. Therefore, the silk cravat (see Figure 2) becomes commonplace in high society by the reign of Louis XIV of France (1643-1715) (Le Blanc, 1828).

Figure 2. Thomas Amaulry's depiction of a man wearing the heavy Venetian lace cravat popularized under the reign of Louis XIV of France.

Although a French poet in the 14th century employs the word "cravat" to describe neckwear, the term is not commonplace until the middle of the 17th century (Gibbings, 1990). The cravat reigns as the most popular neck adornment from the middle of the 17th century until the middle of the 19th century. To reflect the changes in fashion, various tying methods and material choices (see Figure 3) cycle in and out of style (Le Blanc, 1828).

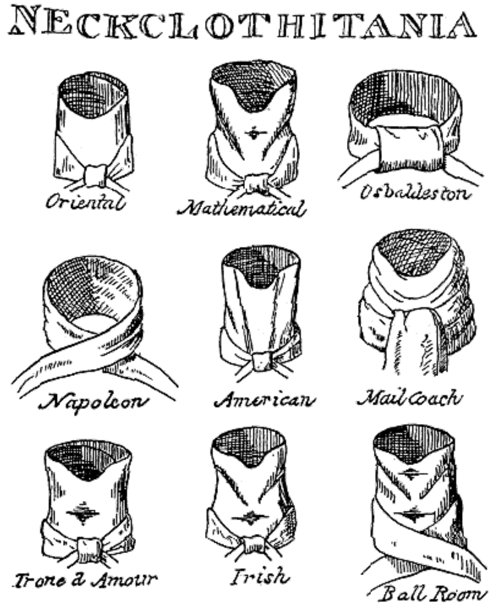

Figure 3. A graphic from the early 19th century satirical pamphlet *Neckclothitania* displaying a range of methods for tying a cravat.

Towards the end of the 17th century, the cravat travels across the Atlantic to the Americas where neckwear follows its own course of development. The southern plantation tie and bandana are common variants on cravats in the Americas throughout the 18th and 19th century (Earle, 2009).

Midway through the 18th century, neckscarfs and bowties replace cravats as the dominant neck piece, joined by ascots a few decades later (Cunnington & Cunnington, 1973a). Historians often cite Charles Dickens (1812-1870) for the advancement of the new gentlemanly style during this time (Gibbings, 1990). Tying variations continue to evolve, including the introduction of the four-in-hand knot that is still in common use today (see Figure 4).

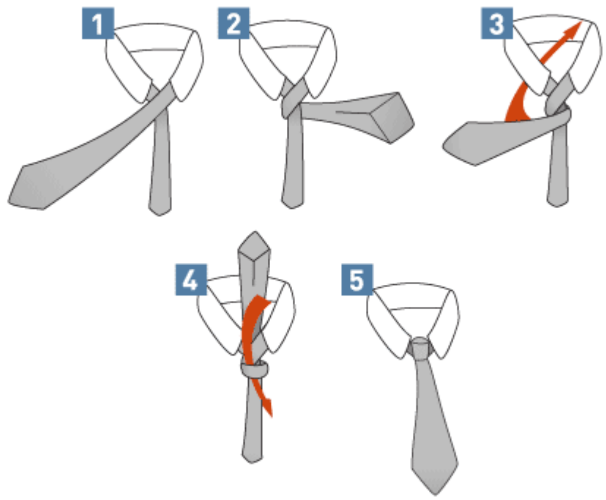

Figure 4. Four-in-hand knot still commonly used today for tying neckties.

In 1924, following the global conflict of The Great War, New Yorker Jesse Langsdorf revolutionizes the necktie (A brief history of, 2008). He is responsible for inventing and patenting the Resilient Construction method of tie manufacturing that causes the tie to lie flat (see Figure 5) against the wearer's chest instead of twisting (Gibbings, 1990). Langsdorf achieves this end by cutting the original material on a 45° bias instead of straight down the material (Gibbings, 1990).

Figure 5. Modern bias-cut neckties designed to lie flat against the wearer's chest.

After Langsdorf's patent in 1924, neckties on the whole remain the same. Variations in width, pattern, and colors change with fashion sense, but the necktie continues as a staple of business fashion globally. In 2008, *Time* magazine estimates that U.S. citizens gifted 4.5 million ties to their fathers for Father's Day (A brief history of, 2008). In 1979, Iran condemns the necktie as a symbol of Western decadence and bans it from being sold. The ban is still in effect today, but enforcement is inconsistent (Dehghan, 2012).

Neckties Used as Today's Singing Attire

Fashion for men in modern society can be variable from year to year. Deciding concert attire as a musician, particularly a singer, creates an interesting intersection of considerations: (a) tradition, (b) fashion, (c) uniformity, and (d) perceived formality. Western classical music depends highly on the perpetuation of tradition. Therefore, it is understandable that a singer's garb would also reflect certain traditions in the classical music world. In the 17^{th} and 18^{th} centuries, the primary arena for secular music exists in the courts of royalty (Ranum, 1987). While comparatively well paid, court musicians very much live within the expectation of servitude (Ahrens, 2010). To maintain semblance to the height of European fashion, these court musicians likely donned cravats frequently. This tradition continues today as characterized by the formal attire of many professional symphony musicians (and their accompanying choruses).

While remaining faithful to tradition, male singers (or whoever is responsible for selecting attire) typically consider what is fashionably appropriate. For example, donning a bolo tie would almost certainly be deemed inappropriate when performing the last movement of Beethoven's Ninth Symphony. Moreover, uniformity is a consideration that chiefly arises for choruses. In general, choruses most often strive for homogeneity across singers.

Performance attire changes are easily observed in the male professional symphony chorister and are dependent on the perceived formality of the event. The most formal attire worn by a male singer is a tailcoat and white bowtie (Symchych, 2014). However, this attire is usually only appropriate in the evenings excluding Sundays. The next tier of formality consists of the black tux with black bowtie and cummerbund, or a black tie and vest. Some semi-professional choruses will adopt the latter citing the impracticality of wearing tails while seated or the likelihood of young singers already having this available in their closets (Symchych, 2014) (see Figure 6).

Figure 6. A professional symphony chorister's attire featuring a black bowtie. Photograph by Thor Liland Larsen (retrieved from Flickr Creative Commons).

It is common for white jackets to replace black tux jackets in outdoor performances during the summer (Symchych, 2014; Watts, 2014). Sunday matinee performances are the most informal as some choruses insist that formalwear as described above is inappropriate for that setting. Male singers are instead asked to wear dark suits and normal neckties. Given the decreased perceived formality of public school choruses, it is common to see the introduction of colored vests or various ties to the established dress code (see Figure 7). It is uncommon to see a chorus perform in any setting without the males wearing some sort of tight-fitting neckwear unless they are wearing choir robes.

Figure 7. Middle school chorus attire assorted neckties. Photograph by Jagrap (retrieved from Flickr Creative Commons).

Outside of costumed performance, male solo singers typically have more variety of choice when it comes to performance attire—including whether or not to wear a tie (see Figure 8). However, consistency of practice varies here, as well. Wolf Trap Opera Company suggests that for an audition a male performer should "probably" wear a bold color tie accompanying a nice shirt and suit jacket—specifically asking that singers leave their cravats at home (KPW & Rahree, 2009). Singer and fashion consultant Joseph Gualtiere (2013) is more insistent on the presence of a necktie in auditions. He instructs singers to "Choose the right tie, and make sure it's tied properly, letting it fall to your belt buckle, but not below it, and make sure it's not too short" and further suggests that bowties should be reserved for afternoon brunch (Gualtiere, 2013).

A resource for Boston-area singers suggests that singers bring a necktie with them to an audition in case all the other singers are also wearing neckties (Angelajajko, 2013). Lastly, an article sponsored by the Kennedy Center suggests that the decision to wear a necktie depends on the genre of the audition. Opera and oratorio auditions require a suit and tie; however, it is suitable to forgo the tie for music theater auditions (Hagen, *n. d.*).

Figure 8. Famous operatic baritone Simon Keenlyside performing with and without a necktie in the same recital.

Need for the Present Study

To date, very little empirical research examines potential acoustical and physiological effects of what vocalists wear while singing. Rollings (2014, 2015) provides extensive examination of the postural and acoustical effects of female solo singers wearing high-heeled shoes. A pilot study by Edwards (2015) measures spectrally the timbre or tone quality of a male chorus with and without neckties.

No study, however, yet investigates necktie wear among male singers in both solo and choral singing contexts using a variety of acoustical and perceptual measures. Results of such a study could interest male singers, voice teachers, and choral conductors as they make decisions about necktie wear when singing.

Purpose of the Study

The purpose of this study was to assess acoustically (long-term average spectra and multi-dimensional voice profile) and perceptually (perceived phonatory ease and expert listening panel) the effect of wearing a necktie on male singing in choral (Experiment 1) and solo (Experiment 2) settings.

Research Questions

The following research questions guided this investigation.

1. What differences, if any, do acoustic (long-term average spectra) and perceptual (perceived phonatory ease and expert listening panel) measures indicate about males singing with and without a necktie in a choral setting? (Experiment 1)
2. What differences, if any, do acoustic (multi-dimensional voice profile and long-term average spectra) and perceptual (perceived phonatory ease and expert listening panel) measures indicate about males singing with and without a necktie in a solo setting? (Experiment 2)

Definitions

Jitter. Jitter is a measure of short-term, cycle-to-cycle variability in fundamental frequency.

Long-term average spectra (LTAS). Long-term average spectra data consist of the mean amplitude of each harmonic of a complex sound across a given time period. Thus, they can be useful for identifying persisting spectral events.

Multi-Dimensional Voice Program (MDVP). MDVP is one of numerous software vocal assessment tools developed for the Computerized Speech Laboratory by KayPENTAX. In this study, it is employed to measure jitter and shimmer percent.

Shimmer. Shimmer measures amplitude perturbation, caused by vibratory variations from one vocal fold cycle to the next.

CHAPTER TWO

Review of Literature

As no study to date has assessed the potential effects of neckties in both choral and solo vocal settings, the first group of empirical studies reviewed in this chapter investigated how wearing a necktie could be linked to the medical considerations of performance anxiety, neurocardiogenic syncope, sensory defensiveness, laryngeal height, and jugular venous compression. The second, comparatively smaller, group of studies examined the potential effects of necktie use on intraocular pressure and range of motion. A concluding section of this literature review considers procedures and results of a single pilot study to date that has explored the matter of male necktie wear while singing.

Medical Considerations

Performance anxiety. As singers in performance scenarios often wear a necktie, there exists a compounding effect of performance anxiety. Iltis (2012) defined music performance anxiety (MPA) as a variant of state and trait anxiety experienced by performers in circumstances the human body perceives as threatening. According to Patestas and Gartner (2006), in these situations a branch of the performer's autonomic nervous system known as the sympathetic nervous system triggers a "fight or flight" response. They continued, describing that the sympathetic nervous system innervates a number of structures within the body causing a series of phenomena to occur including: (a) release of sweat from eccrine sweat glands, (b) release of epinephrine from the suprarenal medulla, (c) vasoconstriction of blood vessels of skin/mucous membranes and abdominal viscera causing a raise in blood pressure, (d) accelerated heart beat by the sinoatrial node of the heart, (e) increased force of contraction of the ventricular myocardium, and (f) relaxation of bronchial smooth muscle (Patestas & Gartner, 2006).

Fishbein, Middlestadt, Ottati, Straus, and Ellis (1988) surveyed 2,212 members of the International Conference of Symphony and Opera Musicians (ICSOM) to assess the status of self-reported, major medical problems among its membership. Nearly a quarter (24%) of those surveyed reported experiencing MPA before a performance with 16% of the sample reporting MPA as a severe problem. The researchers identified medication as the most common method of treating MPA. Of those surveyed, 27% reported having used some kind of beta-blocker before performance situations, most (70%) doing so without a doctor's consent. Participants reported their reasons for taking beta blockers: 72% before auditions, 52% before solo recitals, 50% before difficult orchestral performances, and 42% before concerto performances. From these responses, the researchers concluded that MPA is more common in solo scenarios, but still very present in large group performances.

The overall effects of anxiety on the outcome of task performance have also been examined. Two schemas have emerged from these studies that suggest MPA may not be entirely debilitating. Yerkes and Dodson (1908) first introduced the inverted-U hypothesis. This concept stated that at low levels of arousal, an individual's performance would be below par and subsequently increase as arousal reached an optimal point. Beyond that point, performance would begin to decline. Hanin (1978) expanded upon this approach to suggest that each person operated in an Individual Zone of Optimal Functioning (IZOF) and responded differently to anxiety. Fazey and Hardy's (1988) catastrophe model has been used in a few studies to describe the relationship between anxiety and performance (Hardy & Parfitt, 1991). Researchers have concluded that in a series of tasks, the introduction of anxiety would result in maximum performances being higher and minimum performances being lower. The researchers noted a more pronounced phenomena with participants under high cognitive anxiety conditions.

Researchers have studied the scenarios most conducive to MPA. Cox and Kenardy (1993) surveyed music students (*N*=32) to assess the role of performance setting. The researchers found that participants believed solo settings created the most anxiety, followed by group settings, then practice settings. Level of experience had no significant relationship with these findings. LeBlanc, Jin, Obert, and Siivola (1997) found increased self-reported anxiety of high school band members (*N* = 27) in public solo performance as opposed to private solo practice. Heart rate also increased significantly in public solo performances. Brotons (1994) observed changes in heart rate and state anxiety in undergraduate and graduate music students (*N* = 64) performing with and without musical evaluation. The researcher found significant increases in heart rate and state anxiety in participants under musical evaluation.

Lehrer, Goldman, and Strommen (1990) surveyed musicians of a variety of experience levels (*N* = 238) to discover possible determining factors for MPA. The researchers found five interpretable orthogonal factors in their analysis: (a) planning for coping with anxiety, (b) judgmental attitudes about one's performance, (c) worry about anxiety and its effects on performance, (d) concern with the reactions of others to the performance, and (e) concern with distraction during the performance.

The potential effect of anxiety on fine motor skills has been examined (Meulenbroek, Van Galen, Hulstijn, Hulstijn, Bloemsaat, 2004; Weinberg & Hunt, 1976). Researchers have concluded that co-contraction of muscles and increased energy consumption occurred in participants in stressful conditions. Yoshie, Kudo, Murakoshi, and Ohtsuki (2009) tested this concept with concert pianists (*N* = 18). Participants performed challenging piano sonatas in rehearsal and competition conditions. Researchers measured heart rate, sweat rate, surface electromyographic (sEMG) activity of upper extremity muscles, and state anxiety across conditions. All measures increased from rehearsal to competition conditions. Researchers noted higher levels of the sEMG magnitude of proximal muscles and the co-contraction of forearm antagonistic muscles. The authors concluded that this response could adversely influence pianists by disrupting fine motor skills.

Lorenz (2002) explored potential effects of incorporating Alexander Technique on MPA in a choral ensemble ($N = 22$). In state anxiety responses, participants largely reported findings similar to the instrumental ensembles discussed above. Participants reported MPA levels being highest in audition and solo conditions, and reported symptoms such as general nervousness, worry, increased perspiration, dry mouth, and shortness of breath. Lorenz reported inconclusive results regarding the effect of the Alexander Technique intervention. In another study involving MPA and choirs, Ryan (2009) surveyed semiprofessional choristers ($N = 201$) regarding their experience with MPA. The researcher found MPA to be common amongst participants, especially in solo performances. Choristers with college music training reported less frequent episodes of performance anxiety. Lastly, the conductor emerged as one of the primary factors associated with increased MPA for choristers with 84% responding positively. When asked why, participants noted that perceived conductor anxiety, negative mood, and weak conducting/rehearsal skills informed their opinion.

Kokotsaki and Davidson (2003) investigated the presence of MPA in a specific population of second and third year conservatoire voice students ($N = 43$; $n = 21$ second year; $n = 22$ third year) preparing and performing end of term juries. Participants completed Spielberger's State-Trait Anxiety Inventory (STAI) that measures state anxiety (Y-1) and trait anxiety (Y-2) with two different questionnaires. The researchers administered Y-2 two weeks before the jury date and Y-1 ten minutes prior to performance (pre-performance), immediately following performance (during-performance), and fifteen minutes after performance (post-performance). Results indicated that, in this sample, female participants exhibited more state and trait anxiety compared to norms in anticipation of the jury. Additionally, the researchers found a proportional relationship between state and trait anxiety. Lastly, the researchers found that the more advanced students performed better under the anxious jury conditions than those with less experience.

Sandgren (2009) explored the extent to which psychological and voice-related variables would be related to performance and health anxiety in Swedish opera singers ($N = 49$). Participants completed a questionnaire that addressed occurrence of performance anxiety, somatic symptoms, psychological symptoms, health promoting strategies, and operatic experiences. The researcher found that psychological and voice-related variables were significantly correlated with MPA determinants. These included fear of vocal indisposition, worry about disapproval, and doubts about one's abilities. Participants that reported higher levels of performance anxiety also reported increased levels of MPA determinants. The author concluded that singers, unlike instrumentalists, reported a higher level of anxiety due to the added concern of vocal health.

Neurocardiogenic Syncope. Chen-Scarabelli and Scarabelli (2004) and Brignole, et al. (2001) defined neurocardiogenic syncope as a transient loss of consciousness due to a triggered neural reflex resulting in systemic hypotension causing bradycardia and peripheral vasodialation. The authors then identified a variety of stimuli that may trigger neurocardiogenic syncope. These stimuli included panic, fright and tight collars. The potential effects of panic and fright have already been addressed in this chapter. Singers in performance settings could experience neurocardiogenic syncope due to a tight necktie triggering the carotid sinus reflex.

In their chapter on carotid sinus hypersensitivity, Parry and Kenny (2008) described how carotid sinus stimulation can result in bradycardia, vasodialation, and eventual syncope. The authors subsequently discussed how prolonged standing has also been associated with carotid sinus reflex. One might infer from these experiments that choristers standing on risers could be at higher risk of injury if syncope occurred.

Sensory defensiveness. Wilbarger and Wilbarger (1991) defined sensory defensiveness as a negative reaction to certain sensory inputs (i.e., tactile, vestibular, auditory, visual, gustatory, olfactory, or proprioceptive). Researchers have suggested that articles of clothing could be considered a trigger for individuals with tactile sensory defensiveness (Kinnealey, Oliver & Wilbarger, 1995; Pfeiffer & Kinnealey, 2003).

Wilbarger and Wilbarger (1991) established definitions for three levels of sensory defensiveness in children. For level one, mild, the researchers proposed that a child could appear 'normal' despite demonstrating avoidance of certain stimuli. Level two, moderate, included additional debilitating effects of sensory defensiveness. Included in level three, severe, the researchers acknowledged the potential for additional diagnostic labels (e.g., developmentally delayed, autistic) being given to the child to encompass the total effect of sensory defensiveness. Stagnitti, Raison, and Ryan (1999) expanded upon the original level definitions to create a clearer distinction between individuals with 'pure' sensory defensiveness and those with mental disorders that maintained similar clinical features. The researchers preserved levels one and two from Wilbarger and Wilbarger (1991), and placed them in their own category as representative of 'pure' sensory defensiveness. The second category then broadened the original level three into the specific diagnosed conditions (i.e., Fragile X, developmental delay, autism spectrum disorder, attention deficit disorder, and cerebral palsy). This distinction is necessary as the author notes not all diagnosed conditions would benefit from sensory defensiveness therapy.

In a literature review of six qualitative studies, Abernathy (2010) further dichotomized sensory defensiveness as it presented itself in adults both with and without a mental disorder. In both cases however, Abernathy concluded that the debilitating effects of sensory defensiveness could be improved with therapeutic intervention. One of these studies (Kinnealey, Oliver, & Wilbarger, 1995) interviewed five adults with sensory defensiveness and analyzed their responses to identify how sensory defensiveness affected their daily lives. All five participants discussed tactile sensory defensiveness in some regard. Furthermore, two of the participants commented specifically about discomfort with clothing or jewelry around their neck.

Two studies (Kinnealey & Fuiek, 1999; Pfeiffer & Kinnealey, 2003) linked sensory defensiveness with anxiety in adult subjects. Kinnealey and Fuiek (1999) compared participants' (n = 16 sensory defensive; n = 16 non-sensory defensive) scores on the IPAT Anxiety Scale. The researchers found a significant difference in anxiety scores between the two groups with the sensory defensive group scoring higher. Pfeiffer and Kinnealey studied the potential change in anxiety levels across sensory defensive participants (N = 15) after administration of a sensory integration treatment protocol. Prior to treatment, participants' mean scores reflected a mild anxiety level using the Beck Anxiety Inventory. Following the treatment protocol, the participants' mean scores significantly decreased and categorized as minimal anxiety.

Vertical laryngeal position. Pehlivan and Denizoglu (2009) summarized the physiological findings and phonatory advantages of phonating with a low vertical laryngeal position (VLP). Physiological findings of research studies reviewed included (a) thicker vocal folds, (b) loosened cover tissue of vocal folds, (c) thyroarytenoid muscle relaxation, (d) hypopharyngeal enlargement, (e) vocal tract elongation, (f) palatal rise and tongue depression, and (g) a decrease in extraneous tension in neck in shoulders. Some phonatory advantages listed included (a) lowered fundamental frequency, (b) increased closed quotient, (c) increased vocal intensity, (d) increased resonating volume, and (f) easier facilitation of abdominodiaphragmatic respiration.

Recognizing the benefits of phonating with a low VLP, Pehlivan and Denizoglu set out to created a laryngoaltimeter for use in therapy exercises and voice lessons. The researchers took two condenser microphones and attached one on the suprasternal notch and the other in the supraglottic region to capture corresponding vibrations during phonation. After filtering, the device produced audio and visual signals to act as biofeedback to the singer. In a pilot for the study, researchers tested the device at 87% accuracy across participants ($N = 13$) of various voice classifications.

Given the location of a tied necktie just below the resting point of an individual's larynx, freedom of laryngeal motion may be compromised at rest and during phonation. Brasil, Yamasaki, and Leão (2005) developed a method of measuring VLP at rest. Researchers measured healthy, young adult participants' ($N = 68$; $n = 33$ female, $n = 35$ male) resting VLP by use of a compass and ruler. While asking participants to sit down and lift their heads to maximum hyperextension, researchers used right and left mandible, center of cricoid cartilage arch, and sternal fuculum as anchors for their measurements. In this sample, the researchers found female larynges to rest significantly higher than male larynges. This procedure constituted a practical and accurate method of measuring laryngeal height. The researchers concluded that this method of measuring VLP could produce an interesting parameter in individuals with muscle tension dysphonia.

Lowell, Kelley, Colton, Smith & Portnov (2012) found a higher VLP in individuals with muscle tension dysphonia (MTD). The researchers obtained radiographic measurements of age and sex matched participant ($N = 20$; $n = 10$ MTD, $n = 10$ control) groups during three tasks: (a) resting state, (b) sustained phonation, and (c) swallow-hold maneuver. The researchers normalized measurements for participants to reflect changes from rest during phonation. During phonation, researchers found significantly higher VLP for participants with MTD compared to the control.

Guzman, Castro, Testart, Muñoz, and Gerhard (2013) also examined VLP in participants ($N = 20$) with MTD. The researchers measured VLP, anterior-to-posterior laryngeal compression, and pharyngeal width, as they were affected by eight semioccluded vocal tract exercises: (a) lip trills, (b) hand-over-mouth, (c-f) phonation into four different tubes, and (g-h) tube phonation in water at two different depths. Reinforcing the benefits of low laryngeal posture, the researchers found all semioccluded techniques produced a lower VLP, narrower aryepligottic opening, and a wider pharynx.

Other variables have been linked with VLP including (a) pitch, (b) vowel, (c) and lung volume. Through use of a multi-channel electroglottograph (EGG) Pabst and Sundberg (1992) measured VLP in singers ($N = 8$; $n = 2$ sopranos; $n = 1$ mezzosoprano; $n = 1$ tenor-baritone; $n =$ 4 baritone). Researchers gathered data from several vocal exercises including (a) sustained tones, (b) ascending and descending legato scales, (c) pitch leaps, (d) triad patterns, (e) *messa di voce*, (f) and a repeated scale pattern for as long as possible. The researchers found that VLP behavior varies between voice classifications and to some extent within singers themselves. However, the researchers noted trends associated with a higher larynx with lower lung volume, higher pitches, and [i] vowels. The researchers performed no statistical tests to identify significant changes given the small sample size.

Shipp (1975) examined VLP in discrete (scalar) and continuous (glissando) exercises by measuring electromyographic activity in the thyrohyoid, sternothyroid, cricothyroid, thyroarytenoid, and posterior cricoarytenoid muscles and deviations from resting position. Male participants ($N = 6$) remained supine throughout the procedures. The researchers concluded that in general participants raised their larynges for higher fundamental frequencies and lowered their larynges for lower fundamental frequencies. Additionally, researchers found more pronounced changes in VLP during the continuous exercises.

Iwarsson and Sundberg (1998) evaluated the potential effect of lung volume, pitch, and loudness of voice on VLP in vocally untrained participants ($N = 29$; $n = 16$ males; $n = 13$ females). Researchers used a multi-channel EGG to measure VLP and two respibands (rib cage and below navel) to measure lung volume. Participants repeated the syllable [pæ] starting at maximum lung volume and continuing until they ran out of breath. Then, participants repeated the procedure at medium, high, and low pitch and with medium, soft, and loud phonation. The researchers found that high lung volume was significantly associated with a lower larynx position as compared to low lung volume. Additionally, researchers identified a strong correlation between pitch and VLP. Loudness as a factor by itself did not show significance. Lastly, lung volume and pitch showed a stronger dependency in male participants.

Sundberg and Nordström (1976) explored the potential effect of VLP on vowel formant frequencies. Participants ($N = 2$; $n = 1$ phoniatrician; $n = 1$ singer) demonstrated a developed control over the position of their larynges. Using normal speaking pitch, participants sustained twelve Swedish vowels ([u], [o], [a], [ɑ], [æ], [ɛ], [e], [i], [y], [ɥ], [ø], and [œ]). Through the use of a spectrogram, researchers estimated first, second, third, and fourth formant frequency locations. While phonating with a raised larynx, participants produced (a) a substantial rise in the second formant frequency in high front vowels, (b) a rise in both the fist and second formant frequency in open vowels, and (c) a combined rise in several vowels of the third and fourth formant frequencies. Additionally, the researchers noted that this rise in formant frequencies could be identified in long-term average spectra of phonations with raised and lowered larynx.

Jugular venous compression. Three studies have analyzed the potential effect of jugular venous compression via the placement of different apparatuses around the neck. Hatt, Chang, Tan, Sinkus, and Bilston (2015) examined cerebral cerebrospinal fluid (CSF) hydrodynamics and brain tissue stiffness of supine participants (*N* = 9) with and without bilateral jugular compression. The authors achieved jugular compression by fastening an 8-cm wide elastic bandage around participants' necks. The researchers measured cerebrally CSF hydrodynamics and brain tissue stiffness with magnetic resonance elasography (30-Hz sinusoidal vibration frequency).

Results indicated that the mean percentage of jugular venous flow (PJVF) of participants with jugular compression decreased significantly, triggering excess blood to be rerouted to extrajugular pathways (spinal). Arterial blood flow, however, remained constant through compression. Caudal CSF velocity increased significantly under jugular compression while cranial CSF velocity did not. Brain tissue stiffness increased in participants with higher PJVF during jugular compression.

Frydrychowski, Winklewski, and Guminski (2012) measured pial artery pulsation, cerebral blood flow velocity (CBFV), and subarachnoid width in 19-30 years old male participants (*N* = 32; *n* = 10 first group, *n* = 22 second group) under bilateral jugular compression in two postural positions. The authors achieved jugular compression with the use of a sphygmomanometer placed around the neck of the participants and pumped to the pressure of 40 mmHg. The authors measured subarachnoid width and pial artey pulsation using near-infrared transillumination/backscattering sounding and CBFV using transcranial Doppler. The two groups followed different procedures. Both groups began by sitting upright for ten minutes with their head swayed to the back at 20°, then entered the Bend Over Position (BOPT) assuming a 45° bend forward. The first group began three minutes of jugular compression three minutes after assuming BOPT posture. The second group returned to the initial position three minutes after assuming BOPT. Three minutes of jugular compression began three minutes after resuming initial posture.

Jugular compression in the first group caused a decrease in subarachnoid width, an increase in CBFV, and pial artery pulsation remained constant. However, in the second group, jugular compression caused an increase in pial artery pulsation and CBFV, but insignificant changes in subarachnoid width. The hyperkinetic cerebral circulation caused by the jugular compression creates a hazardous environment for the brain microcirculation which potentially links jugular outflow insufficiency with small vessel arterial cerebral disease.

Myer, et al. (2016) analyzed the potential effect of a jugular vein compression collar on head impact exposure and brain microstructure response in high school football players. Researchers evaluated participants' (*N* = 62; *n* = 30 control, *n* = 32 collar) measurements before and after one football season. The researchers also instituted controls for consistency of data collection throughout the study. An MRI using diffusion tensor imaging (DTI) and a GForce Tracker (GFT) measured changes throughout the season.

The researchers found that the application of the collar in the experimental group accounted for a significant increase in jugular vein size above the level of the collar. The increase was noted to be not as drastic as what occurs during the Valsalva maneuver. Although both groups experienced similar overall g-forces and head impact exposure, researchers only found significant changes in mean diffusivity, axial diffusivity, and radial diffusivity of white matter integrity in the control group. Additionally, the control group demonstrated significantly larger DTI changes in white matter regions than the collar group. Therefore, collar wearing may have provided a protective effect against brain microstructural changes after repetitive head impacts.

Necktie Studies

Intraocular pressure. A series of studies (e.g., Teng, Gurses-Ozden, Liebmann, Tello, & Ritch, 2003; Theelen, et al, 2004, etc.) have associated the potential effect of tight neckties with changes in intraocular pressure. Researchers hypothesized that jugular constriction leads to an increased episcleral venous pressure and subsequently intraocular pressure (IOP), a common risk factor for glaucoma. However, as Jonas (2005) remarked, increased IOP may be countered by an increase in intracranial pressure, therein eliminating the risk for glaucoma.

Teng, Gurses-Ozden, Liebmann, Tello, and Ritch (2003) first explored the potential link between neckties and intraocular pressure. An examiner took simultaneous IOP readings in both eyes of participants ($n = 20$ normal; $n = 20$ glaucoma) seated in a slit lamp position wearing an open collar. The examiner then tightened a necktie around each participant to the point of slight discomfort and waited three minutes before taking IOP readings again. After loosening the neckties and waiting another three minutes, the examiner took a final IOP reading.

Both participant groups experienced statistically significant ($p < .05$) increased mean IOP after wearing a necktie for three minutes. Given elevated IOP's relationship with glaucomatous damage, Teng, et al. concluded that a tight necktie could affect the diagnosis and management of glaucoma.

Results from subsequent studies have both supported and refuted findings from Teng, et al. (2003). Bozic, Hentova-Sencanin, Brankovic, and Sencanin (2012) replicated the procedure of Teng et al. (2003) with the added control of age across participants (n = 20 normal; n = 20 glaucoma). The researchers found significantly different mean IOPs between groups in all three measurements, consistent with the previous study. Additionally, the researchers found higher variability across scores in the glaucoma group compared to the normal group. However, only six normal participants and five glaucoma participants showed an increase in IOP while wearing a tight necktie, which is in opposition to the statistically significant amount of participants in the previous study.

Theelen et al. (2004) controlled for a variety of potentially confounding variables including age, sex, body mass index, and neck circumference across participants (N = 23 normal). The researchers assessed IOP across four conditions: (a) without a necktie sitting upright, (b) with tight necktie sitting in a slit lamp position, (c) with a tight necktie sitting upright, (d) without a necktie sitting in a slit lamp position. Results showed that mean IOP only significantly increased between without a necktie sitting upright and with a tight necktie sitting in a slit lamp position. The researchers noted a trend towards higher IOP in participants wearing a necktie, but the divergence lacked statistical significance. The researchers concluded with the potential effect of sitting position on IOP measurement and refuted the hypothesis that a tight necktie could be a risk factor for glaucoma.

Talty and O'Brien (2005) hypothesized that while an increase in IOP may occur within three minutes of tightening a necktie, auto-regulatory responses could return IOP to baseline levels. Participants (*n* = 18 normal; *n* = 19 normal) followed the exact same procedure as in Teng, et al. (2003) with an additional reading taken after 15 minutes of wearing a necktie.

Although the mean IOP increased in both groups after three minutes wearing a necktie, only the glaucoma mean IOP increased significantly. Similarly, mean IOP decreased by the fifteen-minute mark for both groups, but only significantly for the glaucoma group. An opposite result occurred three minutes after removing the necktie when mean IOP significantly decreased for the normal group, but only minimally in the glaucoma group. The authors conclude that tight neckties worn for an extended period of time are not a risk factor for glaucoma likely due to auto-regulatory responses shortly after putting on the necktie. They further conclude that these auto-regulatory responses may be inhibited slightly due to glaucomatous damage.

Range of motion/Muscle activity. Yoo, Kim, and Yoo (2011) assessed the potential effects of wearing a tight necktie on cervical range of motion and upper trapezius muscle activity. Participants (*N* = 30) consisted of computer workers seated erectly in two conditions: with and without a necktie. The researchers achieved consistency of necktie tightness by tightening a zipper necktie to 95% of the measured circumference of each participant's neck. The researchers used a Cervical Range of Motion (CROM) instrument to measure right and left rotation, flexion, extension, and lateral flexion. Researchers used sEMG to measure upper trapezius muscle activity. The researchers collected CROM data before participants completed any computer work, and then collected sEMG data while participants completed ten minutes of computer work.

Results indicated a significant decrease in neck flexion, neck extension, and lateral flection of participants' cervical range of motion when wearing a necktie compared to without. Additionally, researchers found significantly increased upper trapezius muscle activity while working with a necktie compared to without.

Pilot study. Edwards (2015) assessed the potential effects of wearing a necktie on acoustic and perceptual measures of an all-male (TTBB) choir. The researcher used an established choir of male singers ($N = 16$) from a large Midwestern university. Choristers included undergraduate singers from a variety of majors and one graduate music student. Each voice section consisted of at least three singers thus allowing the potential for a chorusing effect.

The researcher split the singers into two equal groups. Singers performed the Renaissance motet "If ye love me" by Thomas Tallis in four different conditions: (a) Condition 1: All singers not wearing a necktie; Condition 2: Group 1 wearing a necktie; Condition 3: Group 2 wearing a necktie; Condition 4: All singers wearing a necktie.

Immediately following Conditions 2 and 3, participants completed a brief, one-item questionnaire addressing perceived phonatory effort (PPE) by means of a visual analog scale anchored by "Minimum Vocal Effort" and "Maximum Vocal Effort." The researcher compared participant's scales and calculated the total change in PPE for each singer with and without a necktie. A majority of participants ($n = 12$) experienced an increase in vocal effort when singing while wearing a necktie. The remaining participants either experienced a decrease ($n = 3$) or no change ($n = 1$) in vocal effort when singing while wearing a necktie. Participant responses ranged from a minimum of 16.38% (without a necktie) vocal effort to 91.5% (with a necktie) vocal effort. A paired, two-tailed *t*-test found a statistically significant increase between perceived vocal effort while wearing a necktie versus without a necktie. Total PPE increased by an average of 12.78%.

The researcher created equal-length recordings for each of the four conditions and analyzed them using long-term average spectra as an acoustical measure of timbral changes. Each recording where at least a portion of the choir wore a necktie demonstrated a rise in average signal amplitude over the recording with no singers wearing a necktie. The greatest difference (.91 dB) occurred in the condition where all singers wore a necktie. A paired, two-tailed *t*-test found statistically significant increases in the signal amplitudes of the full-necktie condition compared to no necktie ($p < .05$).

CHAPTER THREE

Method

The purpose of this study was to assess acoustically and perceptually the potential effects of wearing a necktie on males (*N* = 60) singing in two contexts: choral singers (*n* = 30) and solo singers (*n* = 30). This chapter describes the research design, independent and dependent variables, procedures, equipment, and data analyses pertinent to this study.

Experiment 1: Choral

Participants

Choral participants (*n* = 30) constituted an established university male chorus from a large Midwestern collegiate music program. The choir maintained established TTBB voicing (*n* = 6 tenor I, *n* = 6 tenor II, *n* = 10 baritone, *n* = 8 bass). Choral participants ranged in age from 18 to 32 years of age (*M* = 20.67 years, *SD* = 2.60 years). All choral participants identified themselves as an undergraduate or (*n* = 29) graduate student (*n* = 1). Choral participants wore a necktie approximately 1-2 times per month as part of the performance attire requirement. When asked how often they wore a necktie, choral participants responded seldom/rarely (*n* = 8), 1-3 times a month (*n* = 6), for concerts (*n* = 4), not often (*n* = 3), 1-3 times a week (*n* = 5), and fairly often/regularly (*n* = 4). Some choral participants (*n* = 10) self-reported vocal production issues (e.g., allergies, sickness) on the day of data collection.

Expert listening panel participants (*N* = 9) consisted of university choral faculty (*n* = 3), high school choral faculty (n = 2), and choral graduate teaching assistants (*n* = 4). Expert listening panel participants ranged in age from 23 to 67 years (*M* = 40.67 years, *SD* = 17.22 years). Expert listening panel participants' years of choral experience ranged from 10 to 50 years (*M* = 27.33 years, *SD* = 15.88 years). To further confirm a rich history of choral experience, participants provided information regarding their choral singing, directing, adjudicating, and clinic experience. Collectively, participants reported experience in the public school, collegiate, community, and professional contexts.

An Institutional Review Board (IRB) approved the first experiment portion of this study prior to beginning data collection (see Appendix A). Participants consented to the study after listening to a prepared consent script (see Appendix B).

Procedures and Equipment

Musical excerpt. Choral participants performed *a cappella* the motet "If ye love me" by Thomas Tallis. The high level of familiarity the ensemble maintained with the piece and its contrasting homophonic and polyphonic sections informed my selection of this particular motet. Choral participants had recently performed the piece in a concert setting and could also perform it memorized. The choir sang all standard repeats within the recordings. The total length of the piece was 141.5 seconds. I used a pre-recorded and projected video of the chorus' primary conductor to ensure that singers responded to the same stimuli throughout each performance. The singers performed the motet four times under these conditions: (a) all singers wearing neckties; (b) half of the ensemble wearing neckties, half not wearing neckties; (c) the other half of the ensemble wearing neckties, half not wearing neckties; and (d) all singers without neckties.

Audio recording. An Edirol R-09HR digital sound recorder captured each choral performance at a sampling rate of 44.1kHz in .wav format. I positioned the recorder 12ft away from the center riser in a location representative of where the conductor would be, and subsequently raised to the conductor's ear level (~68 in (~1.71 m)). I maintained the settings and location of the recorder throughout all recordings.

Choral performance procedure. I asked participants to stand by section (from left to right: tenor I, tenor II, baritone, bass) on the choral risers. From there, counting from the left, half of the singers (*n* = 15) I designated as Group 1 while the remaining participants (*n* = 15) constituted Group 2. I gave all choral participants a packet of questionnaires (see) paired with word puzzles. All participants wore a button-down collared shirt and necktie. I and a trained colleague checked for consistency of necktie tightness. Previous studies (Teng, Gurses-Ozden, Liebmann, Tell, & Ritch, 2003; Theelen, Meulendijks, Geurts, van Leeuwen, Voet, & Deutman, 2004) tightened neckties "to the point of slight discomfort." Given the subjective nature of this variable, I used a spacer to ensure consistency of tightness. The spacer consisted of an unsharpened Dixon® No. 2 Pencil. I inserted the spacer at an angle (~45°) down the back of each participant's neck between his collar and skin (see Figure 1). Each participant tightened his necktie until the spacer could remain in place without assistance. I then removed the spacer and asked participants not to readjust their neckties.

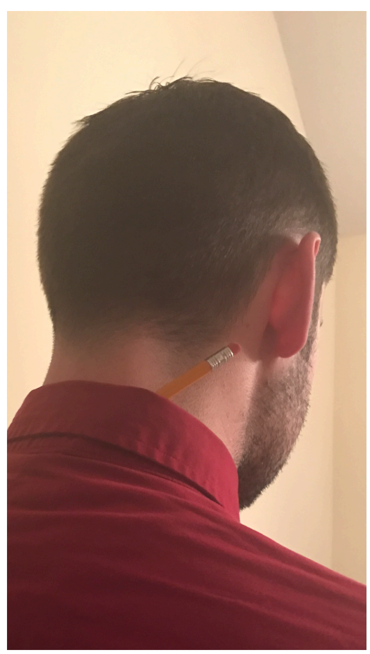

Figure 9. Spacer used to indicate consistency of tightness.

Following the tightness check, I began recording. For the first performance of "If ye love me," all choral participants continued to wear their button-down collared shirts and neckties. I established tonality by means of a triad played on the piano. The video-recorded conductor then led the choir through the motet.

I used the following two renditions to collect questionnaire data. I instructed Group 1 to take off their neckties while Group 2 continued to wear them. In order to distract participants' attention from their neckties, I asked them to work on the word puzzles attached to the questionnaire packet for approximately seven minutes. Thereafter, I reestablished tonality and the choir sang the piece. Immediately following the performance, I asked both groups to complete the first questionnaire in their packet. This process was repeated with Group 1 wearing a necktie and Group 2 taking it off. Spreading the collection of questionnaire data over two renditions controlled for the possible ordering effect and strengthened the internal validity of the study. Participants sang the motet a fourth time with neither Group 1 nor Group 2 wearing a necktie.

Expert listening panel procedure. I burned the original .wav file recordings of the choir singing with (first recording) and without (last recording) a necktie onto a compact disc using Audacity (2.1.0). Expert listening panel participants listened to the two recordings on Sony MDR-7506 Dynamic Stereo Headphones patched into Sony CPD-211 Stereo Compact Disc Player through a PreSonus HP4 4-Channel Headphone Amplifier.

Expert auditors manipulated a The Continuous Response Digital Interface (CRDI) dial as they listened to recorded performances of the motet. The CRDI instrument provided an uninterrupted measurement of each expert listening panel participant's perception of choral tone quality of the entire first (with necktie) and last (without necktie) recorded choral performances.

Capperella-Sheldon (1989) reported reliability coefficients of this apparatus. I used two anchors, *Less Pleasing Overall Sound* and *More Pleasing Overall Sound,* attached to either end of the CRDI's 256-degree arc. I asked participants to manipulate the CRDI throughout the recordings to reflect their perception of how pleasing the overall sound was. The computer program recorded responses twice every second creating a total of 283 responses per listening. To control for ordering effect, I alternated which recording I played first from participant to participant.

Playback volume remained constant across recordings and participants while playback order alternated from participant to participant. Following the listening procedure with the CRDI, participants indicated on paper (a) whether they perceived a difference between the two recordings, and, if so, (b) which recording had a more pleasing overall sound.

Experiment 2: Solo

Participants

Solo participants ($n = 30$) consisted of male singers living in and around a medium-sized Midwestern suburban city. Participants self-identified their voice type ($n = 19$ tenors, $n = 9$ baritones, $n = 1$ bass-baritone, $n = 1$ bass). Solo participants ranged in age from 18 to 37 years of age ($M = 23.47$ years, $SD = 5.09$ years). All solo participants identified themselves as an undergraduate ($n = 18$) or graduate ($n = 12$) music student. When asked how often they wore a necktie, solo participants responded seldom/rarely ($n = 4$), 1-3 times a month ($n = 7$), for performances ($n = 2$), not often ($n = 2$), 1-3 times a week ($n = 13$), and fairly often/regularly ($n = 2$). Some solo participants ($n = 15$) self-reported vocal production issues (e.g., allergies, sickness) prior to the completion of the study.

Expert listening panel participants ($n = 15$) consisted of university faculty ($n = 7$), public high school faculty ($n = 4$), and graduate voice teachers ($n = 4$). Expert listening panel participants ranged in age from 24 to 69 years (*M* = 40.13 years, *SD* = 15.76 years). To further confirm a rich history of solo voice experience, participants provided information regarding years spent performing (*M* = 12.6 years, *SD* = 11.53 years), teaching (*M* = 16.2 years, *SD* = 14.56 years), and adjudicating (*M* = 5.67 years, *SD* = 8.64 years).

The IRB approved a modification of the first experiment that included the procedures of the second experiment before data collection occurred with solo singers (see Appendix A). Participants consented to the study after listening to a prepared consent script (see Appendix B).

Procedures and Equipment

Musical Excerpt. Solo participants performed "The Star-Spangled Banner" beginning at "whose broad stripes" to eliminate the repeated phrase. The common familiarity and wide pitch range of the piece informed choosing this selection for the study. Participants performed the piece twice in the key of Bb and while following an inaudible, visual metronome (quarter note = 104 bpm).

Audio Recording. I recorded all solo performances with a Countryman E6 omni-directional head-mounted microphone positioned out of the direct air stream, 5 cm from the left side of the participants' lip corner. The microphone connected to a Tascam US-122MKII Audio/MIDI interface pre-amplifier. I calibrated the microphone prior to each data collection using a Quest Electronics Model 2800 Impulse Integrating Sound Level Meter and the recording level remained consistent across all participants. I recorded all singing tasks in .wav format with a 44.1 kHz sampling rate with Audacity software (version 2.1.0) on a MacBook Pro computer.

Solo performance procedure. Upon entering a quiet room, I asked solo participants to sing enough that they felt warmed up and adjusted to the room acoustics. The first singing task consisted of sustaining an [*a*] vowel on an E3 for 5 seconds, sung 5 times. I recorded the task using a Shure SM48 standing microphone kept at a consistent 7" away from the singer's mouth. The Multi-Dimensional Voice Program Advanced (MDVP) from KayPentax Computerized Speech Laboratory (CSL) Model 4500 analyzed each recording in real time and averaged the 5 takes. I repeated the first singing task with each participant wearing a necktie. I used the jitter and shimmer measurements taken from the MDVP for further analysis.

Following the MDVP protocol, I fitted the calibrated Countryman microphone to each solo participant. To remove the microphone from the direct air stream, I used a 5cm spacer from the participant's lip corners. The participants then sang "The Star Spangled Banner" twice (with and without a necktie). Throughout the solo performance procedure I controlled for the ordering effect by alternating conditions. Following each iteration of "The Star Spangled Banner," participants completed the PPE instrument (see Appendix C).

Expert listening panel procedure. Once again, I used the CRDI (see procedure above) with two anchors (*Less Pleasing Overall Sound* and *More Pleasing Overall Sound*) to capture expert listener perceptions of each participant's performances. I instituted two controls for ordering effect. The first control involved alternating which recording I played first (with or without necktie). Then, I constructed an incomplete repeated measures Latin Square to randomize the order in which expert listening panel participants heard the pairs of recordings (see Table 1). Panel participants evaluated six pairs of recordings each, which allowed each pair to be evaluated three times. Following each pair of participant recordings, expert listeners indicated on paper (a) whether they perceived a quality difference between the two recordings, and, if so, (b) which recording had a more pleasing overall sound (see Appendix E).

Table 1.

Incomplete Repeated Measures Latin Square for Randomized Order of Listening

Groups	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
C	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
D	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1
E	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
F	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2

Other Dependent Measures: Experiments 1 and 2

Perceived Phonatory Ease (PPE)

Participants used an 8 in (20.32 cm) visual analog scale (VAS) with anchors of *Minimum Vocal Ease* and *Maximum Vocal Ease* to determine their perception of personal vocal ease (see Appendix C). I adapted the measurement of perceived phonatory effort used in the pilot study in order to reduce the negative connotation surrounding the term 'effort.' Therefore, ease was chosen as a replacement measure. Previous scales (Tanner, Roy, Merrill, & Elstad, 2007) used *No Effort* as a minimum measure; however, the researcher believed that phonation without at least minimal effort was not a possibility. Printed directions instructed participants to draw a vertical line somewhere along the scale that reflected their judgments of perceived vocal ease following both choral and solo singing tasks.

Consistent with previous research (Solomon & DiMattia, 2000), I measured distances from the left extreme of the scale to the participant's mark on both occasions. I then divided the number by the length of the line and subsequently converted into a percentage. In order to minimize scale drift, I encouraged participants to view their previous marks before completing the instrument a second time (Erickson & Sivasankar, 2010).

LTAS

During phonation, the vocal folds produce complex sound spectra, which include resonance frequencies in addition to fundamental frequencies. Long-term average spectra data represent a sampled average of spectral harmonic amplitude over time that minimizes short-term variations due to the phonetic structure, thus displaying persisting spectral events (Löfqvist & Mandersson, 1987). Studies have shown that LTAS data vary among (a) various singing styles (e.g., Cleveland, Sundberg, & Stone, 2001), (b) voice classifications (e.g., Johnson & Kempster, 2010), (c) singing experience level (e.g., Barnes, Davis, Oates, & Chapman., 2004; Mitchell & Kenny, 2008; Thorpe, Cala, Chapman, & Davis, 2001; Brown, Rothman, & Sapienza, 2000; Mendes et al., 2003; Oliveira Barrichelo, Heuer, Dean, & Sataloff, 2001), (d) age groups (e.g., Linville & Rens, 2001; Sergeant & Welch, 2008), (e) patients with voice disorders (e.g., Prytz, 1978; Hartl, Hans, Vaissiere, & Brasnu, 2003) and (f) sexes and genders (e.g., Bladon, 1983; Klatt, 1986; Klatt, D. H. & Klatt, L. C., 1990; White, 2001).Therefore, collecting LTAS data for this particular study offered the opportunity to assess overall timbre and tone quality changes ostensibly due to wearing a necktie.

I used KayPentax Computerized Speech Lab (CSL) Model 4500 software to examine all choral and solo recordings made throughout the study. I analyzed LTAS data from each recording using a window size of 512 points with no pre-emphasis or smoothing, a bandwidth of 86.13Hz, and a Hamming window.

Statistical Analyses

I computed the mean difference between participant PPE responses and subsequently converted it to a percentage. Additionally, I used a paired-sample *t*-test to calculate the significance level of differences in PPE and LTAS data. Lastly, I calculated mean signal amplitudes of all recordings from 0-10 kHz and 2-4 kHz.

CHAPTER FOUR

Results

This chapter presents results for this study in order of stated research questions. A pre-determined alpha level of .05 served as an indication of significance for all statistical tests employed.

Experiment 1: Choral Results

Long-term average spectra (LTAS). The acoustical portion of the first research question (Experiment 1) pertained to potential timbral differences in LTAS data across the four choir recordings (With Necktie, With/Without 1, With/Without 2, and Without Necktie). Howard and Angus (2001) indicated that a 1 dB difference in the signal energy of a complex sound constitutes a just noticeable difference (JND) in the perception of vocal timbre. Additionally, as Fletcher and Munson (1933) have shown, the human ear is most sensitive to timbral changes in the 2-4 kHz range. Thus, any LTAS differences exceeding 1 dB SPL and any changes between conditions in the 2-4 kHz frequency range will be of particular interest.

Acquired mean signal amplitudes (0 – 10 kHz) per each recorded condition were: 35.31 dB (*SD* 13.04 dB) for With Necktie, 35.09 dB (*SD* 12.93 dB) for With/Without 1, 35.69 dB (*SD* 12.91 dB) for With/Without 2, and 35.32 dB (*SD* 12.96 dB) for Without Necktie. Mean signal amplitude differences between the four recorded conditions did not exceed a 1 dB SPL JND in the 0 – 10 kHz range.

Given these standard deviations, I then compared LTAS data for the With Necktie and Without Necktie conditions across the 0 – 10 kHz range (see Figure 10). A paired, two-tailed *t*-test demonstrated no significant differences in spectral energy from 0-10 kHz between the With Necktie and Without Necktie conditions ($p > .05$).

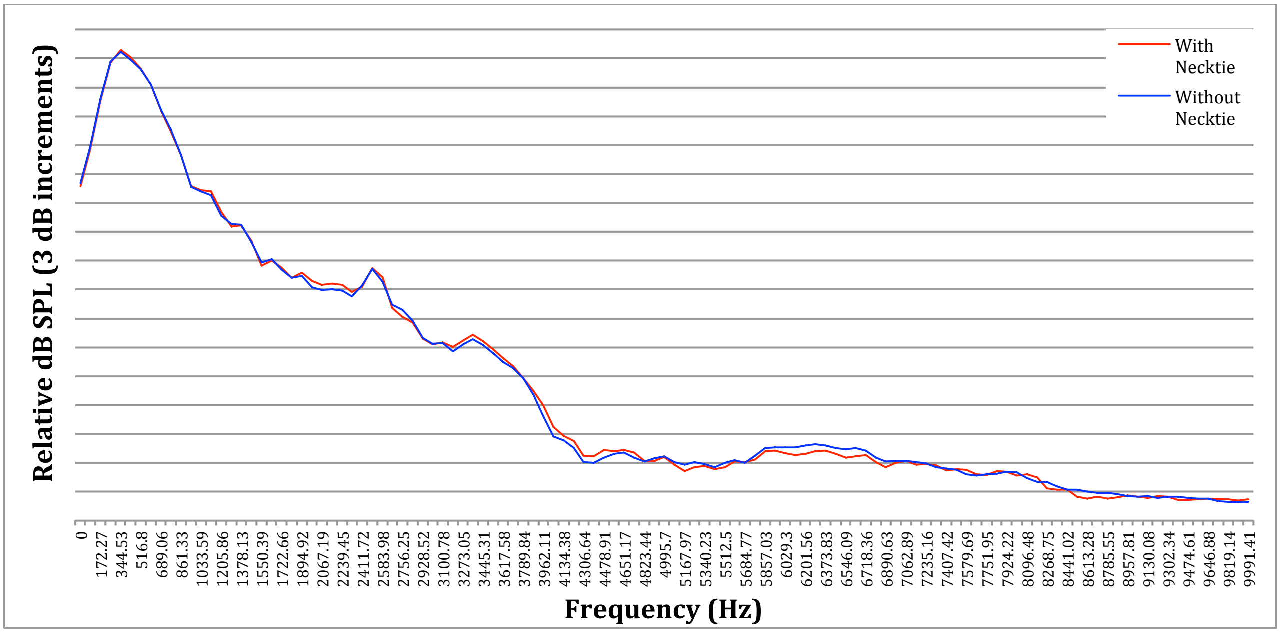

Figure 10. LTAS results for selected choral recordings (0-10 kHz).

I then compared the With Necktie and Without Necktie conditions across the 2 – 4 kHz range. A second paired, two-tailed *t*-test determined significant differences in spectral energy between these two conditions from 2-4 kHz (see Figure 11) ($p < .05$). Amplitude differences in the 2-4 kHz spectrum between the two conditions ranged from -0.76 dB to 1.08 dB. A maximum difference between conditions of 1.08 dB occurred at approximately 4 kHz. One other partial (just above 4k kHz) showed a 1 dB JND difference.

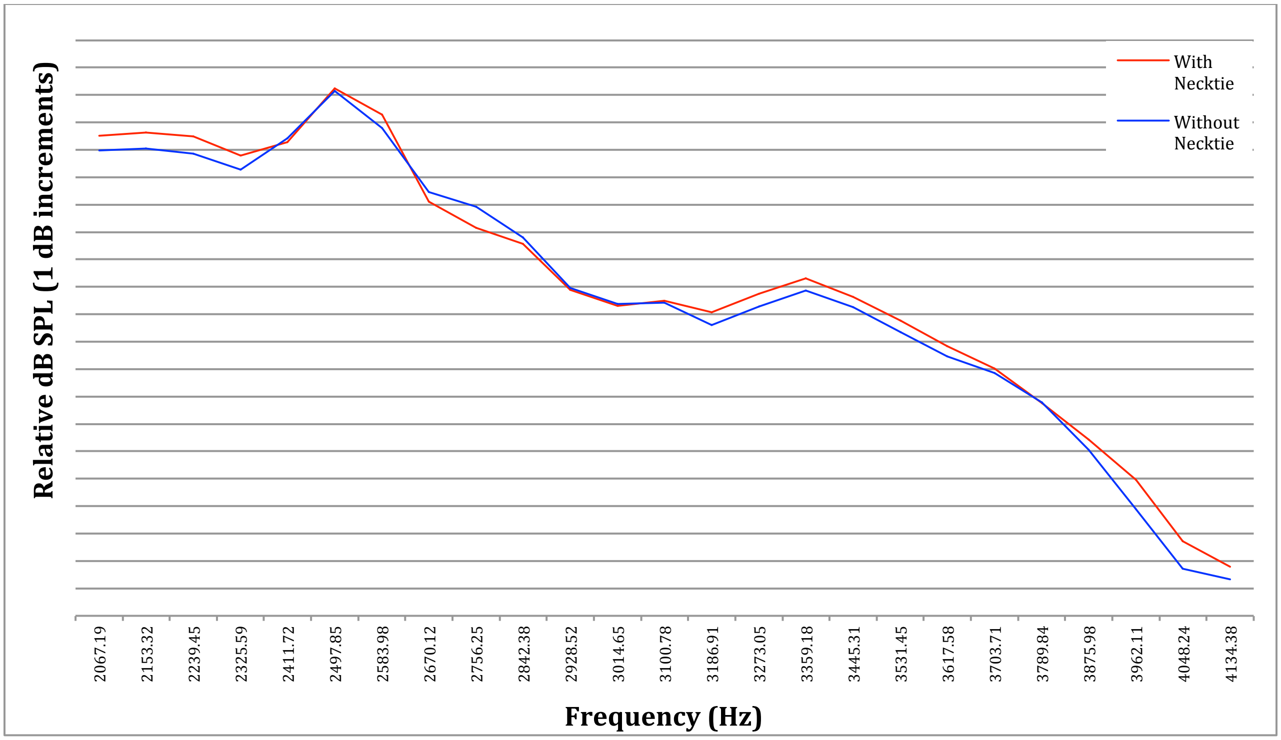

Figure 11. LTAS results for selected choral recordings (2-4 kHz).

Perceived phonatory ease (PPE). The perceptual components of Experiment 1 pertained to participants' PPE perceptions and responses from an expert listening panel. A paired, two-tailed *t*-test showed significant ($p < .05$) differences in singers' perceived phonatory ease between singing with and without a necktie conditions. Most participants (76.67%, $n = 23$) reported a mean reduction in vocal ease. Participants on the whole reported a reduction of 29.69% (*SD* 24.30%) when wearing a necktie. Some participants (16.67%, $n = 5$) reported an increase in vocal ease when singing while wearing a necktie.

I disaggregated the participants' PPE data by voice part (see Figure 12 and Figure 13). Tenor I and Tenor II participants perceived a significant (paired, two-tailed *t*-test) mean reduction in vocal ease of 17.19% (*SD* 25.90%, $p < .05$). Baritone and Bass participants perceived a significant (paired, two-tailed *t*-test) mean reduction in vocal ease of 38.02% (*SD* 19.74%, $p < .05$).

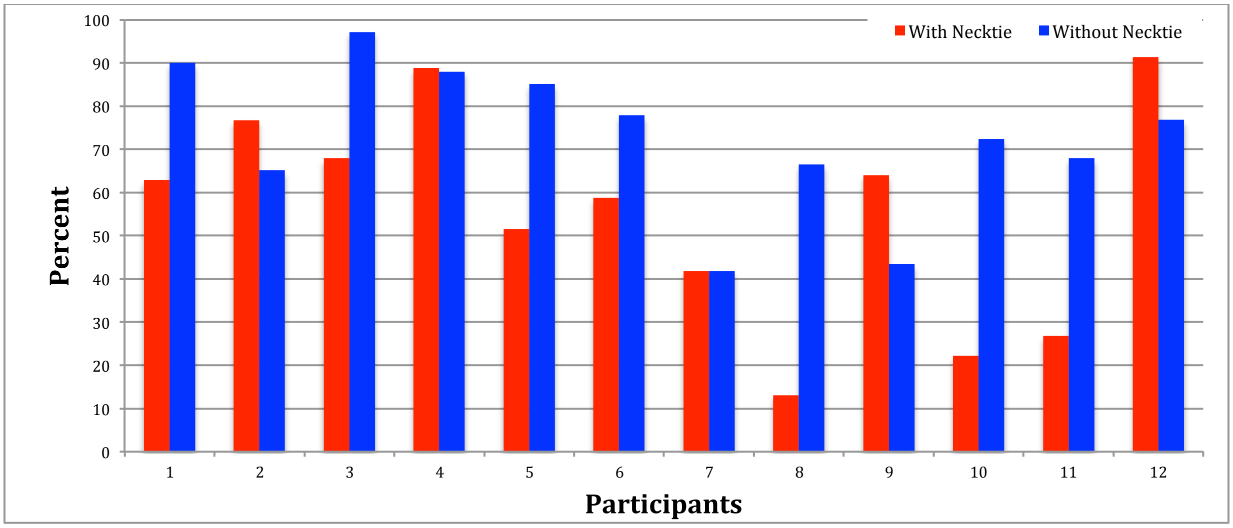

Figure 12. Choristers' perceived phonatory ease results (Tenor/I/Tenor II).

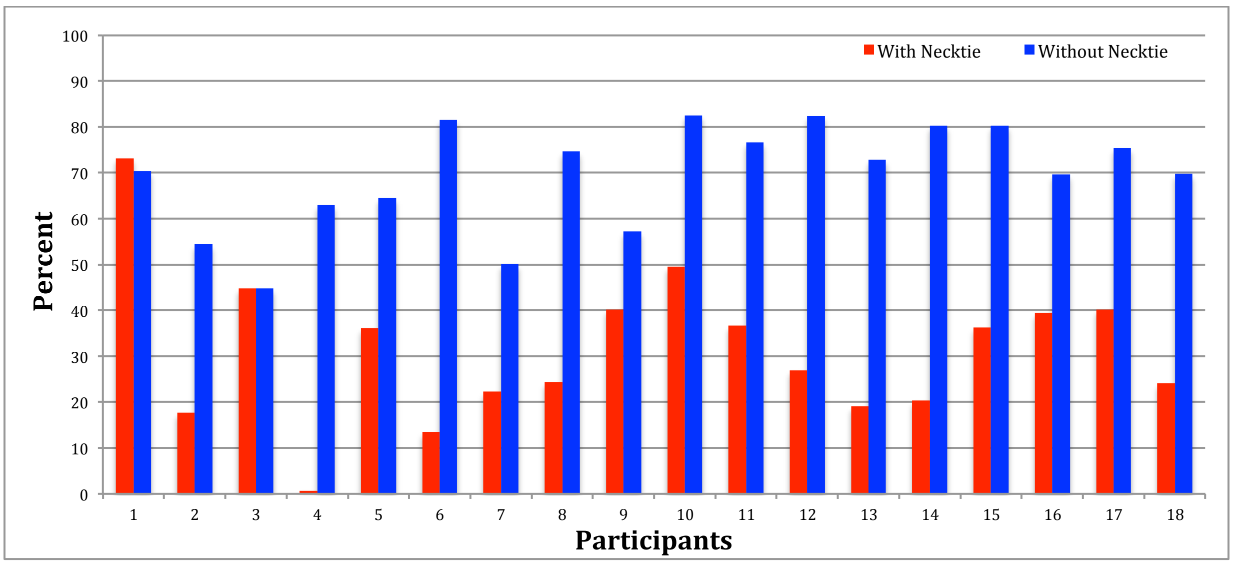

Figure 13. Choristers' perceived phonatory ease results (Bass/Baritone).

As noted previously, some participants self-reported vocal production issues (e.g., allergies, sickness) prior to the beginning of data collection. I disaggregated the PPE data into subgroups of those participants who self-reported vocal production issues and those who did not. Those participants self-reporting vocal production issues on their questionnaire reported a significant (paired, two-tailed *t*-test) mean reduction in vocal ease of 36.86% while wearing a necktie (*SD* 21.48%, $p < .05$) Participants who self-reported no vocal production issues perceived a significant (paired, two-tailed *t*-test) reduction in mean vocal ease of 26.11% while wearing a necktie (*SD* 25.34%, $p < .05$).

Expert listening panel. As displayed in Table 2, choral expert listening panel questionnaire responses conflicted with listeners' mean CRDI responses. A majority (75%) of expert auditors stated that the recording of the choir singing without a necktie had a more pleasing overall sound. However, means calculated from CRDI data (during each listening) indicated that the majority (62.5%) of listeners thought that the recording of the choir singing while wearing a necktie had a more pleasing overall sound.

Table 2

Choral Expert Listener Questionnaire Preferences and CRDI Mean

Listener	Questionnaire	CRDI	Gap Percent
1	With	With	-5.13
2	Without	With	-1.03
3	Without	Without	7.19
4	Without	With	-1.46
5	With	With	-3.41
6	Without	Without	6.86
7	Without	Without	8.53
8	Without	With	-3.01

Note. Gap Percent calculated by finding the difference in CRDI result means and converting to a percentage. The Gap Percent numbers demonstrate the degree to which one recording was selected over the other.

I disaggregated CRDI data for each listener to correspond to the two sections (homophonic and polyphonic) of Tallis' motet. As indicated by Table 3, the majority (75%) of listeners perceived the recording of the choir singing without a necktie during the homophonic section had a more pleasing overall sound, but the majority (62.5%) of listeners reported otherwise for recording of the choir singing while wearing a necktie during the polyphonic section.

Table 3

Choral Expert Listener Questionnaire Preferences and CRDI Mean

Listener	CRDI (Homophonic)	Gap Percent (H)	CRDI (Polyphonic)	Gap Percent (P)
1	With	-0.30	With	-7.28
2	Without	9.21	With	-5.57
3	Without	4.52	Without	8.38
4	Without	10.20	With	-6.64
5	Without	16.42	With	-12.22
6	Without	9.63	Without	5.64
7	Without	13.85	Without	6.17
8	With	-7.96	With	-0.44

Note. Gap Percent calculated by finding the difference in CRDI result means and converting to a percentage. Gap Percentage numbers indicate the degree to which one recording was selected over the other.

Experiment 2: Solo Singing Results

Multi-dimensional voice profile (MDVP). The acoustic portion of the second research question (Experiment 2) pertained to (a) MDVP analysis of jitter and shimmer percentages and (b) LTAS data collected from all solo participants. The mean difference between participants' jitter percentages with and without a necktie demonstrated a 0.0511% (*SD* 0.1775%) increase in jitter percent when singing while wearing a necktie (see Figure 14).

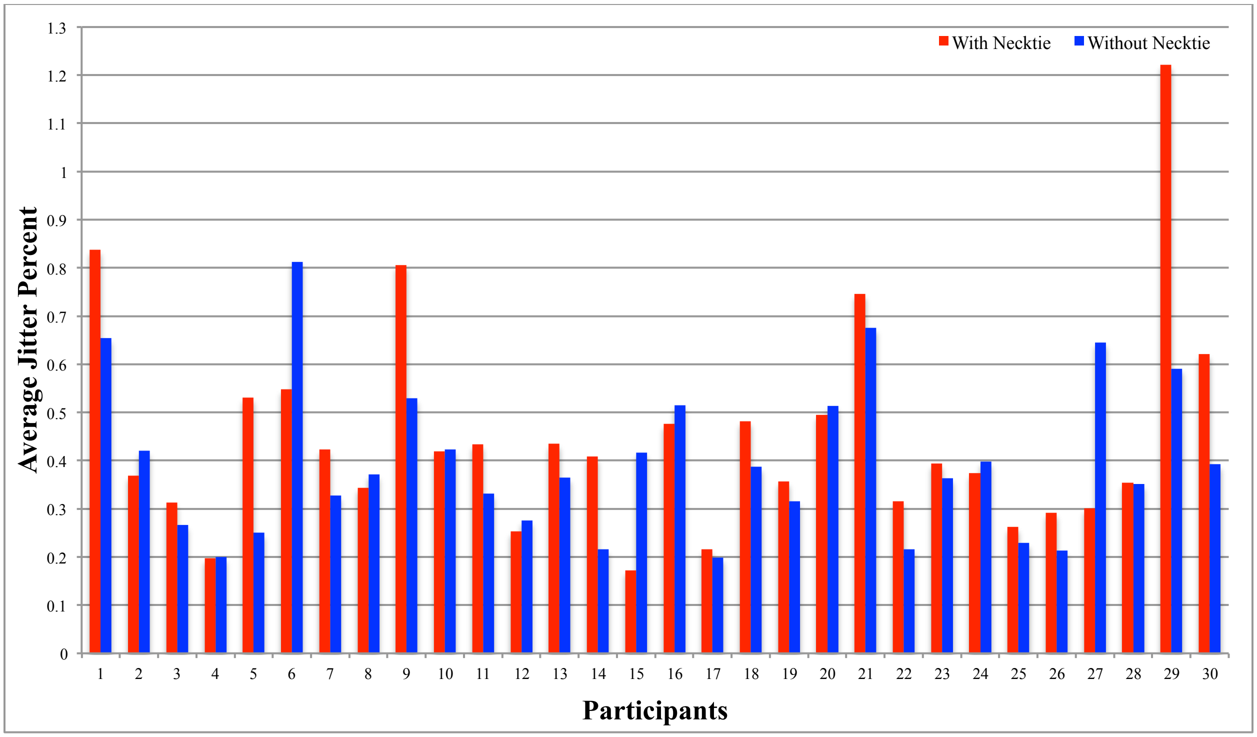

Figure 14. Average jitter percent of solo participants.

The mean difference between shimmer percentages across conditions increased by 0.1198% (*SD* .3487%) when singing while wearing a necktie (see Figure 15).

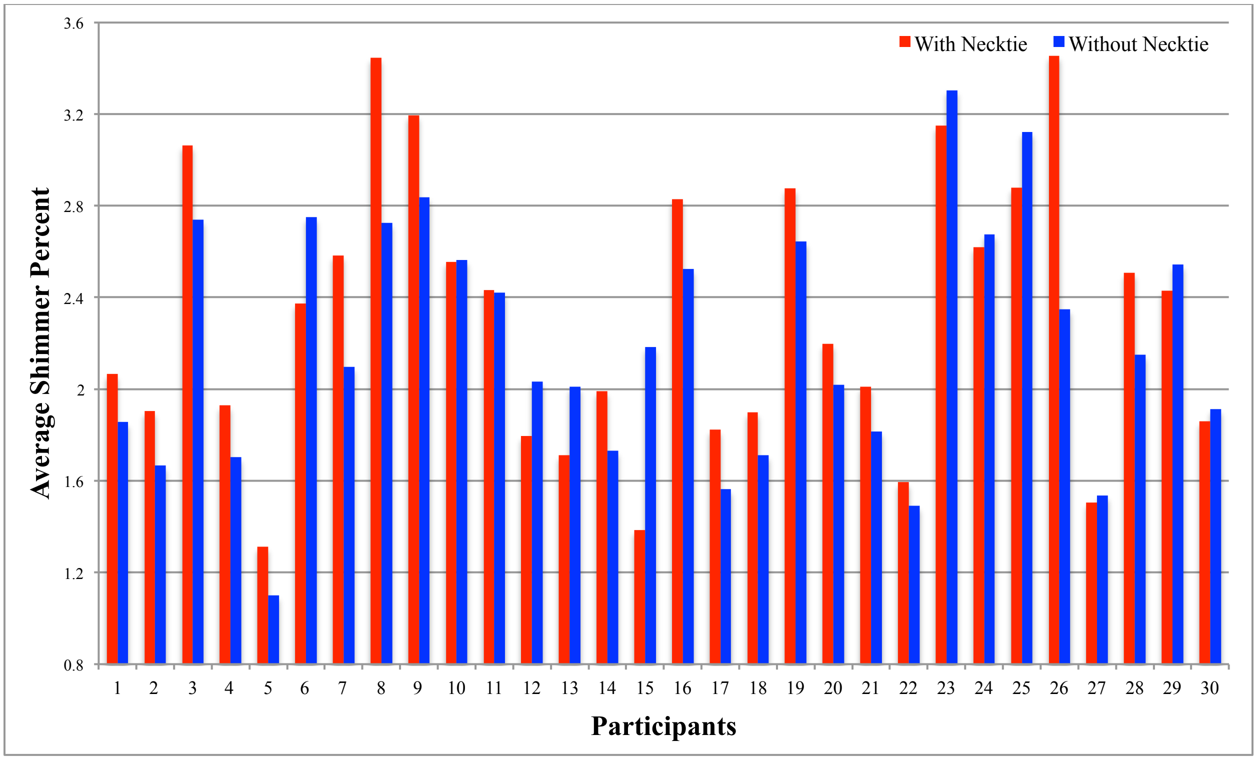

Figure 15. Average shimmer percent of solo participants.

A paired, two-tailed *t*-test indicated no significant difference between either shimmer or jitter percent differences for participants ($p > .05$). Mean jitter percent of participants singing while wearing a necktie equaled 0.4466% (*SD* = 0.2207%) while mean jitter percent of participants singing without wearing a necktie equaled 0.3955% (*SD* = 0.1599%). Mean shimmer percent of participants singing while wearing a necktie equaled 2.312% (*SD* = 0.607%) while mean shimmer percent of participants singing without wearing a necktie equaled 2.193% (*SD* = 0.532%). Participant 29 experienced the largest increase in jitter percent (0.6310%) when singing while wearing a necktie. Participant 26 experienced the largest increase in shimmer percent (1.106%) when singing while wearing a necktie. Changes in jitter and shimmer can be perceived as hoarseness or coarseness in a voice (Bier, Watson, & McCann, 2014). The KayPentax Computerized Speech Lab indicates a threshold of pathology for both shimmer (3.810%) and jitter percent (1.040%). The addition of a necktie to participant 29's singing resulted in his surpassing the threshold of pathology for jitter percent. All other participants remained beneath the thresholds.

I disaggregated the data into voice type (baritone/bass, tenor) and degree level (undergrad, graduate). A series of paired, two-tailed *t*-tests determined that no significant differences existed in jitter percent for all the disaggregated data sets ($p > .05$). Additionally, only tenors singing with and without a necktie demonstrated a significant difference in shimmer percent data ($p < .05$).

Long-term average spectra (LTAS). I averaged all solo participants' LTAS data for each sung condition. Figure 16 shows aggregated mean LTAS data for all solo participants across the 0-10 kHz range. A paired, two-tailed *t*-test showed significant differences between grand mean signal amplitudes in the 0-10 kHz range (see Figure 16) ($p < .05$). Grand mean differences indicated a 0.21 dB (*SD* 0.30 dB) decrease in signal energy when singing with a necktie. Grand mean differences varied, ranging from a maximum decrease in grand mean signal amplitude of 0.83 dB around 3.4 kHz and a maximum increase in grand mean signal amplitude of 0.74 dB around 4 kHz.

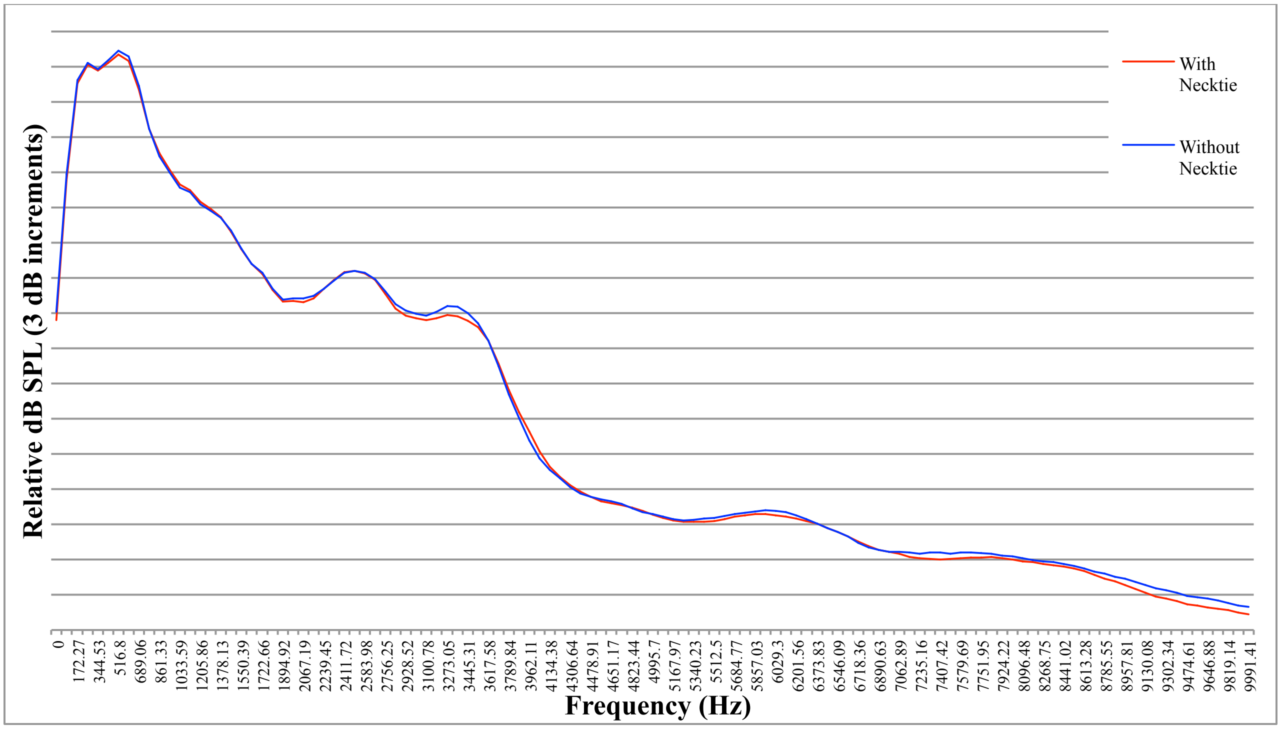

Figure 16. Aggregated LTAS mean signal amplitude results for solo participants (0-10 kHz).

Table 4 displays differences in mean signal amplitudes per participant across the 0-10 kHz and the 2-4 kHz frequency ranges. A greater than 1 dB mean difference existed in 40% of participants in the 0-10 kHz region and 37% of participants in the 2-4 kHz region. A series of paired, two-tailed *t*-tests found significant differences across conditions with 77% (n = 23) of participants from 0-10 kHz and with 70% (n = 21) of participants from 2-4 kHz ($p < .05$). Exactly half of the participants (n = 15) demonstrated a decrease in mean signal amplitude across the 0-10 kHz region when singing while wearing a necktie. Additionally, several participants (n = 13) demonstrated a decrease in mean signal amplitude across the 2-4 kHz region when singing while wearing a necktie.

Table 4

LTAS Mean Signal Amplitude Difference Results (0 – 10 kHz and 2 – 4 kHz) by Singer (With-Without Necktie)

Participant	Voice Type	0-10 kHz (dB)	*SD* (dB)	2-4 kHz (dB)	*SD* (dB)
1	Baritone	**-1.51***	1.45	-0.89*	0.99
2	Tenor	**-1.31***	1.00	**-1.07***	0.92
3	Tenor	**-1.20***	1.32	**-1.97***	1.66
4	Tenor	-0.50*	1.16	-0.22	0.99
5	Tenor	0.47*	0.68	0.66*	0.59
6	Tenor	**-1.04***	0.89	-0.83*	0.44
7	Tenor	-0.08	1.83	**-1.11***	2.41
8	Tenor	**-2.13***	5.92	**1.58**	5.50
9	Tenor	0.21*	0.94	-0.44*	0.75
10	Baritone	0.78*	0.82	0.67*	0.56
11	Bass-Baritone	-0.38*	1.10	0.10	1.24
12	Tenor	**-2.39***	1.40	**-2.56***	1.71
13	Tenor	0.51*	1.06	0.09	1.93
14	Tenor	0.87*	0.44	0.64*	0.58
15	Baritone	0.48*	0.86	0.49*	1.12
16	Tenor	-0.18	1.65	0.33	0.93
17	Tenor	0.24*	0.63	0.46*	0.48
18	Baritone	0.12	0.65	0.05	0.41
19	Tenor	**3.70***	1.15	**3.65***	1.15
20	Tenor	-0.25*	1.09	0.25	1.62
21	Tenor	**1.16***	0.83	**1.09***	0.80
22	Bass	0.05	0.79	0.52*	1.16
23	Baritone	0.56*	0.82	0.52*	0.35
24	Tenor	-0.06	1.50	**-1.41***	1.30
25	Baritone	**1.94***	0.92	**2.30***	0.72
26	Tenor	**-3.23***	1.39	**-3.26***	1.72
27	Baritone	0.24	1.79	-0.32	1.90
28	Baritone	**-2.03***	0.82	**-1.98***	0.50
29	Tenor	0.04	1.62	-0.32	2.50
30	Baritone	**-1.29***	0.50	-0.96*	0.39

Note. Boldface indicates differences greater than 1dB. Asterisk indicates significance after subjected to a paired, two-tailed t-test ($p < .05$).

Among the solo participants, participant 19 demonstrated the greatest differences in energy between the two sung conditions (see Figure 17). He exhibited greater amplitude (*M* =

3.70 dB SPL) across the 0-10 kHz range while wearing a necktie than while singing without a necktie, and likewise greater amplitude (*M* = 3.65 dB) across the 2-4 kHz range when wearing a necktie.

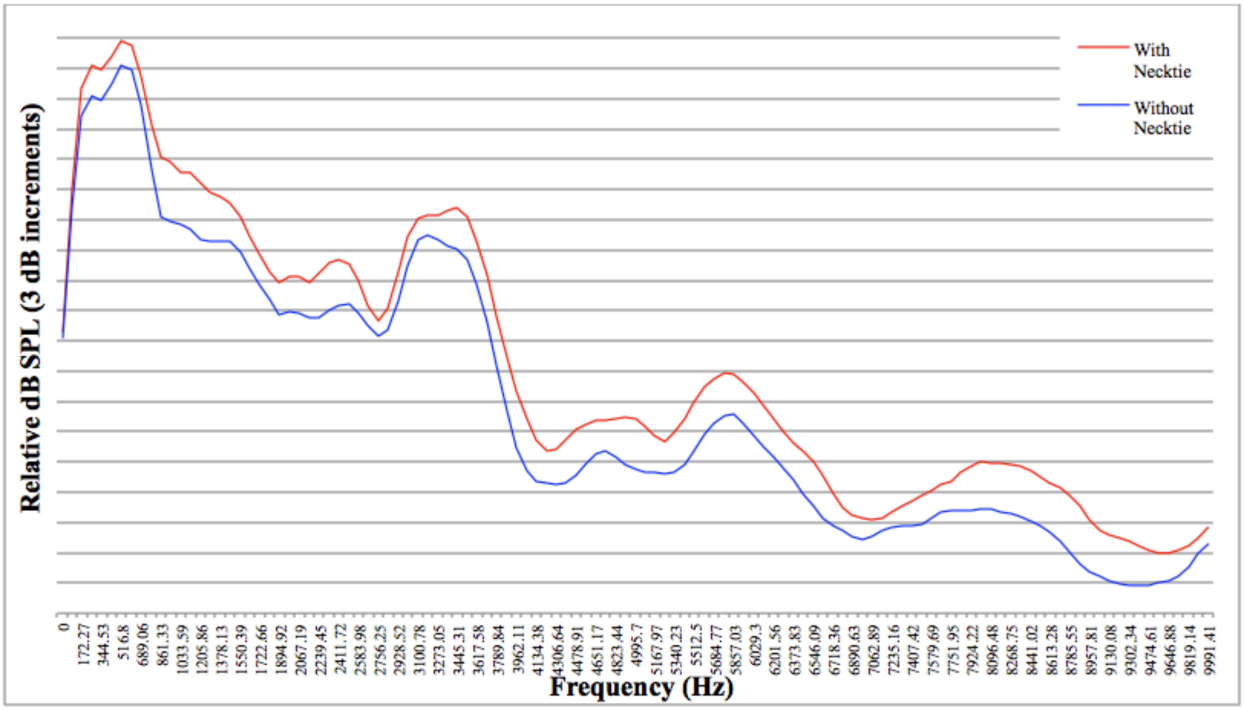

Figure 17. LTAS results for solo participant 19 (0-10 kHz).

I disaggregated the participants further into voice type (baritone/bass and tenor) and degree level (undergraduate, graduate) to identify changes therein (see Table 5). All subgroups demonstrated a decrease in mean signal amplitudes when singing while wearing a necktie. The greatest difference in mean signal amplitude occurred in undergraduate participants (*M*= -.40 dB, *SD*= 1.15 dB).

Table 5

LTAS Mean Signal Amplitude Difference Results by Participant Group

Participant Groups	0-10 kHz (dB)	*SD* (dB)	2 to 4 kHz (dB)	*SD* (dB)
Baritone/Bass	-0.10	1.15	-0.32	1.01
Tenor	-0.27	1.50	-0.02	1.59
Undergraduate	-0.40	1.15	-0.03	1.38
Graduate	-0.09	1.63	-0.29	1.47

Perceived phonatory ease (PPE). The perceptual components of the second research question (Experiment 2) pertained to participants' Perceived Phonatory Ease and responses from an expert listening panel. A paired, two-tailed *t*-test showed significant differences in PPE between singing with and without a necktie (see Figure 18) ($p < .05$). Solo participants reported a mean reduction in vocal ease of 30.72% (*SD* 18.51%) when singing while wearing a necktie. One participant reported no change in PPE when singing with or without a necktie. I calculated mean differences in PPE for baritone/bass (M = -30.04%, SD = 11.74%), tenor (M = -31.11%, SD = 21.79%), undergraduate (M = -27.89%, SD = 15.30%), graduate (M = -33.67%, SD = 21.78%), without self-reported vocal production issues (M = -29.73%, SD = 20.20%), and with self-reported vocal production issues (e.g., allergies, sickness) (M = -31.7%, SD = 17.30%) participants. A series of paired, two-tailed *t*-tests determined that all participant subgroups reported a significant reduction in PPE ($p < .05$) when singing while wearing a necktie.

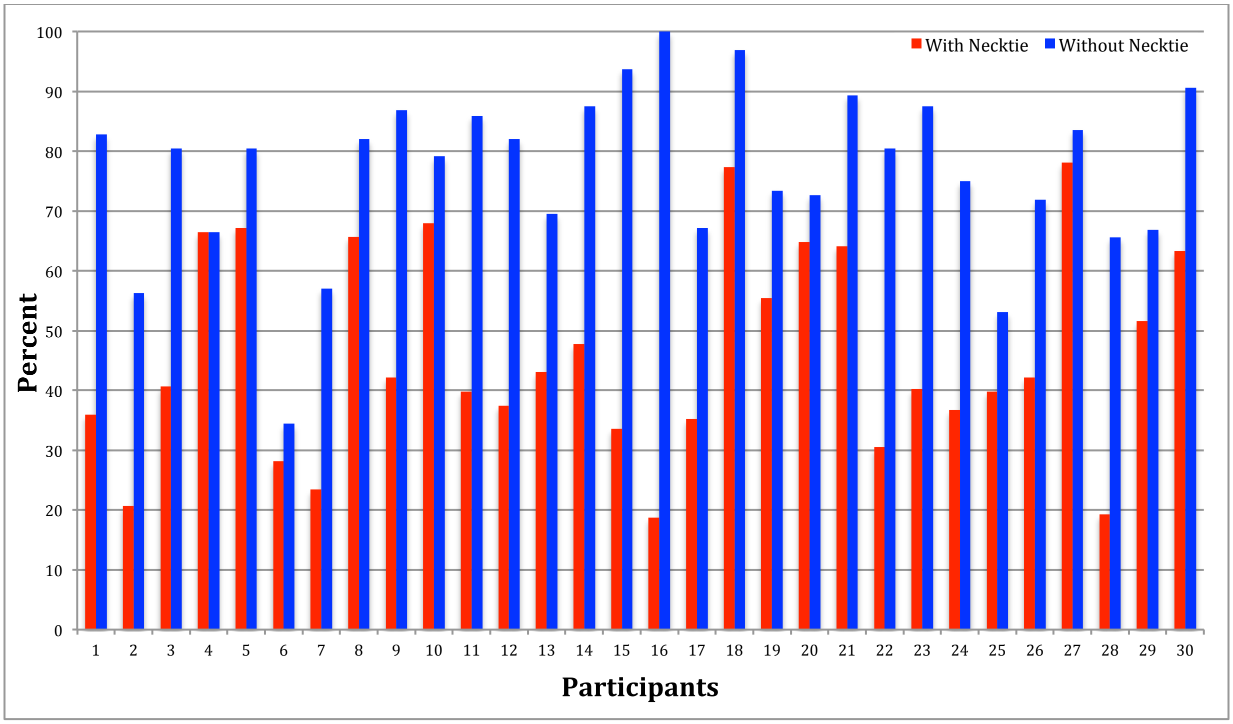

Figure 18. Perceived phonatory ease results for solo participants.

Expert listening panel. Expert listeners reported their selection of most pleasing overall sound in solo singing via the CRDI during each recording and then on a questionnaire following each pair of recordings. Table 6 displays listener preferences recorded on the questionnaire for each singer. I calculated a consensus of preference based on which condition represented the majority of an individual listener's selections. With respect to condition consensus from CRDI assessments, most expert listeners (66.67%, n = 10) preferred the sound of solo singers without a necktie.

Table 6

Expert Listening Panel Questionnaire-Reported Preferences of Solo Pairings

Listener	Singer 1	Singer 2	Singer 3	Singer 4	Singer 5	Singer 6	**Consensus**
1	With	Without	No Diff.	Without	No Diff.	Without	**Without**
2	With	Without	With	Without	No Diff.	Without	**Without**
3	No Diff.	Without	With	Without	No Diff.	Without	**Without**
4	Without	With	Without	Without	Without	Without	**Without**
5	With	Without	Without	No Diff.	Without	Without	**Without**
6	With	Without	Without	Without	Without	Without	**Without**
7	With	Without	With	With	No Diff.	With	**With**
8	Without	Without	With	Without	Without	No Diff.	**Without**
9	Without	Without	Without	No Diff.	Without	No Diff.	**Without**
10	Without	Without	No Diff.	With	With	Without	**Without**
11	Without	With	Without	No Diff.	No Diff.	With	**Tied**
12	With	With	No Diff.	Without	With	Without	**With**
13	Without	Without	No Diff.	With	With	With	**With**
14	No Diff.	With	No Diff.	With	No Diff.	With	**With**
15	Without	Without	Without	Without	With	Without	**Without**

Table 7 displays listener preferences by singer via average CRDI results and questionnaire consensus. Listener CRDI data reflected a 66.67% preference for solo singers without a necktie. According to questionnaire results, listeners preferred 50.00% of recordings without a necktie and 20.00% of recordings while wearing a necktie. Some consensuses (23.00%) yielded an unclear preference and 6.67% perceived no difference.

Table 7

Solo Expert Listener Participant CRDI Preference Means and Questionnaire Consensus of Solo Participants

Participant	CRDI	Gap Percent (%)	Consensus
1	With	-11.94	With
2	Without	4.60	Without
3	Without	4.28	With
4	With	-2.17	Without
5	With	-2.49	Without
6	Without	6.48	Without
7	Without	3.47	Unclear
8	Without	10.73	No Diff.
9	Without	4.32	With
10	Without	13.97	Without
11	Without	2.41	With
12	Without	12.37	Without
13	Without	4.33	Without
14	With	-6.73	Without
15	With	-13.46	With
16	Without	7.63	With
17	Without	1.17	Unclear
18	Without	0.55	Without
19	Without	0.90	Without
20	Without	8.31	Without
21	With	-2.50	Unclear
22	With	-6.70	Without
23	Without	0.92	Unclear
24	Without	3.40	Without
25	With	-2.71	Unclear
26	Without	2.26	No Diff.
27	Without	13.10	Without
28	With	-11.21	Unclear
29	With	-9.70	Unclear
30	Without	10.46	Without

Note. Finding the difference in CRDI result means and converting to a percentage calculated gap percent. I calculated consensus results by majority condition with most pleasing overall sound as reported on the questionnaire. I marked the consensus as unclear in the absence of a majority.

CHAPTER FIVE

Discussion

This study is the first controlled investigation to examine the potential effect of neckties on singing in both choral and solo settings. Its primary findings indicate: (a) statistically significant differences in spectral energy between sung performances with and without a necktie in both the choral (2-4 kHz) and solo (0-10 kHz) contexts, (b) increases in mean jitter and shimmer percentage measurements of solo singers with necktie, (c) significant reduction in perceived phonatory ease when singing with a necktie in both choral and solo settings, and (d) listener preferences for singing without a necktie in solo and homophonic choral settings. Although these findings are limited to the procedures and participants of this particular study, they do raise questions deserving of professional discussion and future research.

A primary, practical question raised by this investigation is whether, apart from considerations of appearance, solo vocalists and choral singers should wear neckties while performing. On that point, perhaps the most judicious interpretation of these findings is that, on average, its participating singers do not appear to benefit from wearing neckties either acoustically or in terms of the perceptions of singers and auditors.

At the same time, however, the acoustical and perceptual data of this study suggest that the differences between singing with and without a necktie (a) may be largely small, nuanced differences and (b) that while, on the whole, most participating singers demonstrate these differences, not every participant does. Significant mean LTAS differences in signal amplitude, for instance, approach or slightly exceed a 1 dB SPL JND. Moreover, although approximately 77% of singers in the choral context perceive decreased ease of vocal production when wearing a necktie, approximately 23% of participants report either no difference or increased ease in vocal production. Aggregated with the nearly 97% of solo singers reporting a decrease in ease of vocal production when wearing a necktie, nearly 87% of all participants perceive decreased ease of vocal production when wearing a necktie.

In light of this perception that the wearing of neckties per se detracts from ease of vocal production, voice teachers and choir directors may wish to consider addressing the matter of necktie wear with their students, especially with those students who may not wear neckties often. It may be, at least to some extent, that the nuanced acoustic changes observed in this study when singers wear neckties constitute a type of self-fulfilling prophecy; if students think a necktie will interfere with phonatory ease, then it might. This possibility is certainly a matter worthy of subsequent research.

Clearly, more research is needed in several areas related to the present investigation. That said, the following discussion considers matters of interest from the perspective of the dependent measures of this study and therein suggestions for future research and implications for vocal pedagogy.

Acoustical Considerations

LTAS data show significant differences in LTAS contours from 2-4 kHz in the choral setting and from 0-10 kHz for the majority (n = 23, 77%) of participants in the solo setting, with both spectra indicating a slight decrease in mean signal amplitude when singing while wearing a necktie. Future studies might explore whether the differences in the concentrations of decreased mean amplitude between choral (2 – 4 kHz) and solo (0 – 10 kHz) performances may be due to mode of singing, literature sung, or the particular sample of singers. In this respect, a limitation of the present study is its use of two different sets of participants who sang different literature.

Designs of future studies might incorporate a single sample of male singers performing the same literature in both choral and solo modes.

LTAS results of Experiment 1 (choral) in the present study differ from results of the pilot investigation (Edwards, 2015). Findings of the previous pilot study indicate a significant increase, rather than decrease, in mean signal amplitude when choristers wear neckties. Both sets of results, of course, suggest that wearing neckties may significantly affect amplitude. However, more research is needed to determine whether wearing neckties decreases or increases mean signal amplitude of choral sound. Previous studies (e.g., Ford, 2003) indicate auditors perceive choral sound with decreased higher partial energy as more blended and balanced. Whether neckties contribute to nuanced increases or decreases in choral sound energy or whether different populations of singers may compensate differently for wearing neckties would be matters of interest for choral teachers.

Average solo singing LTAS results also indicate a slight decrease in amplitude when singers wear neckties. However, half of the solo participants evidence an increase in mean signal amplitude. For example, participant 19 experiences a 3.7 dB average increase in mean signal amplitude from 0-10 kHz. Pedagogically, it can be argued that slight decreases in amplitude could be perceived as desirable in choral sound (cf. Ford, 2003). However, in western, fine arts solo singing an increase in the amplitude of particular partials may be more desirable, particularly in the 2-4 kHz region in and around the singer's formant region. In this regard, it is interesting to note that the significant amplitude decreases among solo participants on average occur across the 0-10 kHz spectrum, including the 2-4 kHz region. That is, for these solo singers on the whole (there are exceptions), which would seem to compromise to some extent the potential of the singing instrument.

Why such might be the case is a matter of speculation at this juncture of research. It could be, for instance, that the addition of a necktie may prompt a singer to “choke” the sound such that he does not avail himself of the full resonating capacity of the vocal tract. Future studies might address this possibility specifically.

It might also be that a necktie could affect the overall position of the larynx to some extent. However, no controlled study to date links the effects a necktie may have on the position of the larynx. Future research needs to measure laryngeal position, perhaps with a laryngoaltimeter (Pehlivan & Denizoglu, 2009), in addition to acoustical and perceptual dimension of singing with and without neckties.

A possible decrease in range of motion associated with necktie wear (Yoo, Kim, & Yoo, 2011) is worthy of investigation with singers in performance contexts. Whether in an opera, musical theatre, or show choir setting, singers of all types are often expected to incorporate some kind of choreographed motion into their performances. Moreover, dress rehearsals (i.e., the first opportunity for a singer to perform while wearing a necktie) come late in the rehearsal process. An addition of a necktie may evoke avoidable changes to a singer’s technique had one not been present beforehand.

Unaddressed also by the results of this study is whether vocal pedagogy instruction about how one might counteract the tendencies experienced when wearing a necktie could make a difference. Subsequent research might explore this potential variable through use of treatment and control groups of solo singers. Longitudinal studies to assess whether acoustical measures taken with and without neckties become more similar over time because of a potential acclimatization effect would be in order as well. Sometimes, singers do not wear neckties except for singing performances or for occasional socially mandated events. Singers already face a number of new variables in public performances (e.g., audience, stage lights, risers) On the face of it, it may be wise to address beforehand something as obvious as wearing a necktie.

Subsequent studies could also examine singers wearing a necktie with various degrees of tightness. Similarly, future research could compare necktie wearing with wearing completely buttoned shirts without neckties, or compare wearing of long neckties with wearing bowties such as those typically used in formal wear.

Increases in jitter (frequency) and shimmer (amplitude) variations typically indicate the presence of a “roughness” or “disturbance” in vocal sound. Analyses of MDVP obtained jitter and shimmer percentages indicate an overall, though not significant, increase in these perturbations among solo singing participants in this study. However, statistically significant and perceptually significant may be two different things. Although jitter and shimmer data from solo participants do not approach the realm of the potentially pathological or disphonic, voice science does not yet know the threshold of a just noticeable increase in jitter and shimmer for singers. Researchers may well wish to explore this matter, perhaps through studies that measure listener perceptions through synthesized sung excerpts that gradually increase the amounts of jitter, shimmer, and combinations of jitter and shimmer.

Future research might consider as well non-MDVP derived measures of jitter and shimmer. The MDVP protocol of a sustained “ah” sound, while instructive, does not constitute a truly sung sound.

Designs of subsequent investigations might also include wearing of an ambulatory phonation monitor by all solo singer participants and by selected choral singer participants. The separate frequency and amplitude readings, as well as the overall distance dose reading, produced by these monitors could be informative.

Some previous studies (e.g., Hatt, Chang, Tan, Sinkus, & Bilston, 2015; Frydrychowski, Winklewski, & Guminski 2012) indicate possible cardiovascular effects arising from necktie constriction due to changes in jugular venous outflow. Increased volumes of blood above the point of constriction could have potentially compromising effects on laryngeal structures. Future studies could incorporate stroboscopic observations of the laryngeal vasculature (i.e., presence of ruddiness) to investigate this possibility when singing while wearing a necktie.

Perceptual Considerations

Most participants, whether choral or solo singers, report significantly decreased ease in vocal production when wearing a necktie, a finding that confirms results of the pilot investigation with choir singers. This finding may be consequential not only in terms of possible explanations for the acoustical results of the study, but also in terms of singers wearing neckties potentially experiencing vocal fatigue over time at a faster rate (Chang & Karnell, 2004).

Hindsight often being better than foresight, I wish now I had asked participants to comment about reasons why they perceived less or more ease of vocal production when wearing a necktie. Subsequent studies should include such a question.

Another possibly germane question to singers in future investigations is to what degree they perceive they sing in tune with and without a necktie. Incorporation of pitch analysis procedures to check the accuracy of such perceptions might also be informative. Anecdotally, several auditors commented about some participants straying from the original key in their sung performances.

The disaggregation of PPE data by voice part and type reveals that, in solo settings, tenors report a larger reduction in PPE when singing while wearing a necktie than baritone/basses. The opposite is true in the choral setting. Following Sundberg and Pabst (1992) who found higher laryngeal positions associated with higher tessitura and range, I speculate that tenors in the choral setting report a lesser reduction in perceived phonatory ease than tenors in the solo setting because their larynges would maintain a consistently higher elevation than those of the baritone/basses due to the tessiturae of the Tallis motet. On the other hand, the selected key (Bb major) extends the sung solo excerpt to the bottom of many of the tenor participants' ranges. Therefore, the discomfort associated with a wider range may account for some of the tenor PPE reductions in the solo setting. Of course, one cannot rule out altogether the possibility that the different participant populations in the choral and solo singing experiments may also contribute to this finding.

Individuals self-reporting vocal production issues (e.g., sickness, allergies, etc.) on the day of recording evidence larger reductions in PPE than those participants self-reporting no vocal production issues while wearing a necktie. Future studies might reject or confirm this trend with other populations of male singers and explore whether wearing a necktie may further compromise perceived PPE for participants who already perceive some reduction in their abilities to sing easily.

Some (n = 5, 16.67%) participants in the choral setting report increased ease of phonation while wearing a necktie. I speculate the possibility of some confusion in the choral context about how to mark the PPE scale. Anecdotally, several solo participants double-checked their interpretation of the survey instrument with me before completion—something easier to do in an individual setting than in a group choral context. Future studies using a PPE scale might incorporate a brief practice, perhaps with an excerpt from a familiar unison melody, on how the scale works.

Fashion psychologist Karen Pine suggests that a person's clothing choices can have psychological implications for the wearer (2014). That said, another possibility that may explain reports by some participants of increased phonatory ease while wearing a necktie is that the act of donning a necktie to sing puts them in an optimal "performance" state of mind. This factor may be especially pertinent for choral singers who regularly wear neckties in group performances. Subsequent investigations might survey participants about whether putting on a necktie to sing may either increase focus of attention to the task at hand or otherwise predispose them mentally to ease of phonation.

Alternatively, in sensory defensive participants, this predisposition could lead to an opposite response. Following previous studies that indicate that clothing can stimulate a sensory defensive response in people (Kinnealey, Oliver & Wilbarger, 1995; Pfeiffer & Kinnealey, 2003), a future study might explore the possibility of defensive responses to necktie wearing among singers.

As a group, expert listener participants in this study globally prefer vocal sound produced without a necktie in both the choral and the solo settings. Aside from the question of global preference ("which recording had a more pleasing overall sound"), however, the procedures of this study also assess expert listener preference in real time, that is, while listening to particular performances as opposed to rendering a verdict afterward, by means of CRDI dial manipulation. Occasionally, questionnaire and CRDI results for the same listener differ in preference. Such differences occur more often in the choral setting than the solo singing context.

This finding raises the question of the possible contribution of the texture of the choral literature sung, because CRDI results indicate changes in listener preferences between the homophonic and the polyphonic portions of the Tallis motet performed for this study. Some (n =

3) listeners whose CRDI dial manipulations indicate they prefer the sound of choral singing without a necktie during the homophonic portion of the motet indicate greater preference for choral singing with a necktie during the polyphonic portion. One might speculate that the reason why this change in preference occurs has to do with (a) the more exposed sound of individual voice sections during the polyphonic portion and (b) the higher tessiturae, especially for first tenors, present in the polyphonic section of the motet. Subsequent studies should explore whether this difference in listener preference reflected in CRDI readings is an artifact of this study or is attributable to changes in the texture of sung choral literature by giving expert auditors the opportunity to listen to two separate pieces (homophonic and polyphonic) sung by the same choir with and without neckties.

A related line of perceptual research, one not addressed by this investigation, would be to explore the potential visual or aesthetic effects of neckties on perceptions of preferred vocal sound, in both ensemble and solo contexts. Future studies, for example, might invite participants to rate a series of video recordings featuring the same audio track but differing in whether the performers wear neckties or not.

Few vocal pedagogy resources address the potential acoustical and perceptual ramifications of wearing neckties while singing. Given the primary results of this investigation, voice teachers and choir directors may wish to consider addressing this matter in their teaching, especially with singers who may not wear neckties except for special occasions. There may be various visually aesthetic and social reasons for donning a necktie to sing publicly. Yet there may be for particular singers some unanticipated, nuanced acoustical and perceptual drawbacks to doing so. A potential short-term solution for such an issue could be incorporating the wearing of neckties into the rehearsal process earlier on to give singers (and directors) the opportunity to acclimate to a potentially implicating variable.

Ellerbee (*n.d.*) laments, “If men can run the world, why can’t they stop wearing neckties? How intelligent is it to start the day by tying a little noose around your neck?” While perhaps tongue in cheek, her latter question serves to underscore that for singers wearing a necktie may not be simply a fashion decision.

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Appendix A

THE UNIVERSITY OF KANSAS
Research

APPROVAL OF PROTOCOL

April 18, 2016

Evan Edwards

Dear Evan Edwards:

On 4/18/2016, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	The Effect of Wearing a Necktie on Acoustic and Perceptual Measures of Male Choral Sound
Investigator:	Evan Edwards
IRB ID:	STUDY00003969
Funding:	None
Grant ID:	None
Documents Reviewed:	• Necktie Consent Script.docx, • Necktie HSCL Submission.pdf, • Necktie Analog Scale.docx, • Listening Panel Questionnaire .docx

The IRB approved the submission from 4/18/2016 to 4/17/2017.

1. Before 4/17/2017 submit a Continuing Review request and required attachments to request continuing approval or closure.
2. Any significant change to the protocol requires a modification approval prior to altering the project.
3. Notify HSCL about any new investigators not named in original application. Note that new investigators must take the online tutorial at https://rgs.drupal.ku.edu/human_subjects_compliance_training.
4. Any injury to a subject because of the research procedure must be reported immediately.
5. When signed consent documents are required, the primary investigator must retain the signed consent documents for at least three years past completion of the research activity.

If continuing review approval is not granted before the expiration date of 4/17/2017 approval of this protocol expires on that date.

Please note university data security and handling requirements for your project:
https://documents.ku.edu/policies/IT/DataClassificationandHandlingProceduresGuide.htm

You must use the final, watermarked version of the consent form, available under the "Documents" tab in eCompliance.

Sincerely,

Stephanie Dyson Elms, MPA
IRB Administrator, KU Lawrence Campus

THE UNIVERSITY OF KANSAS
Research

APPROVAL OF PROTOCOL

January 17, 2017

Evan Edwards
evanucm@ku.edu

Dear Evan Edwards:

On 1/17/2017, the IRB reviewed the following submission:

Type of Review:	Modification
Title of Study:	The Effect of Wearing a Necktie on Acoustic and Perceptual Measures of Male Choral Sound
Investigator:	Evan Edwards
IRB ID:	STUDY00003969
Funding:	None
Grant ID:	None
Documents Reviewed:	• Necktie Consent Script.docx, • Necktie HSCL Submission.pdf, • Solo Listening Panel Questionnaire .docx

The IRB approved the study from 1/17/2017 to 4/17/2017.

1. Before 4/17/2017 submit a Continuing Review request and required attachments to request continuing approval or closure.
2. Any significant change to the protocol requires a modification approval prior to altering the project.
3. Notify HSCL about any new investigators not named in original application. Note that new investigators must take the online tutorial at https://rgs.drupal.ku.edu/human_subjects_compliance_training.
4. Any injury to a subject because of the research procedure must be reported immediately.
5. When signed consent documents are required, the primary investigator must retain the signed consent documents for at least three years past completion of the research activity.

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Please note university data security and handling requirements for your project:
https://documents.ku.edu/policies/IT/DataClassificationandHandlingProceduresGuide.htm

You must use the final, watermarked version of the consent form, available under the "Documents" tab in eCompliance.

Sincerely,

Stephanie Dyson Elms, MPA
IRB Administrator, KU Lawrence Campus

Appendix B

Consent Script (Men's Chorus)

As a student in the University of Kansas' Department of Music Education/Music Therapy, I am conducting a research project about the effect of neckties on phonation. This study requires you to be audio recorded several times with and without a necktie and to fill out a perception survey. Recorded data will be locked in a file cabinet within Murphy Hall until it can be analyzed and subsequently deleted. This will take place no later than May 2017. In addition to the researcher, several graduate choral students and music faculty will listen to the recordings. Your participation is expected to take about 30 minutes. Audio recording is required for participation, but you have no obligation to participate. You may ask the recording cease and discontinue your involvement at any time.

Your participation should cause no more discomfort than you would experience in your everyday life. Although participation may not benefit you directly, the information obtained from the study will help us gain a better understanding of the effect neckties have on phonation. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Participation in the survey indicates your willingness to take part in this study and that you are at least 18 years old. Should you have any questions about this project or your participation in it you may ask me or my faculty supervisor, Dr. Daugherty, at the Department Music Education/Music Therapy. If you have any questions about your rights as a research participant, you may call the Human Subjects Protection Office at (785) 864-7429 or email irb@ku.edu.

Consent Script (Expert Listening Panel)

As a student in the University of Kansas' Department of Music Education/Music Therapy, I am conducting a research project about the effect of neckties on phonation. You will listen to two recordings of a men's ensemble singing with and without a necktie and manipulate a Continuous Response Digital Interface (with anchors of "Less Pleasing Overall Sound" and "More Pleasing Overall Sound") to evaluate choral sound. Your participation is expected to take about 10 minutes. You have no obligation to participate and you may discontinue your involvement at any time.

Your participation should cause no more discomfort than you would experience in your everyday life. Although participation may not benefit you directly, the information obtained from the study will help us gain a better understanding of the effect neckties have on phonation. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Participation in the survey indicates your willingness to take part in this study and that you are at least 18 years old. Should you have any questions about this project or your participation in it you may ask me or my faculty supervisor, Dr. Daugherty, at the Department Music Education/Music Therapy. If you have any questions about your rights as a research participant, you may call the Human Subjects Protection Office at (785) 864-7429 or email irb@ku.edu.

Consent Script (Solo Singers)

As a student in the University of Kansas' Department of Music Education/Music Therapy, I am conducting a research project about the effect of neckties on phonation. This study requires you to be audio recorded several times with and without a necktie and to fill out a perception survey. Recorded data will be locked in a file cabinet within Murphy Hall until it can be analyzed and subsequently deleted. This will take place no later than May 2017. In addition to the researcher, several graduate choral students will listen to the recordings, but will not have access to them beyond the date of the listening. The researcher will maintain sole possession of recorded material until it is destroyed following the conclusion of data analysis. Your participation is expected to take about 30 minutes. Audio recording is required for participation, but you have no obligation to participate. You may ask the recording cease and discontinue your involvement at any time.

Your participation should cause no more discomfort than you would experience in your everyday life. Although participation may not benefit you directly, the information obtained from the study will help us gain a better understanding of the effect neckties have on phonation. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Participation in the survey indicates your willingness to take part in this study and that you are at least 18 years old. Should you have any questions about this project or your participation in it you may ask me or my faculty supervisor, Dr. Daugherty, at the Department Music Education/Music Therapy. If you have any questions about your rights as a research participant, you may call the Human Subjects Protection Office at (785) 864-7429 or email irb@ku.edu.

Consent Script (Solo Expert Listening Panel)

As a student in the University of Kansas' Department of Music Education/Music Therapy, I am conducting a research project about the effect of neckties on phonation. You will listen to twelve recordings of six different male soloists singing with and without a necktie and manipulate a Continuous Response Digital Interface (with anchors of "Less Pleasing Overall Sound" and "More Pleasing Overall Sound") to evaluate solo sound. Your participation is expected to take about 30 minutes. You have no obligation to participate and you may discontinue your involvement at any time.

Your participation should cause no more discomfort than you would experience in your everyday life. Although participation may not benefit you directly, the information obtained from the study will help us gain a better understanding of the effect neckties have on phonation. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission.

Participation in the survey indicates your willingness to take part in this study and that you are at least 18 years old. Should you have any questions about this project or your participation in it you may ask me or my faculty supervisor, Dr. Daugherty, at the Department Music Education/Music Therapy. If you have any questions about your rights as a research participant, you may call the Human Subjects Protection Office at (785) 864-7429 or email irb@ku.edu.

Appendix C

Voice Part: ____________ Age: ______ How often do you wear a necktie? ____________________

Are you experiencing today any issues affecting vocal production (e.g. allergies, cold/flu, etc.)?

____

DIRECTIONS: Please draw a vertical line somewhere along the scale that reflects your ease of singing.

Minimum Vocal Ease | Maximum Vocal Ease

Appendix D

Expert Listening Panel Questionnaire

1. Sex: ________

2. Age:________

3. Years of choral experience (singing, directing, adjudication, etc.): ______________

4. Choral experience (circle all that apply):

   a. Singing in a choir: Grade school, Collegiate, Community, Professional
   b. Directing choir: Grade school, Collegiate, Community, Professional
   c. Adjudicating choir: Grade school, Collegiate, Community, Professional
   d. Choral clinician: Grade school, Collegiate, Community, Professional

5. Was there a difference between Recording A and Recording B?

   Yes No

   If so, which recording had a more pleasing overall sound?

   Recording A Recording B

Appendix E

Expert Listening Panel Questionnaire

1. Name: ___________________________________
2. Sex: ________
3. Age:________
4. Solo voice experience:
    Performing (years): _______
    Brief description:

    Teaching (years): _______
    Brief description:

    Adjudicating (years): _______
    Brief description:

Singer 1:
Was there a quality difference between Recording A and Recording B?

Yes No

If so, which recording had a more pleasing overall sound?

Recording A Recording B

Singer 2:
Was there a quality difference between Recording A and Recording B?

Yes No

If so, which recording had a more pleasing overall sound?

Recording A Recording B

Singer 3:
Was there a quality difference between Recording A and Recording B?

Yes No

If so, which recording had a more pleasing overall sound?

Recording A Recording B

Singer 4:
Was there a quality difference between Recording A and Recording B?

Yes No

If so, which recording had a more pleasing overall sound?

Recording A Recording B

Singer 5:
Was there a quality difference between Recording A and Recording B?

Yes No

If so, which recording had a more pleasing overall sound?

Recording A Recording B

Singer 6:
Was there a quality difference between Recording A and Recording B?

Yes No

If so, which recording had a more pleasing overall sound?

Recording A Recording B