

Acoustic and Perceptual Impacts of Straw Phonation Exercises on Barbershop Quartets: A Pilot Study

Context

Semi-Occluded Vocal Tract Exercises (SOVTEs) - vocal exercises featuring a partially-closed mouth including lip and tongue trills, voiced fricatives, and straw/tube phonation (STP) - are commonly utilized in voice therapy and vocal music education (Titze, 2006). Previous research suggests that SOVTEs may improve vocal efficiency in both speech (Guzmán *et al.*, 2013; Kang *et al.*, 2019b; Laukkanen *et al.*, 2011) and singing contexts (B. Manternach, Maxfield, and J. Manternach, 2021; Kang *et al.*, 2019b). However, these studies have primarily focused on individual vocalists or Western Classical choral ensembles (Manternach and Daugherty, 2019; Manternach, Kotsonis, and Mann, 2022; Manternach, Schloneger, and Maxfield, 2019). Only one known study to date (Manternach and Clark, 2018) focused on a barbershop chorus (BC), and none have focused on barbershop quartets (BQs). This study will address a literature gap and adapt the methodology of Manternach and Clark (2018) to study how a brief straw phonation (SP) regimen impacts objective acoustic data and subjective perceptual observations of BQs.

Justification

Most barbershoppers are avocational singers who lack substantial vocal training outside of their barbershop experience (Gongaware, 2025). This positions barbershop ensemble directors and vocal coaches to strongly influence the vocal technique of the singers with whom they work, including helping them improve their baseline vocal efficiency. According to the Barbershop Harmony Society's (BHS) Contest and Judging Committee (BHSSCJC), this is especially critical for barbershop singers, as "expanded sound" (BHSSCJC, 2025, pp. 39), or the sense that an ensemble's total sound is greater than the sum of its individual parts, is a defining characteristic of the barbershop style and is achieved in part by barbershop singers utilizing precise intonation, balanced vocal fold closure, and complementary resonance strategies to reinforce each other's harmonics.

Previous research has shown that SP may improve singers' vocal efficiency, including singers in BCs (Manternach and Clark, 2018), which supports the use of SP in BC settings. No known research has investigated their impact on BQs, so a pilot study will help establish a baseline of how SP impacts the objective acoustic properties and subjective perceptual observations of BQ sound.

Intended Impact

This pilot study will provide preliminary evidence of how SP impacts the acoustic properties of BQ sound, third-party expert listeners' (EL) perception of BQ sound, and BQ singers' perception of their sound and singing experience. If evidence is found that SP may have a significant positive impact on the acoustic output or perceptions of the quartet sound or singing experience, this would support the use of SP as an intervention in BQ settings. This study could also serve as a model for future research on how other vocal exercises or resonance strategies impact the acoustic output of BQ sound, as well as perceptions of that sound.

Outlined Intention

In Phase One of this project, I will review the literature related to the impact of STP on the voice, with particular emphasis on peer-reviewed studies on STP in ensemble-singing. I will also review literature on other relevant topics such as experimental and survey design as needed to support my Phase Two work and inform my experimental protocol.

Next, I will use findings from my literature review to design the experiment in Phase Two of this project. I will make key methodological decisions including QP and ELP inclusion criteria, which type of straw to use for the SP regimen, which specific vocal exercises will be included in the SP regimen, recording specifications, and which questions will be included in the QP survey based on combining findings from my literature review as well as my anecdotal experience coaching BQs.

Phase Three will involve recruiting participants, based on criteria determined in Phase Two. I will first develop informed consent forms and recruitment communication strategies for each participant type and then reach out to potential participants until I reach the target number of commitments for each participant type.

I will then attend the Summer Vocology Institute (SVI) at the University of Utah for Phase Four of my project, where I will complete courses including Principles of Voice Production by Ingo Titze and Instrumentation for Voice Analysis by Lynn Maxfield. Learnings from SVI - in particular these courses - will help me firmly ground my methodology in scientific principles of SOVTEs and SP and align my acoustic data collection and analysis methods with established best practices.

In Phase Five, I will first complete the experimental protocol to collect acoustic and perceptual data from QPs. After this, I will share the quartet recordings with the ELPs so they can submit a Singing score for each recording. Then, I will jointly analyze the acoustic, perceptual, and scoring data to determine what impacts the SP had on the acoustic output of the participant quartets, the perceptions of the singing experience and quartet sound from the perspective of the quartet singers, and/or the perceptions of the quartet sound from the perspective of the ELPs.

Finally, in Phase 6, I will write my paper summarizing the project and my findings, implications for BQ singers and coaches, and recommendations for future research on these topics.

Timeline

Task Number	Task Title	Start Date	End Date	Duration (Days)	Week Number																																
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
1	Conduct literature search and review	2026-03-01	2026-04-30	60																																	
1.1	Conduct literature search and review	2026-03-01	2026-04-30	60																																	
2	Design experiment	2026-05-01	2026-05-31	31																																	
2.1	Finalize research question(s)	2026-05-01	2026-05-07	7																																	
2.2	Determine eligibility criteria for quartets	2026-05-08	2026-05-14	7																																	
2.3	Determine recording specifications and experimental protocol	2026-05-14	2026-05-31	18																																	
3	Recruit participants	2026-06-01	2026-08-12	72																																	
3.1	Develop informed consent forms	2026-06-01	2026-06-07	7																																	
3.2	Develop recruitment strategy	2026-06-08	2026-06-14	7																																	
3.3	Contact potential participants	2026-06-15	2026-07-31	47																																	
3.4	Finalize data collection arrangements	2026-08-01	2026-08-12	12																																	
4	Attend Summer Vocology Institute	2026-06-08	2026-07-23	46																																	
4.1	Complete Principles of Voice Production	2026-06-08	2026-06-26	19																																	
4.2	Complete Instrumentation for Voice Analysis	2026-06-29	2026-07-10	12																																	
4.3	Complete Voice Habilitation	2026-06-29	2026-07-17	19																																	
4.4	Complete Voice for Performers	2026-07-15	2026-07-23	9																																	
5	Collect and analyze data	2026-08-12	2026-09-07	26																																	
5.1	Conduct experiment/collect acoustic data	2026-08-12	2026-08-23	12																																	
5.2	Collect expert listener perceptual data	2026-08-24	2026-08-31	8																																	
5.3	Analyze experimental data	2026-09-01	2026-09-07	7																																	
6	Write paper	2026-08-26	2026-10-07	42																																	
6.1	Write draft of paper	2026-08-26	2026-09-15	20																																	
6.2	Revise paper	2026-09-15	2026-09-30	16																																	
6.3	Submit final paper	2026-09-30	2026-09-30	1																																	
6.4	Prepare and execute presentation	2026-09-30	2026-10-07	8																																	

Expected Learning Outcomes

By completing this study, I expect to learn at a high level whether SP impacts BQ singers similarly to how it has been shown to impact singers in other styles of music. Anecdotal evidence suggests that SP does have similar impacts for BQ singers, but this study will potentially produce concrete evidence of such impacts, and such evidence would support the continued employment of SP as a vocal exercise by BQs. Additionally, I expect to learn whether SP seems to impact singers of different voice parts or BQs of different voicings differently. In my coaching practice, I am often tasked with recommending exercises that will provide as much positive impact as possible for a singer or quartet in a given situation. Therefore, any evidence of whether SP is likely to have a particularly large or small positive impact - or even a negative impact - on a singer will play into my decision-making process moving forward, and may change whether I employ SP as a strategy in different scenarios.

Ethical Considerations

Informed consent is critical in all human research, so I will summarize this study along with participants' rights, answer all questions, and obtain written consent from all participants prior to their participation. Data privacy is also paramount, so I will follow standard practices like collecting only data that are necessary for the study, saving data in password-protected locations accessible only to me, and deleting data upon project completion. I will securely share quartet recordings only with the ELPs, and I will remove all personally identifiable information from the recordings before doing so.

I will set eligibility requirements and design the experimental protocol to maximize consistency and minimize the risk of biased results. I will use neutral wording for instructions to avoid implying any hypotheses

or expected outcomes to QPs to avoid influencing their responses to the post-experiment survey. I will also design the ELP survey in a way that minimizes risk of listener bias and encourages honest and objective evaluations of the recordings.

Finally, I am undoubtedly an insider researcher within the barbershop community. I may have a pre-existing relationship with some of the participants, or some participants may have preconceived notions about me given my position as a choral leader, coach, and Singing Judge. This could create a power dynamic between me and the participants in this research, or participants could feel pressure to respond to survey questions dishonestly but in alignment with the types of responses they feel I am looking for. To help mitigate this risk, I will attempt to recruit quartet singer participants with whom I do not have a close prior relationship and also not disclose any research hypotheses with the quartet singer participants before finishing data collection.

Acoustic and Perceptual Impacts of Straw Phonation Exercises on Barbershop Quartets: A Pilot Study

Introduction

Previous research on the potential benefits of straw phonation (SP) has shown that it may improve vocal economy in both speech and singing, including choral ensemble singing (Manternach and Clark, 2018; Manternach and Daugherty, 2019; Manternach, Kotsonis, and Mann, 2022; Manternach, Schloneger, and Maxfield, 2019). Only one previous study researched SP in the context of barbershop chorus (BC) singing (Manternach and Clark, 2018), and no known research to date has studied the impact of SP on barbershop quartet (BQ) singing. Although there is not yet directly-relevant empirical evidence to support it, anecdotally straw phonation is employed by some BQ singers and quartet coaches, seemingly with the assumption that they can expect similar benefits from SP as have been observed in other previously-researched settings.

Since they are mostly avocational singers who lack substantial vocal training outside of their barbershop experience (Gongaware, 2025), barbershop singers in general may substantially benefit from improving their baseline vocal efficiency, and therefore potentially from practicing SP. In particular, BQ singers may benefit even more from improved vocal efficiency than BC singers. While a BC singer is typically one of multiple voices in a section, a BQ singer is the only individual in their ensemble singing their voice part. This means that unlike BC singers who may practice stagger breathing throughout a song and strategically opt out of notes that are in uncomfortable parts of their voices, BQ singers must sing every note in the arrangements they perform, and therefore must approach breathing in a way that permits this (BHSSCJC, 2025). Anecdotally, these additional requirements faced by quartet singers make it more likely that they will experience adverse effects of vocal fatigue and make establishing and maintaining vocal efficiency crucial.

Despite these higher stakes, there is a literature gap on potential impacts of SP on BQ singers' perceptions of their own singing and sound, the acoustic output of BQs, and EL's perceptions of BQs' sound. This pilot study will address this gap and its aims and objectives are outlined below:

Aims

- To generate pilot data on the impact of of SP on various aspects of BQ singing including the following:
 - Singers' perceptions of their individual vocal effort (VE) level
 - Singers' perceptions of the feeling and sound of their individual singing
 - Singers' perceptions of their quartet's sound
 - Long-term average spectrum (LTAS) of BQ sound
 - BHS Singing score awarded to a BQ's performance

- To investigate how the impact of SP on BQs may vary based on the following potential factors:
 - Quartet Classification (Men's, Mixed Harmony, and Women's)
 - Barbershop Voice Part (Tenor, Lead, Baritone, and Bass)
 - Previous SP Experience
 - Use of SOVTEs in vocal warm up

Objectives

- Identify potential benefits of SP for BQ singers to justify its use as a vocal exercise in BQ settings
- Identify how SP impacts may vary across different groups of barbershop singers and BQs
- Identify potential future research opportunities to build on this study's findings

Literature Review

Foundational Studies

Peer-reviewed research into STP stems from the work of Bickley and Stevens (1986), who observed that vocal tract constrictions impact vocal fold vibration and therefore the resulting sound. Other authors theorized that this was because SOVTEs, including SP, increase vocal tract input impedance, thereby influencing characteristics of vocal fold vibration, as well as amplitude and harmonic content of the glottal pulse (Titze and Story, 1997; Story, Laukkanen, and Titze, 2000; Titze and Laukkanen, 2007). Bele (2005) highlights the utility of SOVTEs in voice therapy for conditions like vocal nodules and paresis, as well as helping “normal-voiced subjects obtain a brighter and more sonorous voice quality” (p. 38). More recent research has shown that SOVTEs improve vocal efficiency and economy (Titze, 2006) by helping voice users produce sound with lower phonation threshold pressure (PTP) and a non-pressed tone (Titze *et al.*, 2021). Each SOVTE posture produces a unique impedance level (Titze, 2020), suggesting that BQ coaches have a variety of options at their disposal to test and decide which is most effective for each singer and vocal task. Foundational studies like these led to a plethora of other studies on impacts of SOVTEs, including ones focused on individual and ensemble singing which are most immediately relevant to the current study.

Acoustic Impacts of STP

Acoustic measurements of vocal output have frequently been outcomes of interest in STP studies. However, studies reporting statistically-significant acoustic impacts of STP are relatively rare, with authors often noting no significant changes (Bonette *et al.*, 2020; Costa *et al.*, 2011; Devadas, Vinod, and Maruthy, 2022; de Oliveira, *et al.*, 2022; Di Natale *et al.*, 2022; Fujiki, Huber, and Sivasankar, 2021; Kang *et al.*, 2018; Kang *et al.*, 2019a; Paixão *et al.*, 2021; Piragibe *et al.*, 2020) or foregoing statistical testing entirely due to insufficient sample size (Mailänder, Mühre, and Barsties, 2017; B. Manternach, Maxfield, and J. Manternach, 2021).

STP has been shown to significantly impact key acoustic measures of vocal clarity and periodicity. STP has been shown to contribute to immediate improvement in cepstral peak prominence (CPP) (Yu *et al.*, 2025), as well as improvements in smoothed CPP both immediately (Antonetti *et al.*, 2022; Ülvan *et al.*, 2024) and longitudinally (Wu and Chan, 2020). STP has also been shown to significantly improve other acoustic measurements like jitter (Ülvan *et al.*, 2024), shimmer (Yu *et al.*, 2025), and harmonics-to-noise ratio (HNR) (Wu and Chan, 2020). While no statistical analysis was done, Brian Manternach, Maxfield, and Jeremy Manternach (2021) found that SP may induce modest improvement in jitter, shimmer, HNR, and CPP, supporting usage of SP in contemporary singing styles. This body of research suggests that regular SP practice may help BQ singers achieve greater vocal clarity and consistency, both of which are stylistically important for barbershop and are rewarded in BHS contests (BHSSCJC, 2025). Since this study is focused on the overall acoustic output of a vocal ensemble rather than individual vocalists, metrics like these will not be studied, but future researchers could also explore SP's impact on each individual singer's acoustic output.

Likely related to the increased clarity and periodicity described above, SP has been associated with higher sound pressure level (SPL) and wider frequency range, meaning that SP may help people achieve louder dynamics and more extreme pitches with a similar vocal approach and effort level. Laukkanen *et al.* (2011) observed an increase in overall SPL and SPL of the speaker's formant cluster frequency range following SP. Additionally, Ter and Wong (2022) noted an increase in maximum intensity and voice range profile (VRP) - a measure of a person's minimum and maximum achievable intensity levels across their vocal range - following SP. These studies reiterate that SP may increase vocal economy and efficiency, and therefore may be a useful vocal exercise for BQ singers.

Previous research also supports SP as an effective exercise to warm up the voice, as well as reset or cool down the voice following a period of vocal loading. Singers completing a traditional vocal warm up have been shown to experience a notable decrease in SPL following their warm up, while similar singers completing an SOVTE-based regimen including SP did not (Portillo *et al.*, 2018; Saldías *et al.*, 2020). This suggests that the SOVTE groups may have been impacted less by vocal fatigue than the traditional warm up groups. Ülvan *et al.* (2024) also found that SP reduced jitter and CPP following vocal loading, similar to what may be experienced in the middle or later parts of a BQ rehearsal. While additional research is needed, SOVTE-based vocal exercises including SP may help BQ singers achieve greater vocal clarity and consistency when used as a warm up exercise preceding a singing session, and also may help preserve vocal clarity and consistency throughout a singing session.

Other studies investigating acoustic impacts of STP provide important learnings for future research methodology, including for this study. Manjunatha, Nayak, and Bhat (2022) utilized SP as a vocal warm up exercise for speech language pathologists (SLPs) and noted a significant post-exercise change in formant 1 frequency, along with notable but insignificant changes in other acoustic variables such as other formant frequencies, intensity, and shimmer. Perhaps one contributing factor to why this study produced stronger acoustic results than other studies is that the participants, SLPs, were likely familiar with proper SP technique, and so they may have been employing the technique more efficiently than subjects in other studies who lacked

that a priori knowledge. This warrants careful consideration of the SP knowledge and experience level of subjects in this study. While it may be impossible to study participants with identical levels of SP knowledge and experience, it will be important to consider this potential confounding variable when analyzing the data. Another recent study has shown that SP provides acoustic benefits up to a certain point, after which the benefits degrade (Tetik-Hacıtahtiroğlu and Düzenli-Öztürk, 2025). Men received their maximal voice quality effects after 5-7 minutes of SP, while women received their maximal voice quality effects after 3-5 minutes of SP. Additionally, Echternach observed that only 5 minutes after completing a STP-in-water (STPW) exercise, participants experienced declines in the efficiency gained from the exercise. These findings support testing an SP regimen that takes about 5-minutes to complete so that all participants are near their point of maximal potential benefit at the time of their post-SP performance.

STP Research on Self-Assessment of Vocal Function

Another common outcome of interest in STP research is self-assessments of how STP impacted the participants' voices and vocal production. In longitudinal studies, researchers have often employed standardized scales like VHI or the Vocal Fatigue Index (Nanjundeswaran *et al.*, 2015) to measure how regular STP practice impacted participants' typical vocal quality-of-life (VQOL). Most evidence suggests that regular STP practice improved VQOL ratings over time (Davis *et al.*, 2024; de Souza, Masson, and de Araujo, 2017; Guzmán *et al.*, 2023; Heller-Stark *et al.*, 2024; Kaspner-Smith *et al.*, 2015; Mailänder, Mühre, and Barstie, 2017; Wu and Chan, 2020; Yu *et al.*, 2025). However, the literature is not unanimous on this finding, as at least one study failed to detect significant improvement in VQOL over time with regular STP practice. (Meerschman *et al.*, 2017). This study is focused on immediate impacts of SP on BQs so VQOL metrics will not be measured, but future research could explore how regular SP practice impacts BQ singers' VQOL over longer intervals.

Other studies explored the self-assessment of immediate impacts of STP on participants' voices and vocal production, employing other scales including the Borg CR10 scale of VE (van Leer and van Mersbergen, 2017) and the OMNI VE scale (Shoffel-Havakuk *et al.*, 2018), among others. Experimental participants often reported perceiving their voice to be easier and/or better following STP (Bonette *et al.*, 2020; Costa *et al.*, 2011; Gonçalves *et al.*, 2019; Manjunatha, Nayak, and Bhat, 2022; Sampaio, Oliveira, and Behlau, 2008). Participants have also reported improvement in more specific vocal attributes like perceived VE (Duke *et al.*, 2015; Fujiki, Huber, and Sivasankar, 2021; Manternach, B., Maxfield, and Manternach, J., 2021; Moura *et al.*, 2025; Ülvan *et al.*, 2024), vocal clarity (Di Natale *et al.*, 2022), vocal power (Di Natale *et al.*, 2022), resonant/sonorous voice quality (Di Natale *et al.*, 2022; Guzmán *et al.*, 2017; Portillo *et al.*, 2018), sensation of muscle relaxation (Guzmán *et al.*, 2017), ease of vocal production (Portillo *et al.*, 2018), increased phonatory comfort (Di Natale *et al.*, 2022; Gonçalves *et al.*, 2019), low pitched voice symptom in male participants (Antonetti *et al.*, 2022), and other vocal, laryngeal, respiratory, and articulatory sensations (Piragibe *et al.*, 2020). Other studies, however, were inconclusive (Antonetti *et al.*, 2019; Devadas, Vinod, and Maruthy, 2023; Paixão *et al.*, 2021; Whittling *et al.*, 2023), signalling the need for additional research. I have anecdotally

observed similar impacts in my own voice after completing STP exercises in a BQ context and have heard similar reports of perceived impact from STP from other BQ singers, suggesting that these benefits may transfer to BQ singing.

Of particular interest for this study's experimental protocol is research studying self-reported vocal effort levels (VELs) after different durations of STP. Paes and Behlau (2017) noted that normal-voiced participants' self-reported VELs remained statistically flat up to seven minutes of STP, while participants' with dysphonia saw dramatic reductions in VELs up to three minutes of STP, with effort levels after three minutes increasing, eventually reaching the baseline level. Therefore, dysphonic participants may be more greatly impacted by STP than normal-voiced patients, which is an important lens through which to interpret this study's results. Other studies have found that females reported more negative vocal sensations and increased VE following seven to ten minutes of STP (Bassetto and Constantini, 2024; Tetik-Hacıtahtiroğlu and Düzenli-Öztürk, 2025), while males experienced increased VE and discomfort following ten minutes of STP. These studies suggest that impacts of STP may differ by sex, especially after about seven minutes of STP, which is a key consideration for both study design and data analysis.

STP Research on Expert Listener Assessment of Vocal Function

Studies involving panels of expert listeners (ELs) have returned mixed results. Enflo *et al.* (2013) solicited feedback from a panel of ELs on their participants' vocal performance following STPW, finding that the listeners generally perceived an improvement in voice quality following STPW, and perceived the largest improvement in singers with the least experience and who practiced least frequently. Given that barbershoppers are primarily amateur singers (Gongaware, 2025), they may benefit from exercises like SP even more on average than singers with more formal training or experience. Another study reported that a panel perceived better voice quality from women after 3-5 minutes of SP, with no other differences noted (Bassetto and Constantini, 2024) perhaps in part due to the more prominent glottal gap present in vocally healthy females than males (Cielo *et al.*, 2019). This suggests that soprano-soprano-alto-alto (SSAA) or soprano-alto-tenor-bass (SATB)-voiced barbershop ensembles may benefit more from SP than tenor-tenor-bass-bass (TTBB)-voiced barbershop ensembles. Conversely, panels in other experiments did not detect any meaningful difference in voice quality following SP (Bonette *et al.*, 2020; Di Natale *et al.*, 2022; Fadel *et al.*, 2015). More research involving EL panels is needed to more clearly understand perceptual impacts of SP on voice quality.

STP Research on Vocal Ensembles

The body of extant research most closely related to this study is the set of studies on the impact of STP on vocal ensembles. Manternach, Clark, and Daugherty (2017) opened this line of inquiry by testing the impact of a brief SP protocol on the long-term average spectrum (LTAS) of a mixed choir, finding that the ensemble experienced a significant boost in spectral energy in the 0 - 10 kHz and 2 - 4 kHz frequency bands, although these increases were unlikely to be perceptible by the average listener.

Manternach and Daugherty (2019) again tested the impact of a SP protocol on a mixed choir's acoustic output, along with the choir members' perceptions of their choral sound. While there was not a statistically-significant increase in spectral energy following the SP protocol, most choir members felt that the ensemble's sound and their individual vocal economy improved.

Manternach, J.N., Schloneger, and Maxfield, L. (2019) noted the potential for bias in relying on self-reported participant perceptual data in a one-group, pretest-posttest study, so they employed a two-group design, testing SP against a neutral vowel protocol in two comparable choral ensembles. They collected acoustic data and perceptual data from ELs, finding that both ensembles experienced an increase in spectral energy following their respective protocols, with the SP group experiencing an increase of over 1 decibels (dB) SPL across the entire spectrum. The EL data were inconclusive, as increased acoustic energy in the post-test groups was noted just over half the time, with some ELs feeling that they experienced increased acoustic energy in the pre-test groups. This signals that even ELs may struggle to detect differences in full-spectrum LTAS that is theoretically above the level of just-noticeable difference (JND) threshold of 1 dB SPL (Howard and Angus, 2009). Rather than exploring whether BHS Singing Judges accurately perceive LTAS differences, my study will investigate how they would score a pre-SP and post-SP recording of the same song from the same quartet, and therefore implicitly which performance they perceive to be holistically stronger. Of course LTAS is but one aspect of an ensemble's sound that may influence the perception of overall quality, so future studies may wish to investigate the relationship between an array of aspects of ensemble sound and BHS Singing score.

Manternach, Kotsonis, and Mann (2022) observed that some SP novices reported difficulty performing the protocol, and the researchers wanted to test whether results notably differed after multiple SP sessions. The study involved four choirs who completed a SP protocol in their vocal warmup in four consecutive rehearsals, with data collected at the first and fourth rehearsals. Choristers reported improved choral sound and ease of singing on both data collection days, with a perceived greater impact at the fourth rehearsal. Each choir experienced increased acoustic energy following the protocol on both days, with the increase for one choir being highest on day one, the increase for another being highest on day four, and the increase for the remaining two choirs being statistically comparable on both days, suggesting a possible mild acclimation effect. Like the VQOL metrics previously discussed, ensemble differences over multiple sessions will be out-of-scope for this one-session study, but future longitudinal research could investigate whether quartets completing multiple SP sessions may experience a similar acclimation effect.

The most relevant study to mine is one by Manternach and Clark (2018) which so far represents the only SP-related research involving a barbershop ensemble. They tested the impact of SP on the acoustic output and perceptual observations of a TTBB barbershop chorus, finding that following SP, the chorus had approximately 1 dB SPL increased acoustic energy across the entire spectrum, and most ensemble members noted improvements in the group's overall sound and their own individual vocal efficiency. These findings are the strongest evidence to-date of potential positive impacts of SP on barbershop ensembles. Clearly, the improvement in singers' perceptions of the overall ensemble sound and the efficiency of their own singing are

desirable changes that may be associated with SP. Additionally, increased acoustic energy - especially in the 2 kHz - 4 kHz range where the human ear is most sensitive (Fletcher and Munson, 1933) - may be perceived as a higher degree of ring and expansion in the sound, which would likely be rewarded with higher Singing scores in a BHS contest (BHSSCJC, 2025), all else equal. Of course, it is possible that SP induces additional acoustic changes that are not captured by LTAS that would impact the BHS Singing score differently. Until and unless evidence emerges that LTAS and BHS Singing score are strongly correlated, LTAS measures should be viewed as an imperfect proxy for overall vocal output.

Methodology and Methods

As I amass additional knowledge and experience in voice pedagogy, I increasingly view my practice-based research through the pragmatic paradigm. The definition of vocology - “the science and practice of voice habilitation” (Titze and Verdolini Abbott, 2012, p. 11) - encapsulates this well and implicitly acknowledges that voice training is not an objective science. Furthermore, the artistic nature of the barbershop singing voice adds an additional layer of subjectivity to my practice and research. Pragmatism is well-suited for practice-based research on barbershop voice pedagogy, as it prioritizes research that helps improve pedagogical practice and acknowledges value in both quantitative and qualitative research methods (Denscombe, 2010). Given this blend of art and science in my practice and research, this study is also grounded in a constructivist epistemology, valuing both objective measures of and subjective interpretations of reality (Pretorius, 2024).

The following methodology, was approved by the University of Wales Trinity Saint David’s (UWTSD) Research Ethics Committee and was largely based on previous studies on the impact of SOVTEs on vocal ensembles (Manternach, Clark, and Daugherty, 2017; Manternach and Clark, 2018; Manternach and Daugherty, 2019; Manternach, Schloneger, and Maxfield, 2019; Manternach, Kotsonis, and Mann, 2022) with some key differences as noted below.

Research Questions

This study investigated the following research questions:

What impact does a brief SP regimen have on...

- ...BQ singers’ perceptions of their individual VEL?
- ...BQ singers’ perceptions of the feeling and sound of their individual singing?
- ...BQ singers’ perceptions of their quartet’s sound?
- ...LTAS of BQ sound?
- ...the BHS Singing score awarded to a BQ’s performance?

Participants

This mixed-methods study featured two participant types: quartet participants (QP) and expert listener participants (ELP). To recruit potential QPs, I reached out directly to several BQs based within a 5-hour drive of my home. Five established, BHS-affiliated quartets ($n = 20$) with non-overlapping membership agreed to participate: one women's quartet (WQs), two mixed harmony quartets (MHQs) and two men's quartets (MQs), according to their official BHS gender classification. Quartet data collection took place on five separate occasions between 12 and 23 August 2026, with each session being conducted at the home of a member of the quartet and lasting approximately one hour. Before beginning each session, all QPs attested that they were at least 18 years of age, were vocally healthy, and were not experiencing vocal pain or discomfort. This study featured more distinct ensembles than the other previously-published studies on the impacts of SOVTEs on vocal ensembles, with the next largest number of distinct ensembles being only two (Manternach, Schloneger, and Maxfield, 2019).

To recruit ELPs, I contacted ten certified BHS Singing Judges directly via email. Eight of these ten individuals expressed interest in the study, and six ultimately participated. All ELPs ($n = 6$) were at least 18 years of age. I informed ELPs that this study was not sponsored by, endorsed by, or in any way affiliated with the BHS or the SCJC and that I was undertaking the study independently, despite using the standard BHS scoring system. Only one previously-published studies on the impacts of SOVTEs on vocal ensembles investigated EL ratings of choral sound (Manternach, Schloneger, and Maxfield, 2019). I recruited all participants directly, so both samples of participants are convenience samples (Berenson *et al.*, 2018). Prior to their participation, all participants were briefed on the study and their rights as participants, had the opportunity to ask clarifying questions, and subsequently provided informed consent.

The foremost ethical considerations in this study are related to my position as an insider researcher in the barbershop community. I have relationships with all QPs and ELPs that predate this study and have worked with many of them as a chorus director, coach, and/or judge. Despite this, I was careful to treat the informed consent requirements of the study seriously and ensured participants that they were under no obligation to answer every question, participate in every task, or even participate in the study at all if they were uncomfortable doing so. I also tried in the analysis and writing phases of the study to put aside any expectations or assumptions I had about what the results would look like going into the experiment and rather let the data speak for themselves. Finally, with this being my first research study working with human participants in an in-person experiment, I attempted to critically analyze each phase of the study and identify factors that may have influenced the results, as well as areas of improvement for potential future studies.

Procedures

After briefing QPs on the study and obtaining informed consent, I set a timer for 15 minutes and invited QPs to warm up, either individually or collectively, using methods of their choosing. During this period, I set up my recording equipment (ZOOM H6 Studio with 19.4 mm large diameter stereo X-Y microphones - see

Appendix 10) and marked the floor to simulate a typical microphone placement used in BHS quartet contests (Brooks, 2026). The setup was based on a regular hexagon with 21inch sides. Each singer stood in the middle of one of four adjacent sides and the microphone was placed in the middle of the octagon, facing the singers, at a distance of approximately 25.35 inches from each singer (see Appendices 5-7).

After the warm-up period, I instructed QP on where to stand and asked them to sing two brief passages to assist with microphone level setting: one at approximately the loudest volume they would be singing during the experiment and one at approximately the softest. I then used a sound level meter (Triplett SLM600 - see Appendix 11) to measure the intensity level of a relatively consistent sound (e.g. ambient noise in the room, quartet sustaining one chord at a constant volume) to use for intensity calibration in the acoustic data analysis phase.

QPs then performed one entire barbershop song from their repertoire and I recorded audio (WAV file, 32 bit float, 96 kHz sampling rate) of their performance. Following this performance, QPs completed a paper questionnaire with two questions: one asking them to rate their individual VEL during the performance on the OMNI VE Scale (OMNIVES) (Shoffel-Havakuk, 2018) and another asking them to describe how they warmed up before the performance. I chose the OMNIVES as my measurement scale over the Borg CR10 scale (van Leer and van Mersbergen, 2017) as I found it more likely to be intuitive and self-explanatory to a novice scale user than the Borg CR10, which would have required more explanation.

Next, I distributed one standard plastic drinking straw (Essential Everyday Flexible Plastic Straws, 7.625 inches/19.37 centimeters in length, 0.25 inches/6 millimeters in diameter - see Appendices 8 - 9) to each QP. I then instructed them on and modeled the proper SP technique for this study before leading them through a SP exercise protocol based on the protocol used in similar studies, which was originally presented in *Vocal Straw Exercise* (Titze, 2010). For each quartet, the SP protocol lasted approximately 4.5 to 5 minutes (270 to 300 seconds). A key difference between this study's methodology and those of previous studies is the type of straw used: previous studies like Manternach and Clark (2018) utilized narrow stirring straws with diameters between 2.5 and 3 mm rather than standard drinking straws. I chose to use standard drinking straws based on anecdotal evidence that some singers find that a narrow stirring straw induces vocal fatigue, and on the findings of Maxfield *et al.* (2014) that a standard drinking straw induced a more moderate amount of back pressure than a stirring straw. This was desirable to minimize risk of vocal discomfort or injury to QPs, but also may have contributed to differences in results compared to previous studies.

The SP protocol began with QPs completing six repetitions of a vocal glide beginning in their lower range, ascending to their upper range, and descending again back to their lower range (approximately 90 - 100 seconds). Then, QPs completed five repetitions of similar glides with added accents during both the ascending and descending glides. The first set of glides with accents included three accents in each section of the exercise (six accents total) (approximately 90 - 100 seconds). The number of accents per section increased incrementally, concluding with a set of glides featuring seven accents while ascending and another seven accents while descending. Finally, QPs performed 'The Star-Spangled Banner' through SP in the key of A-major and their choice starting octave (approximately 90 - 100 seconds). Throughout the protocol, I

reminded QPs to use abdominal support to try to maintain consistent tone throughout the exercise and avoid introducing neck muscle tension, and also to avoid pulses in their tone, instead striving to keep their tone smooth and connected. For ease of explanation, I chose to have QPs sing the entirety of 'The Star-Spangled Banner', where previous studies and the demonstration *Vocal Straw Exercise* omitted the second verse ("whose broad stripes...gallantly streaming"), making my protocol slightly longer than the ones previously studied.

Immediately after completing the SP protocol, QPs performed the same repertoire song they performed earlier again in its entirety from the same standing positions, and this was again audio recorded. Following performance two, QPs completed another questionnaire with seven questions: One question asked them to rate their individual level of VE in performance two on the OMNIVES (Shoffel-Havakuk, 2018) and the remaining questions asked about observed differences in the overall quartet sound and their own individual voice between the two performances, as well their previous SP experience. Participants could choose to opt out of a question by leaving it blank on their questionnaire forms.

Following QP data collection on 24 August 2026, I extracted the ten performance recordings and sent them to the eight potential ELPs, asking them to listen to each recording and score it according to the standard BHS scoring system (BHSSCJC, 2025). I pseudonymized all recordings and randomized the order in which they were presented, meaning that ELPs were not aware which quartets were featured in the recordings, nor were they aware of whether each recording was pre-SP or post-SP. Six of the eight potential ELPs provided informed consent and submitted scores for the full set of ten recordings by 31 August 2026.

I used Praat version 7.0 (Boersma, Weenink, and Shchupak, 2026) to construct the LTAS of each performance, using a 512-point analysis window and a Hanning window for each. I chose these parameters to align as closely as possible to those used in previous research, noting that a Hamming window - which was used in prior research such as Manternach and Clark (2018) that used KayPENTAX Multi-Speech Model 3700 software for LTAS analysis - is not available in Praat, but the Hamming window which is very similar (Dumitrescu and Boiangiu, 2019) is. I used the SPL readings recorded during QP data collection sessions to calibrate the recordings within Praat so the SPL readings represented true dB values.

I then leveraged Google's Gemini Artificial Intelligence chatbot for assistance writing Praat scripts to remove parts of each recording where there was a significant rest or breath to include only moments of singing in the LTAS analysis, and also to calculate the LTAS of each performance using the appropriate parameters and export the results to a .csv file. To validate these scripts, I manually reviewed each while referencing the Praat documentation and made adjustments as needed.

Then, I performed thematic analysis on the four open-ended questions in the QP questionnaire. I first familiarized myself with the data by reading all comments and then assigned codes to each response according to the topics mentioned in the comments, and finally extrapolated themes based on the number of respondents mentioning each topic in their responses.

Next, I used R (R Core Team, 2024) to perform joint analysis of the perceptual, acoustic, and ELP data to address my research questions. Again, I utilized Gemini to assist with development of analysis scripts,

validating them by manually reviewing each while referencing the relevant R package documentation and adjusting as needed. I performed statistical testing to compare pre-SP and post-SP values for perception of individual VEL. Like other similar studies, my sample size was small and my sampling method was non-random, so readers should use caution when attempting to extrapolate these findings to other quartets or contexts.

Finally in alignment with my stated paradigmatic and epistemological positions, I synthesized the perceptual, acoustic, and ELP findings to produce an integrated discussion of this study's results and implications for future practice and research.

Findings

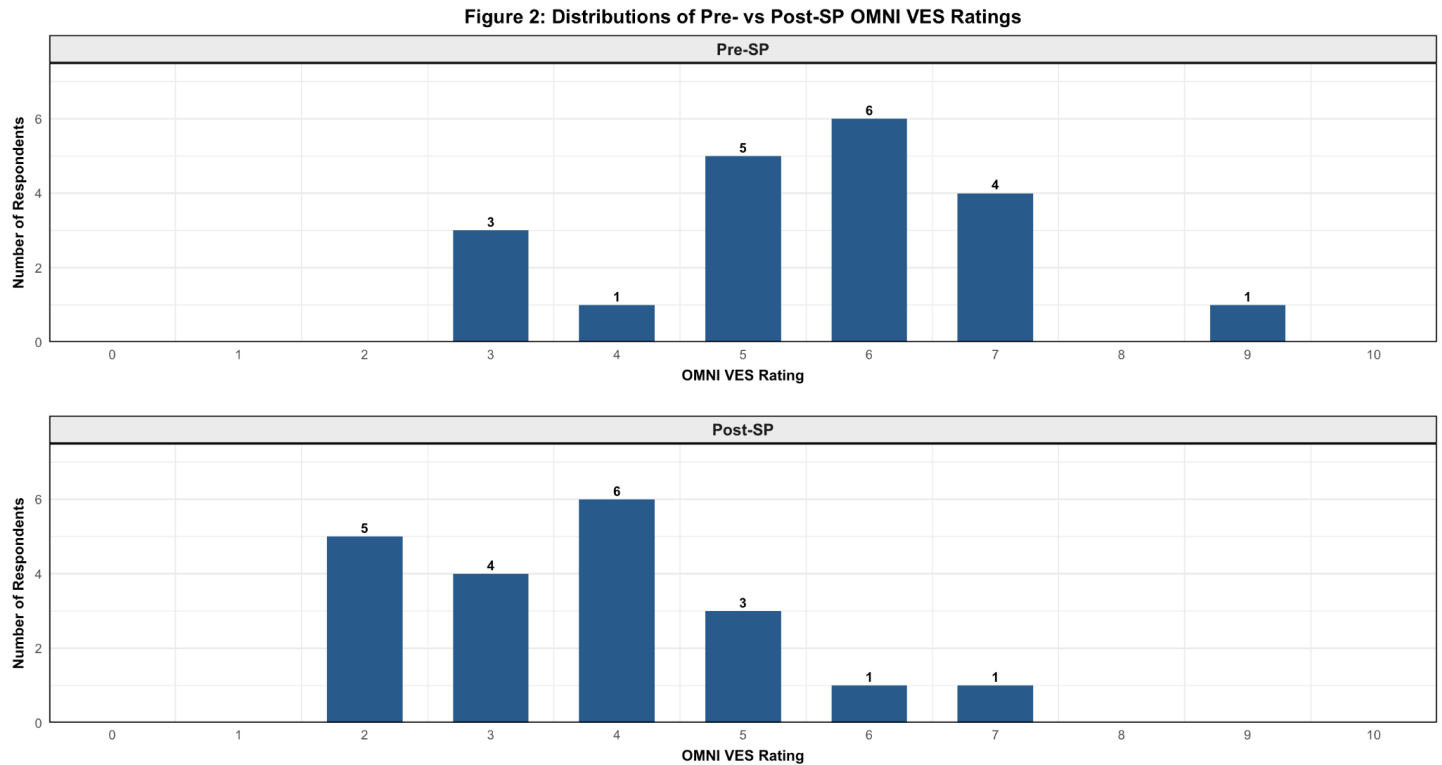
QP Questionnaire Results

Figure 1: QP Perceived SP Impact - Quantitative Summary									
	n	Mean Pre-SP Vocal Effort	Mean Post-SP Vocal Effort	Mean Pre-to- Post SP Change	p-value [†]	% Post-SP Performance > Pre-SP Performance	SP Impact on Quartet Sound	SP Impact on Individual Sound	SP Impact on Individual Feeling
Overall									
Overall	20	5.55	3.70	-1.85	0.000***	95.00%	6.45	6.35	7.45
Voice Part									
Tenor	5	5.40	4.80	-0.60		100.00%	6.40	6.40	6.80
Lead	5	5.80	3.20	-2.60		100.00%	7.60	8.00	9.00
Baritone	5	6.60	3.80	-2.80		100.00%	7.20	6.80	7.40
Bass	5	4.40	3.00	-1.40		80.00%	4.60	4.20	6.60
Voicing									
Women's	4	5.00	3.50	-1.50		100.00%	6.00	6.25	7.25
Mixed Harmony	8	5.75	3.88	-1.88		100.00%	6.25	6.50	7.75
Men's	8	5.62	3.62	-2.00		87.50%	6.88	6.25	7.25
Previous Experience with SP									
Yes	16	5.75	3.50	-2.25		100.00%	6.62	6.56	7.62
No/Not Sure	4	4.75	4.50	-0.25		75.00%	5.75	5.50	6.75
Did SOVTE in Warmup									
Yes	9	5.22	3.22	-2.00		100.00%	6.11	5.78	7.56
No	11	5.82	4.09	-1.73		90.91%	6.73	6.82	7.36
[†] ***p < 0.001 (Overall Paired t-test) - t-tests not done within subgroups due to small sample size									

Pre-SP and Post-SP Perceived Individual VE Ratings on OMNIVES

The overall mean QP rating of individual VEL during their pre-SP performance was 5.55 out of 10 on the 11-point OMNIVES (n = 20). Individual responses ranged from 3 (n = 3) to 9 (n = 1), with the most common rating being 6 (n = 6). Conversely, the mean QP rating of their individual VEL during their post-SP performance was a 3.70 out of 10 (n = 20), with individual responses ranging from 2 (n = 5) to 7 (n = 1) and the most common rating being 4 (n = 6). All QPs (n = 20) reported changes in their individual VEL from pre-SP

performance to post-SP performance, with the rating decreasing for 85% of respondents ($n = 17$) and increasing for 15% ($n = 3$). On average, the pre-to-post OMNIVES rating decreased by 1.85 points, a statistically-significant change ($p\text{-value} < 0.0001$). Figure 2 clearly shows a leftward shift in the OMNIVES rating distribution from pre-SP ratings to post-SP ratings, representing the reduction in effort experienced by most QPs.



Middle voice part singers - baritones ($n = 5$) and leads ($n = 5$) - reported the largest OMNIVES decrease, with 2.8-point and 2.6-point mean decreases, respectively. Basses ($n = 5$) - the lowest BQ singers - reported a smaller mean OMNIVES decrease of 1.4 points, while tenors ($n = 5$) - the highest BQ singers - reported the lowest mean OMNIVES decrease of only 0.6 points. All non-tenors ($n = 15$) reported a decrease in their OMNIVES in the post-SP performance relative to the pre-SP performance, while 60% of tenors ($n = 3$) reported an increase. Differences by quartet classification were less notable, with MQ ($n = 8$), MHQ ($n = 8$), and WQ ($n = 4$) singers each reporting a mean decrease of between 1.5 and 2 points. Singers with previous SP experience ($n = 16$) reported an average decrease in OMNIVES of 2.25 points from their pre-SP to post-SP performance, while those who did not note previous SP experience ($n = 4$) had a very small average OMNIVES decrease of only 0.25 points from pre-SP performance to post-SP performance. Singers who included SOVTEs in their warm up ($n = 11$) reported a mean 2-point decrease in OMNIVES from pre-SP performance to post-SP performance, while those who did not report including SOVTEs in their warm up ($n = 9$) reported a smaller mean decrease of only 1.73 points. Due to low sample size for each subgroup, t-testing was only done at the overall level.

Perceived Differences from Pre-SP Performance to Post-SP Performance

The most common difference QPs reportedly observed between their pre-SP performance and their post-SP performance was a sense of freer and easier singing and/or lower VE in the post-SP performance (n = 11). One participant noted that they “felt less vocal strain and ...more relaxed” post-SP. Another experienced a surprising level of ease post-SP, saying that in their post-SP performance they “had to pay attention more because the ease of singing kept distracting [them].” Another commonly-mentioned difference (n = 8) was that post-SP, the overall quartet resonance and vowels felt more unified and there was accordingly more chord ringing. “A lot more chords were locking in the second half of the song during the second run as compared to the first” said one singer. Another commented that “the second run felt louder, even though I’m not sure it was” and that they felt their quartet’s “resonance was much more unified.” One quarter of respondents (n = 5) also mentioned improved breath support or breath management following SP. One individual noted they “felt less like [they were] running out of breath” post-SP, while another said they “felt more in control of [their] breath and it felt like it was easier to manage [their] breath through the end of the phrase.”

QPs’ observed differences between their pre-SP and post-SP performances were not unanimously positive. One singer felt that their VEL was higher at times post-SP, explaining that “initially [they] felt [themselves] working harder” and that singing at low dynamic levels required more effort than singing at high dynamic levels. Another felt that SP “caused a bit of muscle fatigue,” and a third felt that their pitch control was worse post-SP. However, despite some singers observing adverse effects of SP in their post-SP performance, 95% (n = 19) felt that their overall quartet sound was better in the post-SP performance relative to their pre-SP performance, while only one singer (n = 1) felt that their overall quartet sound was better in their pre-SP performance.

Perceived Impact of SP on Quartet Sound

When asked how much they felt SP impacted their overall quartet sound, QPs (n = 20) provided an average rating of 6.45 out of 10, suggesting a moderate perceived impact. Middle voices perceived a stronger impact than outer voices with an average of 7.60 for leads (n = 5) and 7.20 for baritones (n = 5), respectively. Meanwhile, the average tenor rating (n = 5) was just below the overall average at 6.40, and basses (n = 5) perceived a notably lower impact, with an average rating of only 4.60. The average rating for all three quartet classifications fell between 6 and 7, with MQ singers’ (n = 8) mean rating being the highest at 6.88, followed by MHQ singers’ (n = 8) at 6.25, and WQ singers’ (n = 8) being the lowest at 6.00. Those with previous SP experience (n = 16) felt SP had a larger impact on the quartets’ sounds compared to those who did not note previous SP experience (n = 4), with mean ratings of 6.62 and 5.75, respectively. Those who did not utilize SOVTEs in their warm up (n = 9) felt SP had slightly more impact on their quartet sound than those who utilized SOVTEs in their quartet warm up (n = 11), with average ratings of 6.73 and 6.11 respectively.

When asked what differences they observed in their overall quartet sound between their pre-SP post-SP performances, the most common response related to improved resonance and vowel unity across the quartet and/or more chord ringing (n = 12). One singer said “the blend felt better...” and “ringier,” while another expressed that their quartet was “more locked in as a unit” post-SP. The second most commonly-mentioned

observation (n = 9) was that the post-SP quartet sound was freer, easier and/or less effortful. One singer felt their quartet “sounded less labored and more relaxed” post-SP. Another noted that following SP, they “perceived voices...seemingly requiring less effort.” One singer related the two most common themes to one another, saying that “when everyone is singing more relaxed, the chord ringing increases.” 20% of respondents (n = 4) also felt their quartet’s intonation improved post-SP. One participant remarked that in their post-SP performance, they “barely dipped in pitch, which is often a major hurdle for [them].”

While 95% of respondents felt that their overall quartet sound was better post-SP, some reported observations were neutral or negative in sentiment. One singer mentioned they did not observe any specific differences because they were “focused on [their individual] sound.” Another participant felt that their quartet’s post-SP performance was less unified than their pre-SP performance. A third suggested there was an adjustment period post-SP and that the quartet sound changed following that adjustment period, explaining their sound was “harder to control in the beginning [post-SP] because [they] were used to working harder than [they] needed to” and that after adjusting, “the sound rang/tuned better.”

Perceived Impact of SP on Individual Singing

QP responses (n = 20) suggest that they felt that SP had a greater impact on the feeling of their singing than the sound of their singing, with mean ratings of 7.45 and 6.35, respectively. Leads (n = 5) felt that SP impacted their singing more than singers of other voice parts, rating the impact on the sound of their individual singing an 8.00 and the impact on the feeling of their individual singing a 9.00 on average. Baritones (n = 5) perceived more modest impacts on both their individual sound and the feeling of their voice with mean ratings of 6.80 and 7.40, respectively. Basses (n = 5) provided a relatively low rating for how they felt SP impacted the sound of their singing with a mean of 4.20, but a moderate impact of SP on the feeling of their singing at a mean rating of 6.60. Tenors (n = 5) had a moderate rating for both the impact on their sound and the feeling of their singing, with mean ratings of 6.40 and 6.80, respectively. All quartet classifications had comparable mean ratings for these two questions. MQ (n = 8) and WQ (n = 4) singers rated the impact of SP on the sound of their individual singing a mean of 6.25 and the impact of SP on the feeling of their individual singing a mean of 7.25. MHQ singers (n = 8) provided slightly higher ratings for both questions, with means of 6.50 and 7.75. Singers who did not report prior SP experience (n = 4) rated SP’s impact on their individual sound a mean of 5.50 and the impact on the feeling of their voice a mean of 6.75, while singers with previous SP experience (n = 16) rated both impacts higher at means of 6.56 and 7.62, respectively. Singers who included SOVTEs in their warm up (n = 11) rated the impact of SP on the sound of their voice a mean of 5.78, while singers who did not include SOVTEs in their warm up (n = 9) rated this impact higher at a mean of 6.82. Conversely, singers who included SOVTEs in their warm up rated the impact of SP on the feeling of their voice a mean of 7.56, while singers who did not include SOVTEs in their warm up rated this impact slightly lower with a mean of 7.36.

The most commonly-mentioned observed change in QPs’ own singing was freer and easier singing with lower VE after SP (n = 12). One singer remarked that they “used less effort and [were] more relaxed throughout the performance” following the SP regimen. Another explained that they felt they were “singing

more efficiently” post-SP and achieved “more vocal fold closure with less tension.” The second most common observation noted by QPs (n = 4) was that transitioning between different parts of their vocal range and/or between different pitches was easier in their post-SP performance. One individual noted that it “felt a little smoother” moving from their high range to their low range and they experienced “fewer bumps.” Another observed a similar phenomenon and experienced an “easier transition between notes, especially from chest to head tone.”

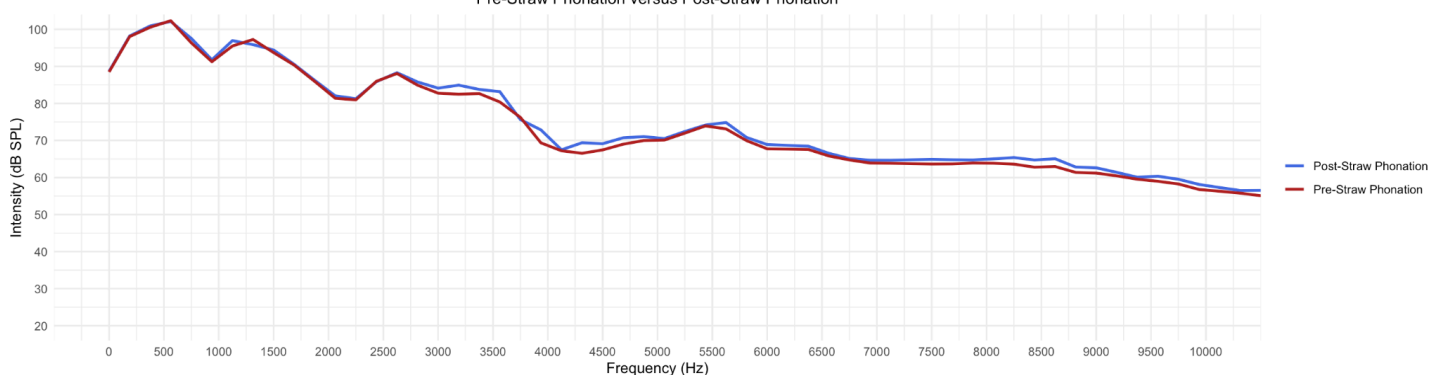
Again, not all observations were strictly positive. One singer expressed that they did not perceive a difference in how their own singing felt between the two performances. Another participant explained that singing after the SP regimen was challenging, commenting that “overall vocal production was more difficult...slightly more difficult but not significant.” A third singer noted challenges trying to sing smoothly after the exercise, related to difficulty managing breath flow. Another respondent simply explained that they were more aware of the muscles they were using in their singing after completing the SP routine.

Acoustic LTAS

LTAS differences between pre-SP and post-SP performances, shown in Figures 3 - 7, were variable across quartets. Quartet 1’s (Q1’s) (MQ) LTAS was comparable between performances for frequencies below about 2.75 kHz. However, for frequencies above 2.75 kHz, the average intensity was higher post-SP than it was pre-SP. In particular, for frequencies between 2 kHz and 4 kHz - where the human ear is particularly sensitive (Fletcher and Munson, 1933) - Q1 saw an average intensity level of about 1.07 dB SPL higher in the post-SP recording than in the pre-SP recording. This is slightly above the standard JND threshold of 1 dB SPL (Howard and Angus, 2009), meaning that this intensity boost may be large enough to be perceived by typical listeners.

Figure 3: Quartet 1 Long-Term Average Spectrum

Pre-Straw Phonation versus Post-Straw Phonation

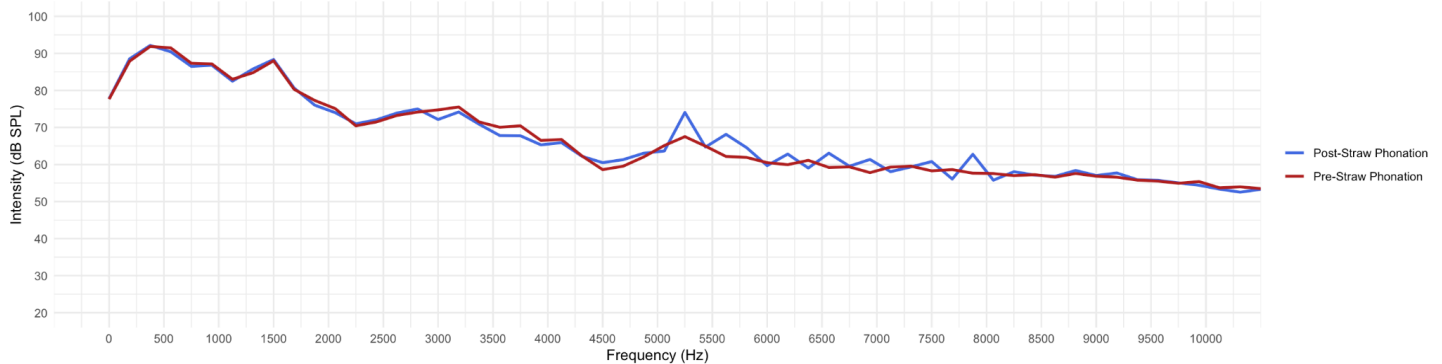


Like Q1, Quartet 2’s (Q2’s) (WQ) LTAS was comparable between performances at lower frequencies. However, while Q1’s intensity was consistently higher in the post-SP performance above 2.75 kHz, Q2’s intensity was higher at some frequencies in the pre-SP recording and higher at other frequencies in the post-SP recording. Particularly noteworthy are several spikes in intensity in the post-SP recording LTAS from 5 kHz - 10 kHz. These spikes are largely due to the substantial degree of high-frequency overtone reinforcement that was present in the final chord of Q2’s post-SP performance but not in their pre-SP performance. Removing

the audio from the final chord and rerunning the LTAS analysis produces a post-SP LTAS curve that more closely resembles the pattern seen in Q2's pre-SP LTAS curve (see Appendix 12). On average, Q2 saw a decline in intensity levels for frequencies from 2 kHz - 4 kHz in their post-SP performance of about 0.87 dB SPL. This decline is less than the JND threshold of 1.00 dB SPL, but still could be perceived by some listeners, as the JND can be as low as 0.3 dB SPL depending on the frequency, initial intensity level, and other characteristics of the sound (Howard and Angus, 2009).

Figure 4: Quartet 2 Long-Term Average Spectrum

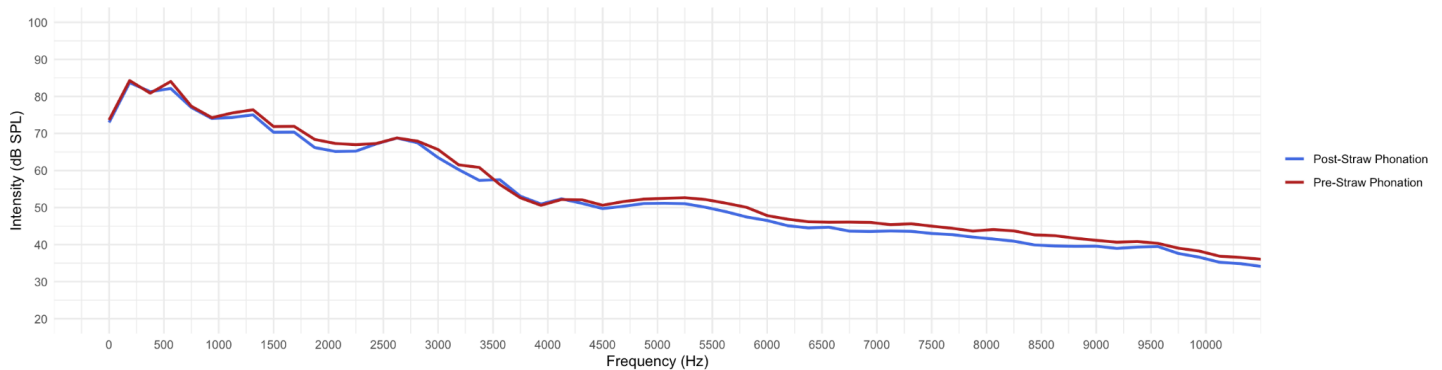
Pre-Straw Phonation versus Post-Straw Phonation



Quartet 3 (Q3) (MQ) had similar intensity levels in their pre-SP and post-SP performances up to about 1 kHz. However, at most frequencies between 1 kHz and 10 kHz, their post-SP performance had lower intensity levels, including a difference of about 0.96 dB SPL in the critical 2 kHz - 4 kHz range. This approaches the level of the JND threshold of 1 dB SPL, so it may be perceptible to some listeners.

Figure 5: Quartet 3 Long-Term Average Spectrum

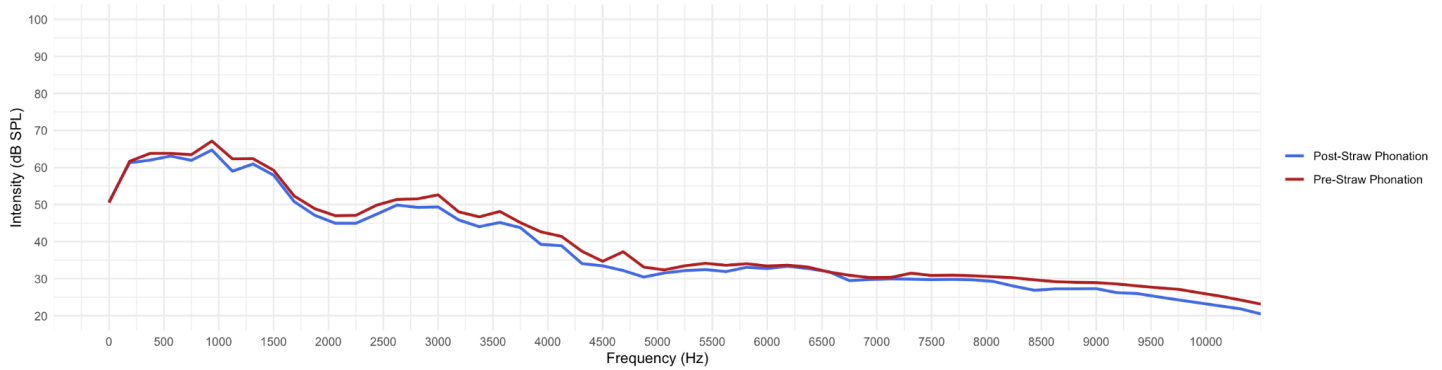
Pre-Straw Phonation versus Post-Straw Phonation



Quartet 4 (Q4) (MHQ) saw lower intensity levels for nearly the entire frequency range up to 10 kHz in their post-SP performance, with an average decline of 2.34 dB SPL in the 2 kHz - 4 kHz range. This is well above the JND threshold of 1 dB SPL and therefore would likely be perceived by the typical listener.

Figure 6: Quartet 4 Long-Term Average Spectrum

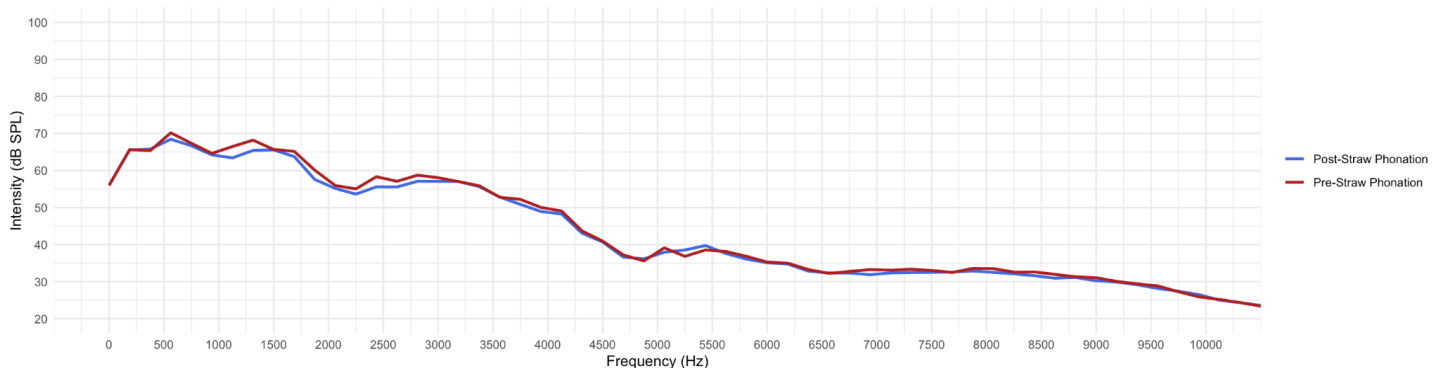
Pre-Straw Phonation versus Post-Straw Phonation



Quartet 5 (Q5) (MHQ) saw comparable intensity levels below about 750 Hz in their post-SP performance relative to their pre-SP performance. They then saw lower intensity levels between about 750 Hz and 3.25 kHz, and again saw comparable intensity levels between 3.25 kHz and 10 kHz, with their post-SP performance even having higher intensity levels at some frequencies in this range. This suggests that Q5 was interestingly able to produce similar levels of energy above about 3.25 kHz in both performances, despite experiencing a decline in intensity between about 750 Hz and 3.25 kHz. The difference in intensity in the 2 kHz - 4 kHz range was approximately average about 1.45 dB SPL, which is above the JND threshold and therefore likely large enough to be perceived by the typical listener.

Figure 7: Quartet 5 Long-Term Average Spectrum

Pre-Straw Phonation versus Post-Straw Phonation



I conducted paired t-tests to compare each quartet's pre-SP and post-SP LTAS dB SPL in both the 0 - 10 kHz and 2 - 4 kHz ranges, which were the same tests done in prior studies. Adjusting for the family-wise error rate with a Bonferroni correction (Armstrong, 2014), six of the ten changes are significant at the 1% significance level (see Figure 8).

Figure 8: LTAS t-Testing Data				
Quartet	Frequency Range (kHz)	dB SPL Difference (Post-SP vs. Pre-SP)	p-value	Significance [†]
Quartet 1	0 - 10	0.97267	0.00000	***
Quartet 1	2 - 4	1.07067	0.01264	
Quartet 2	0 - 10	0.34898	0.20173	
Quartet 2	2 - 4	-0.86909	0.03847	
Quartet 3	0 - 10	-1.41303	0.00000	***
Quartet 3	2 - 4	-0.9621	0.03881	
Quartet 4	0 - 10	-1.78314	0.00000	***
Quartet 4	2 - 4	-2.33842	0.00000	***
Quartet 5	0 - 10	-0.6551	0.00000	***
Quartet 5	2 - 4	-1.18194	0.00074	***
[†] ***p < 0.001 (0.01 Significance Level with Bonferroni adjustment for 10 simultaneous t-tests)				

ELP Singing scores

Like Acoustic LTAS results, ELP Singing score results, shown in Figure 9, were variable by quartet. Following the convention used in BHS contests (BHSSCJC, 2025), ELP results are reported as the average score from the panel of ELP respondents (n = 6), rather than a cumulative score. The average ELP Singing score for three quartets' (Quartets 1, 3, and 5) post-SP recordings were higher than the average scores for their pre-SP recording. The opposite was true for the other two quartets (Quartets 2 and 4) who had lower average scores for their post-SP recording relative to their pre-SP recording. On the BHS Singing score scale from 0 -100 points, the quartets whose score was lower for their post-SP performance had average pre-to-post SP score decreases of 2.50 points and 3.17 points, respectively. On the other hand, quartets whose score was higher for their post-SP performance than their pre-SP performance saw more modest increases of between 1.5 and 1.67 points.

Figure 9: ELP Singing Scores by Quartet			
Pre-SP vs. Post-SP			
Quartet Name	Pre-SP Mean Score	Post-SP Mean Score	Mean Score Difference
Quartet 1	66.00	67.67	1.67
Quartet 2	68.83	65.67	-3.17
Quartet 3	72.17	73.83	1.67
Quartet 4	70.67	68.17	-2.50
Quartet 5	75.00	76.50	1.50

Discussion

This study's strongest results suggest that SP may reduce VE in BQ singers, with 85% of QPs (n = 17) reporting such a decline in their OMNIVES between their pre-SP and post-SP performances, as well as freer and easier singing with lower levels of effort being a common theme in QPs' open-ended comments.

Participants also attributed a large amount of their VE decrease to the SP exercises, with a mean rating of 7.45 for how they felt SP impacted the feeling of their singing. These findings are consistent with previous research on solo and ensemble singers that have broadly concluded that SP was associated with reduced VEL. With SP having been extensively studied and there being a large body of evidence pointing to its efficacy in improving vocal economy, these findings are unsurprising. This study also provides evidence that SP may reduce VEL regardless of the singer's quartet voicing, previous SP experience, and whether they include SOVTEs in their vocal warm up routine, pointing to a broad potential impact.

Baritones (n = 5) and leads (n = 5) reported the most impact of SP on their individual voices, with respective mean ratings of 9.00 and 7.40 for the level of impact on the feeling of their individual singing and respective mean ratings of 8.00 and 6.80 for the level of impact on the sound of their individual singing. This aligns with my anecdotal experience as I have seen SP and other SOVTEs be particularly impactful for singers experiencing vocal inconsistency through register transitions. While barbershop arrangements generally are written such that basses generally sing in their lower register and tenors will sing in their upper register, baritones and lead often need to switch back and forth and therefore encounter register transitions more frequently than basses or tenors. Some QP comments alluded to this and the increased ease with which they were able to accomplish register transitions post-SP.

Another interesting observation is that tenors (n = 5) were the least likely to report a decrease in OMNIVES after SP. 60% (n = 3) actually reported an increase in OMNIVES while no non-tenors (n = 15) reported such an increase. This suggests that perhaps SP with standard drinking straws is more likely to increase effort in BQ singers who sing in higher ranges and/or who primarily utilize lighter vocal mechanisms like falsetto than in singers who sing in lower ranges and/or primarily utilize heavier vocal mechanisms like chest/modal voice. Additional research is warranted to better understand the potential impacts of SP on BQ tenors. BQ coaches may wish to encourage tenor singers to explore alternative SOVTEs besides SP with a standard drinking straw, with a goal of identifying one that induces a decline in VE as was consistently reported by other voice parts.

Overall, and for all subgroups analyzed, QPs rated SP's impact on the feeling of their singing voice higher than the impact of the sound of their singing voice. This could be in part because during their performances while they were singing with three other singers, they were better able to monitor the feeling of their own voice than the sound of it. Additionally, since bone conduction distorts how people perceive the sound of their own voice compared to how others perceive it (Orepic *et al.*, 2023), QPs may have been less able to detect subtle changes in the sound of their voice resulting from SP than an outside listener would, even if they were singing alone. Future studies could record each individual singer with their own microphone and have the participants listen back to their own pre-SP and post-SP recordings before rating the impact of SP on the sound of their individual singing to see how this impacts QPs' perceptual ratings of their own voice.

Another interesting difference in OMNIVES changes by subgroup relates to whether the singer had previous SP experience. Participants with prior SP experience (n = 16) reported considerable individual VEL declines, with a mean OMNIVES decrease of 2.25 points. Conversely, those who did not report previous SP

experience ($n = 4$), reported almost no average individual VEL change, with a mean decline of only 0.25 points. One possible explanation for this difference is that singers with previous SP experience were more comfortable with SP technique and better able to employ it in a way such that it reduced their VEL than those without previous SP experience. I attempted to mitigate this potential confounding factor by explaining and demonstrating proper SP technique to all QPs in a way similar to Titze (2010). Another explanation is that previous SP experience is likely to be accompanied by information related to potential benefits of SP and other SOVTEs, including improved vocal economy, and so those with previous SP experience may have had preconceived biases related to SP that influenced their responses. Anecdotally, I know this is the case for some QPs in this study, as I have personally discussed this information with them. Some QPs also used technical terms like “SOVTE” in their open-ended responses, suggesting they are likely familiar with such techniques and the science behind them. Future studies may wish to exclude singers with previous SP experience to eliminate this potential source of bias.

Another possible confounding factor that is inextricably linked with a pre-post study design is that post-SP performance necessarily occurred after the pre-SP performance, meaning that at the time of the post-SP performance, each singer had completed more singing on the day of data collection than they had at the time of the pre-SP performance. Thus, even in the absence of a SP protocol, it is possible that some singers simply would have simply felt more warmed up at the end of the first performance than they did at the beginning, leading to subsequent improvements in the second performance. This is less likely to have been the case for singers who had been vocalizing for some time before the experimental proceedings commenced, but could very well have been the case for singers who did little-to-no vocalizing before the 15-minute experimental warm up period. Even singers who may not have noticed any difference in their vocal condition between performances may have felt more mentally focused or less impacted by performance anxiety after completing one full performance of the song. Such changes may have helped them achieve a stronger individual performance even without completing any SP exercises, which also may have impacted their perception of their individual VEL. Further research is needed to try to disentangle the impact of a SP protocol from other impacts related to simply performing a song a second time, which would likely require a non-pre-post design.

The LTAS results are surprising, as each quartet’s LTAS seemed to be impacted differently by the SP protocol. For instance, Q1 generally saw increases in their spectral intensity in a wide range of higher frequencies, Q3 and Q4 generally saw the opposite, and Q2 and Q5 saw intensity increases at some frequency levels and decreases at others. These results differ from studies on SP in vocal ensemble settings that each observed LTAS intensity increases across the entire frequency range examined (Manternach and Daugherty, 2019; Manternach, Kotsonis, and Mann, 2022; Manternach, Schloneger, and Maxfield, 2019). This difference is likely primarily due to the difference in straw type, as the previous studies tested a narrower stirring straw with diameters between 2.5 and 3 mm, while this study tested a standard drinking straw with a wider 6 mm. As anticipated, this study’s LTAS results are different from those of previous studies. A primary driver for this difference may be seen in the results of Maxfield *et al.* (2014), who measured approximately twice the level of intraoral pressure from vocalists performing SP with a stirring straw than with a drinking

straw. SP with a stirring straw produced the third-highest level of intraoral pressure of the 13 SOVTE postures measured, suggesting that it is likely to have a more uniform impact on singers of different voice types and ranges than a more moderate level of pressure, as would have been experienced by this study's QPs. The higher level of intraoral pressure from SP with a stirring straw may generally be accompanied by a higher level of lung pressure, and therefore a higher intensity level (Titze, 2000). Future research could repeat this study with stirring straws instead of drinking straws to see if the ensembles' LTAS results align more closely with those in previous research.

Additionally, some members of Q2, Q3, and Q4 indicated in open-ended responses that they felt their sound was overall louder and/or ringier. While these terms were not well-defined, this seemingly contradicts their quartets' LTAS results, which showed lower intensity levels across wide frequency ranges that were likely large enough to be perceptible by most listeners. This raises the question of whether quartet singers may have a fundamentally different perception of their quartet's sound in-the-moment from outside listeners,, and whether in-the-moment self perception of ensemble sound is even a meaningful outcome to consider in future research. In a contest setting, quartet singers' perception of their own ensemble sound is certainly less practically relevant than others studied, since in a contest setting only the Singing Judge's perception of a quartet sound impacts the Singing score (BHSSCJC, 2025). Anecdotally, the same is also generally true in a non-contest setting, with barbershop ensembles typically striving for a sound that is maximally enjoyable for their audience over a sound that is maximally enjoyable for the quartet singers' themselves, although it may be more relevant in informal tag singing sessions when no audience is present to consider (BHS, 2026). Future studies could instead have QPs listen back to their pre-SP and post-SP recordings and rate the impact they felt SP had on the overall quartet sound, rather than basing it entirely on in-the-moment perception. To minimize potential bias, recordings could be presented blindly so that the QPs are not aware of which was the pre-SP recording and which was the post-SP recording, although it may still be apparent if there are noticeable idiosyncrasies between the two performances (e.g. a participant experiencing a prominent registration event in one performance but not the other).

QPs nearly-unanimously agreed that their quartet sound was overall better post-SP, with only 5% (n = 1) disagreeing. However, the Singing scores from the panel of ELPs tell a different story, with two quartets' scores being markedly lower post-SP. ELPs did not provide rationale for their scores, so it cannot be known specifically what contributed to score differences between performances for each quartet. The BHS Singing score is one holistic measure that can be impacted by myriad different technical and artistic aspects of an ensemble's performance, so it is possible that ELPs would agree that these quartets' post-SP recordings were overall stronger in some aspects and weaker in others, with the latter outweighing the former. It is also possible that the opinion of some of the QPs in these quartets could change if they were able to listen to both performances and comment again on which of their performances featured an overall better quartet sound.

The ELPs also showed a fair amount of disagreement within the panel, only achieving unanimous agreement in the score change direction from pre-SP to post-SP for one quartet (Q2). For the four other quartets, each had at least one ELP score their post-SP performance lower than their pre-SP performance and

at least one ELP score their post-SP performance higher than their pre-SP performance. Anecdotally, scoring based on recordings is challenging as scores can be impacted heavily by the listening device the listener is using, so some inconsistency is expected beyond what would typically be seen in a typical in-person contest setting. It would not be possible to do a pre-post study like this with an in-person panel of ELPs without the ELPs knowing which performance was which, so results from any such future study should be interpreted with caution due to potential biased responses as discussed previously.

There was no clear relationship between LTAS results and ELP Singing scores. One possible explanation is that quartets whose post-SP recording featured noticeable more energy in some part of the critical 2 kHz - 4 kHz range discussed previously would score higher on average, due to the perception of more expansion of sound. This was true in this study for two of the quartets whose score increased (Q1 and Q3), who each had at least one frequency band in this range that was at least 1.00 dB SPL higher in their post-SP recording than it was in their pre-SP recording. Additionally, the two quartets whose score decreased between their pre-SP recording and their post-SP recording (Q2 and Q4) did not have any such intensity increases in their LTAS results from 2 kHz - 4 kHz. However, while this may be sufficient to see a modest score increase in the Singing Category, it may not be necessary, as Q5's score increased without having such an increase in spectral energy like Q1 and Q3 had. Of course, Singing scores are influenced by more than just spectral energy, so there are many other factors that may have changed between performances that are not captured in LTAS measurements and future research could explore additional acoustic measures to try to establish a set of key acoustic drivers for BHS Singing scores.

Limitations

This study has several limitations - some of which have already been discussed - and its results should be interpreted with these limitations in mind. Both the samples of QPs and ELPs are convenience samples, individuals in my network who were recruited non-randomly. This is not uncommon in research on singers or musical ensembles, but inherently means that readers should use caution when attempting to generalize this study's results to the overall population of BQs and barbershop singers more broadly.

The quartet data collection sessions were each completed on five separate occasions in five separate locations. None of these locations were sound-proofed to reduce ambient noise or otherwise optimize recording conditions. While efforts were made to maintain a consistently quiet environment during the experimental process, each acoustic environment still had its own unique pattern of ambient noise that is present in the recordings. It is possible that for some quartets, unique audible events occurred during one of their performances but not the other and impacted the LTAS analysis or the ELP scoring exercise as a result, although no such obvious cases were noted. Future studies could be conducted in a space designed for audio recording to reduce the likelihood of environmental noise interfering with results derived from audio recordings.

While I marked the floor with a visible guide of where to stand and instructed each QP to stand in the same location for each recording, some QPs' standing positions may have shifted slightly throughout or between performances. This could have altered some singers' physical positions relative to the recording

device and therefore may have impacted the resulting recording and therefore the LTAS or ELP scoring results based on this recording. Singers standing on the ends of the quartet would be most likely to be impacted by such a change position, since the recording device only has a 90-degree pickup pattern, and sound coming from beyond this angle would have been greatly attenuated. While this was not an obvious or significant issue in this study, future research could employ recording devices with a wider pickup pattern to reduce the likelihood of the sound from QPs standing in one of the end positions of their quartet from being reduced and thereby influencing the LTAS and ELP scoring results. Future studies could also attempt to more strictly control quartet members' positions relative to the recording device to reduce variability between recordings, although this may be challenging as BQs often have a substantial visual component of their performance, which often translates to various types of movement throughout the performance.

Previous studies investigating the impacts of SP on choirs utilized videos of a conductor to control for inherent variability between performances. As explained in the writeup of one such study, this guaranteed "consistent gesture size, facial expression, hand shape, tempo, preparatory cue, and other visual stimuli between pretest and posttest performances" (Manternach and Clark, 2018, pp. 25). Since BQs perform without a conductor, this type of control is impossible and the quartets were not prevented from consciously or unconsciously making changes in their approach between performances. For a study featuring BQs, this is likely a source of potential variability that cannot be controlled for, as forcing the quartet to sing with a conductor would be an atypical experience for most quartets and actually may introduce more variability to their performances than allowing them to self-direct as usual.

ELPs, who listened to and scored quartet performances in this study on their own personal devices, were not given any instructions or restrictions on what type of listening devices they should use. Since each model of speakers or headphones have their own specifications and may have variable responses to different frequency and intensity ranges, it is possible that despite listening to the same audio files, that they were in essence judging different performances from one another. Future studies utilizing recordings could distribute identical listening devices to their ELP panel to control for this variability and ensure that each ELP is hearing and judging identical audio output.

The study only featured quartets who were scoring in the B-range of the Singing Category, with average panel scores on the ten recordings ranging from 65.67 to 76.50 (BHSSCJC, 2025). It is possible that SP would have notably different impacts on singers from quartets that are consistently operating at lower or higher scoring levels in the Singing Category, so future research would benefit from including a wider range of quartets as participants to understand how the impact of SP may differ by score level.

This study also featured exclusively BHS quartets and utilized the BHS standard scoring system in its ELP scoring component. Other barbershop organizations utilize different scoring systems such as SingUnited International (SUI) (SUI, 2026), so SP may impact quartet scores in other systems differently and additional research is warranted to understand these potential differences. Practitioners working with quartets competing in other organizations such as SUI should interpret these results with caution until the impacts of SP on SUI scores are better understood.

And of course, a key consideration for anyone interpreting these results is that I am an insider researcher in my field. As such, there is always some risk that some respondents may alter their responses in an effort to please the researcher or give them responses they feel they are looking for. I made every effort to mitigate this by asking respondents to complete the survey questions honestly according to their own experience, but there is always an inherent risk of bias in studies conducted by insider researchers like this one.

Conclusion

This study provides preliminary evidence that SP with a standard drinking straw may lower perceived VE in BQ singers, with the most impact likely to be seen in leads and baritones and less impact likely to be seen in tenors and basses. Tenors may be the most likely to have adverse impacts on VEL, as tenors were the only singers who reported a VEL increase following SP. In addition, it also provides evidence that BQ singers feel that SP has at least a moderate impact on the feeling of their individual singing, the sound of their individual singing, and their quartet's overall sound. These perceptions are fairly consistent across quartet classifications - with members of WQs, MHQs and MQs providing similar feedback. Singers reporting previous SP experience were likely to perceive larger impacts of SP on the sound and feeling of their voices, as well as their quartet's sound, possibly due to biases influenced by previous knowledge or education on SOVTEs and their potential benefits. Singers commonly observed changes like freer or easier singing with lower VE, increased resonance unity and more chord ringing, and greater ease when transitioning between pitches or vocal registers after SP, which are aligned with the quantitative ratings discussed previously. Other singers noted neutral-to-negative observations from SP, indicating that it may not be a recommended exercise for all singers and that BQ coaches should encourage each singer with whom they work to experiment with different types of SP and/or other SOVTEs to identify exercises that produce desirable benefits in their voice.

While the results related to QPs' perceptions of their own sound and singing are relatively straightforward, several key questions require additional research to answer more definitively. Unlike previous SP studies on vocal ensembles which saw a consistent post-LTAS intensity level increase, the pre-SP to post-SP LTAS changes seen from quartets in this study followed a variety of patterns. This inconsistency is somewhat expected given the difference in straw type used in this study, and more research is needed to definitively determine how SP with a wider drinking straw impacts BQ acoustics. Furthermore, research testing a variety of straw sizes and types, as well as other SOVTEs, could provide barbershop voice practitioners valuable insights that could inform their exercise recommendations in different scenarios. The relationship between LTAS and BHS Singing scores is also still unclear, with a possible sufficient, but not necessary condition to increase BHS Singing scores being a noticeable increase in part of the 2 kHz - 4 kHz frequency range where the human ear is most sensitive, likely increasing the perception of ringing chords and expanded sound. A separate line of research could be opened to more identify key acoustic drivers of BHS Singing score, which could provide BHS ensemble coaches and quartet singers who are interested in improving their

Singing scores more objective acoustic targets to work toward. If better understood, findings in both of these lines of inquiry would provide information that is immediately actionable for BQ coaches and singers.

Additionally, one of this study's most interesting results was that several QPs felt their quartet sounded louder and/or ringier when this was not the case according to their LTAS data. This raises the question of how reliable ensemble singers' in-the-moment perceptions of their ensemble's sound are, and this could be investigated. The immediate impact of SP on BHS Singing scores is also unclear, as three quartets experienced average score increases post-SP while the other two experienced score declines post-SP. Because BHS Singing scores provide one number representing the net impact of a variety of technical and artistic aspects of singing, and scorers did not provide rationale for their scores, a more in-depth study focused on BHS Singing scores is recommended to more definitively understand how SP may impact them. Although interesting, these two possible research topics would likely not be as beneficial in practice and should be prioritized below the topics mentioned above.

This study reinforced some of my prior beliefs about SOVTEs and SP, including that SP may help reduce perceived VELs in BQ singing, and that a singer's experience with different SOVTEs is highly individualized, meaning vocal coaches should have several options in their repertoire to help each singer experiment and find ones that are effective for their voice. It also challenged some of my expectations, including that SP would demonstrate a more consistent impact on both LTAS results and ELP scores across quartets. Even despite the inconsistent acoustic and expert-listener results which warrant additional research, this study provides evidence to support continued use of SP in barbershop voice coaching when lower levels of VE are desired and that SP with a standard drinking straw may be a particularly helpful technique for lead and baritone quartet singers.

References

- Antonetti, A. E. d. S. *et al.* (2019) "Voiced High-frequency Oscillation and LaxVox: Analysis of Their Immediate Effects in Subjects With Healthy Voice", *Journal of Voice*, 33(5), pp. 808.e7 – 808.e14. Available at: <https://doi.org/10.1016/j.jvoice.2018.02.022>.
- Antonetti, A.E. d. S. *et al.* (2022) "Effects of Performance Time of the Voiced High-Frequency Oscillation and Lax Vox Technique in Vocally Healthy Subjects", *Journal of Voice*, 36(1), pp. 140.e29 - 140.e37. Available at: <https://doi.org/10.1016/j.jvoice.2020.04.008>.
- Armstrong, R. A. (2014) "When to use the Bonferroni Correction", *Ophthalmic & Physiological Optics*, 34(5), pp. 502 - 508. Available at: <https://doi.org/10.1111/opo.12131>.
- Barbershop Harmony Society (2026) *What is barbershop music?* | *Barbershop Harmony Society*. Available at: <https://www.barbershop.org/music/about-our-music> (Accessed: 27 September 2026).
- Bassetto, M.R. and Constantini, A.C. (2024) "Is There an Ideal Performance Time for the Latex Tube Exercise?", *Journal of Voice*, 38(1), pp. 144 - 151. Available at: <https://doi.org/10.1016/j.jvoice.2021.07.016>.
- Bele, I. V. (2005) "Artificially lengthened and constricted vocal tract in vocal training method", *Logopedics Phoniatrics Vocology*, 30(1), pp.34 - 40. Available at: <https://www.tandfonline.com/doi/abs/10.1080/14015430510006677>.
- Berenson, M.L. *et al.* (2018) *Basic Business Statistics: Concepts and Applications*. 14th edn. New York, NY: Pearson.
- Bickley, C. A. and Stevens, K. N. (1986) "Effects of a vocal-tract constriction on the glottal source: experimental and modelling studies", *Journal of Phonetics*, 14(3-4), pp. 373 - 382. Available at: [https://doi.org/10.1016/S0095-4470\(19\)30711-9](https://doi.org/10.1016/S0095-4470(19)30711-9).
- Bonette, M.C. *et al.* (2020) "Immediate Effect of Semioccluded Vocal Tract Exercises Using Resonance Tube Phonation in Water on Women Without Vocal Complaints", *Journal of Voice*, 34(6), pp. 962.e19 - 962.e2. Available at: <https://doi.org/10.1016/j.jvoice.2019.06.020>.
- Boersma, P., Weenink, D. and Shchupak, A. (2026) *Praat: doing phonetics by computer*. University of Amsterdam. Available at: <https://praat.org> (Accessed: 14 August 2026).

Brooks, T. (2026) "Asterisk Judge Training", Barbershop Harmony Society Contest and Judging Committee Category School, Denver, CO, 26 July.

Costa, C.B. *et al.* (2011) "Immediate effects of the phonation into a straw exercise", *Brazilian Journal of Otorhinolaryngology*, 77(4), pp. 461 - 465. Available at: <https://doi.org/10.1590/S1808-86942011000400009>.

Davis, S. *et al.* (2024) "Does the daily practice of a structured voice exercise protocol affect the fitness instructor's self-perceived vocal effort, vocal fatigue, and voice handicap?", *Journal of Voice* [Preprint]. Available at: <https://doi.org/10.1016/j.jvoice.2024.09.033>.

Denscombe, M. (2010) *The Good Research Guide: For Small-Scale Social Research Projects*. Fourth Edition. Berkshire, UK: McGraw Hill Open University Press.

Dumitrescu, D. and Boiangiu, C.-A. (2019) "A Study of Image Upsampling and Downsampling Filters", *Computers*, 8(2), 30, pp. 1 - 19. Available at: <https://doi.org/10.3390/computers8020030>.

de Oliveira, K.G.S.C. *et al.* (2022) "Oropharyngeal Geometry and the Singing Voice: Immediate Effect of Two Semi-Occluded Vocal Tract Exercises", *Journal of Voice*, 36(4), pp. 523 - 530. Available at: <https://doi.org/10.1016/j.jvoice.2020.06.027>.

de Souza, R.C., Masson, M.L.V. and de Araujo, T.M. (2017) "Effects of the exercise of the semi-occluded vocal tract with a commercial straw in the teachers' voice", *Revista CEFAC*, 19(3), pp. 360-369. Available at: <https://doi.org/10.1590/1982-0216201719315516>.

Devadas, U., Vinod, D. and Maruthy, S. (2020) "Immediate Effects of Straw Phonation in Water Exercises on Parameters of Vocal Loading in Carnatic Classical Singers", *Journal of Voice*, 37(1), pp. 142.e13 – 142.e22. Available at: <https://doi.org/10.1016/j.jvoice.2020.11.007>.

Di Natale, V. *et al.* (2022) "Semioccluded Vocal Tract Exercises Improve Self-Perceived Voice Quality in Healthy Actors", *Journal of Voice*, 36(4), pp. 584.e7 - 584.e14. Available at: <https://doi.org/10.1016/j.jvoice.2020.07.024>.

Duke, E. *et al.* (2015) "The Effect of Traditional Singing Warm-Up Versus Semioccluded Vocal Tract Exercises on the Acoustic Parameters of Singing Voice", *Journal of Voice*, 29(6), pp. 727 - 732. Available at: <https://doi.org/10.1016/j.jvoice.2014.12.009>.

Echternach, M. *et al.* (2021) "Duration of biodynamic changes associated with water resistance therapy", *Logopedics Phoniatrics Vocology*, 46(3), pp. 126 - 133. Available at: <https://doi.org/10.1080/14015439.2020.1785000>.

Enflo, L. *et al.* (2013) "Effects on Vocal Fold Collision and Phonation Threshold Pressure of Resonance Tube Phonation With Tube End in Water", *Journal of Speech, Language, and Hearing Research*, 56(5), pp. 1530 - 1538. Available at: [https://doi.org/10.1044/1092-4388\(2013/12-0040\)](https://doi.org/10.1044/1092-4388(2013/12-0040)).

Fadel, C.B.X. *et al.* (2015) "Immediate effects of the semi-occluded vocal tract exercise with LaxVox tube in singers", *CoDAS*, 28(5), pp. 618 - 624. Available at: <https://doi.org/10.1590/2317-1782/20162015168>.

Fletcher, H. and Munson, W.A. (1933) "Loudness, its definition, measurement and calculation", *Bell System Technical Journal*, 12(4), pp. 377 - 430. Available at: <https://doi.org/10.1002/j.1538-7305.1933.tb00403.x>.

Fujiki, R.B., Huber, J.E. and Sivasankar, M.P. (2021) "Mitigating the Effects of Acute Vocal Exertion in Individuals With Vocal Fatigue", *The Laryngoscope*, 131(12), pp. 2732 - 2739. Available at: <https://doi.org/10.1002/lary.29627>.

Gonçalves, D.M.d.R. *et al.* (2019) "Immediate effect of phonation into silicone tube on gospel singers", *CoDAS*, 31(6), pp. 1 - 5. Available at: <https://doi.org/10.1590/2317-1782/20192018117>.

Gongaware, J. J. (2025) "Individual Vocal Practice Habits of Barbershop Chorus Singers: A Mixed-Methods Investigation". Unpublished Manuscript. Voice Study Centre/University of Wales-Trinity Saint David. Available at: https://docs.google.com/document/d/18r-UbAXbr01DPh8jK4hN0A-v6WP62tJ6_v388uuWGV0/edit?usp=sharing (Accessed: 28 February 2026).

Guzmán, M. *et al.* (2013) "Vocal Tract and Glottal Function During and After Vocal Exercising With Resonance Tube and Straw", *Journal of Voice*, 27(4), pp. 523.e19 - 523.e34. Available at: <https://doi.org/10.1016/j.jvoice.2013.02.007>.

Guzmán, M. *et al.* (2017) "The Impact of Double Source of Vibration Semioccluded Voice Exercises on Objective and Subjective Outcomes in Subjects with Voice Complaints", *Journal of Voice*, 32(6), pp. 770.e1 - 770.e9. Available at: <https://doi.org/10.1016/j.jvoice.2017.08.021>.

Guzmán, M. *et al.* (2023) "Physiologic Voice Rehabilitation Based on Water Resistance Therapy With Connected Speech in Subjects With Vocal Fatigue", *Journal of Voice*, 37(2), pp. 300.e1 - 300.e10. Available at: <https://doi.org/10.1016/j.jvoice.2020.12.022>.

Heller-Stark, A. *et al.* (2024) "Comparative study of two semi-occluded vocal tract protocols: A randomized clinical trial", *Journal of Speech, Language, and Hearing Research*, 67(11), pp. 4275 - 4287. Available at: https://doi.org/10.1044/2024_jslhr-22-00456.

Howard, D.M. and Angus, J. (2009) *Acoustics and Psychoacoustics*. Fourth Edition. Oxford, UK: Focal Press.

Kang, J., *et al.* (2018), "Comparing the Exposure-Response Relationships of Physiological and Traditional Vocal Warm-ups on Aerodynamic and Acoustic Parameters in Untrained Singers", *Journal of Voice*, 33(4), pp. 420 - 428. Available at: <https://doi.org/10.1016/j.jvoice.2017.12.019>.

Kang, J. *et al.* (2019a) "Comparing the Exposure-Response Relationships of Physiological and Traditional Vocal Warm-ups on Aerodynamic and Acoustic Parameters in Untrained Singers", *Journal of Voice*, 33(4), pp. 420 - 428. Available at: <https://doi.org/10.1016/j.jvoice.2017.12.019>.

Kang, J. *et al.* (2019b) "Lingering Effects of Straw Phonation Exercises on Aerodynamic, Electroglottographic, and Acoustic Parameters", *Journal of Voice*, 33(5), pp. 810.e5 - 810.e11. Available at: <https://doi.org/10.1016/j.jvoice.2018.05.002>.

Kapsner-Smith, M.R. *et al.* (2015) "A randomized controlled trial of two semi-occluded vocal tract voice therapy protocols", *Journal of Speech, Language, and Hearing Research*, 58(3), pp. 535 - 549. Available at: https://doi.org/10.1044/2015_jslhr-s-13-0231.

Laukkanen, A.-M. *et al.* (2011) "The effect of phonation into a straw on the vocal tract adjustments and formant frequencies. A preliminary MRI study on a single subject completed with acoustic results", *Biomedical Signal Processing and Control*, 7(1) pp. 50 - 57. Available at: <https://doi.org/10.1016/j.bspc.2011.02.004>.

Mailänder, E., Mühre, L. and Barsties, B. (2017) "Lax Vox as a Voice Training Program for Teachers: A Pilot Study", *Journal of Voice*, 31(2), pp. 262.e13 - 262.e22. Available at: <http://dx.doi.org/10.1016/j.jvoice.2016.04.011>.

Manjunatha, U., Nayak, P. S. and Bhat, J. S. (2022) "Can Straw Phonation Be Considered As Vocal Warm Up Among Speech Language Pathologists?", *Journal of Voice*, 36(5), pp. 735.e1 - 735.e6. Available at: <https://doi.org/10.1016/J.JVOICE.2020.08.016>.

Manternach, B., Maxfield, L. and Manternach, J. N. (2021) "Effects of Varied Semi-Occluded Vocal Tract Exercises on Acoustic and Perceptual Measures of Music Theatre Singers: A Pilot Study", *Voice and Speech Review*, 15(1), pp. 40 - 50. Available at: <https://doi.org/10.1080/23268263.2020.1781373>.

Manternach, J. N. and Clark, C. (2018) "Effects of straw phonation on acoustic and perceptual measures of a barbershop chorus", *Bulletin of the Council for Research in Music Education*, (218), pp. 21 - 33. Available at: <https://doi.org/10.5406/bulcouresmusedu.218.0021>.

Manternach, J. N. and Daugherty, J. F. (2019) "Effects of a Straw Phonation Protocol on Acoustic and Perceptual Measures of an SATB Chorus", *Journal of Voice*, 33(1), pp. 80 - 86. Available at: <https://doi.org/10.1016/j.jvoice.2017.09.017>.

Manternach, J. N., Kotsonis, A. and Mann, L. M. (2022) "Effects of straw phonation on choral acoustic and perceptual measures after an acclimation period", *International Journal of Music Education*, 40(2), pp. 177 - 189. Available at: <https://doi.org/10.1177/02557614211073145>.

Manternach, J. N., Schloneger, M. and Maxfield, L. (2019) "Effects of Straw Phonation and Neutral Vowel Protocols on the Choral Sound of Two Matched Women's Choirs", *Journal of Research in Music Education*, 66(4), pp. 465 - 480. Available at: <https://doi.org/10.1177/0022429418809976>.

Maxfield, L. *et al.* (2014) "Intraoral pressures produced by thirteen semi-occluded vocal tract gestures", *Logopedics Phoniatrics Vocology*, 40(2), pp. 86 - 92. Available at: <https://doi.org/10.3109/14015439.2014.913074>.

Meerschman, I. *et al.* (2017) "Short-Term Effect of Two Semi-Occluded Vocal Tract Training Programs on the Vocal Quality of Future Occupational Voice Users: 'Resonant Voice Training Using Nasal Consonants' Versus 'Straw Phonation'", *Journal of Speech, Language, and Hearing Research*, 60(9), pp. 2519 - 2536. Available at: https://doi.org/10.1044/2017_JSLHR-S-17-0017.

Moura, S.R.C. *et al.* (2025) "Transcranial Direct Current Stimulation Combined With Straw Phonation in Water Technique in Subjects With and Without Vocal Symptoms: Exploratory Study", *Journal of Voice* [Preprint]. Available at: <https://doi.org/10.1016/j.jvoice.2025.06.030>.

Nanjundeswaran, C. *et al.* (2015) "Vocal Fatigue Index (VFI): Development and Validation", *Journal of Voice*, 29(4), pp. 433 - 440. Available at: <https://doi.org/10.1016/j.jvoice.2014.09.012>.

Orepic, P. *et al.* (2023) "Bone conduction facilitates self-other voice discrimination", *Royal Society Open Science*, 10(2), pp. 1 - 17. Available at: <https://doi.org/10.1098/rsos.221561>.

Paes, S. M. and Behlau, M. (2017) "Dosage dependent effect of high-resistance straw exercise in dysphonic and non-dysphonic women", *CoDAS*, 29(1), pp. 1 - 9. Available at: <https://doi.org/10.1590/2317-1782/20172016048>.

Paixão, L.R. da *et al.* (2021) "Vocal and self-perception effects of straw phonation exercises", *Revista CEFAC*, 23(6), pp.e8521. Available at: <https://doi.org/10.1590/1982-0216/20212368521>.

Piragibe, P.C. *et al.* (2020) "Comparison of the immediate effect of voiced oral high-frequency oscillation and flow phonation with resonance tube in vocally-healthy elderly women", *CoDAS*, 32(4), pp. e20190074. Available at: <https://doi.org/10.1590/2317-1782/20192019074>.

Portillo, M.P. *et al.* (2018) "Comparison of Effects Produced by Physiological Versus Traditional Vocal Warm-up in Contemporary Commercial Music Singers", *Journal of Voice*, 32(2), pp. 200 - 208. Available at: <https://doi.org/10.1016/j.jvoice.2017.03.022>.

Pretorius, L. (2024) "Demystifying Research Paradigms: Navigating Ontology, Epistemology, and Axiology in Research", *The Qualitative Report*, 29(10), pp. 2698 - 2715. Available at <https://doi.org/10.46743/2160-3715/2024.7632>.

R Core Team (2024, *R: A Language and Environment for Statistical Computing* (2024). Available at: <https://www.R-project.org/>.

Saldías, M. *et al.* (2020) "Water Resistance Therapy as Vocal Warm-Up Method in Contemporary Commercial Music Singers", *Folia Phoniatrica et Logopaedica*, 72(1), pp. 1 - 12. Available at: <https://doi.org/10.1159/000494722>

Sampaio, M. Oliveira, G., and Behlau, M. (2008) "Investigation of the immediate effects of two semi-occluded vocal tract exercises", *Pró-Fono Revista de Atualização Científica*, 20(4), pp. 261 - 266. Available at: <https://doi.org/10.1590/S0104-56872008000400010>.

Shoffel-Havakuk, H. *et al.* (2018) "Validation of the OMNI Vocal Effort Scale in the Treatment of Adductor Spasmodic Dysphonia, " *The Laryngoscope*, 129, pp. 448 - 453. Available at: <https://doi.org/10.1002/lary.27430>.

SingUnited International (2026) *Judging Category Description Book* [online]. Available at: https://singunited.org/sites/default/files/Education/JCDB/SingUnited_Judging-Category-Description-Book_2026-Web.pdf.

Society Contest and Judging Committee, Barbershop Harmony Society (2025) *Contest and Judging Handbook* [online]. Available at: https://files.barbershop.org/PDFs/Contests-Judging/Contest-and-Judging-Handbook_v17.0.pdf [accessed 28 February 2026].

Story, B. H., Laukkanen, A.-M. and Titze, I. R. (2000) "Acoustic impedance of an artificially lengthened and constricted vocal tract", *Journal of Voice*, 14(4), pp. 455 - 469. Available at: [https://doi.org/10.1016/S0892-1997\(00\)80003-X](https://doi.org/10.1016/S0892-1997(00)80003-X).

Ter, W. S. and Wong, K. Y. (2022) "The effect of semi-occluded Vocal tract exercise (SOVTE) and traditional vocal warm-up (TVW) on the vocal quality of untrained female singers in Malaysia: A Comparison", *Pertanika Journal of Social Sciences and Humanities*, 30(2), pp. 557 - 577. Available at: <https://doi.org/10.47836/pjssh.30.2.08>.

Titze, I. R. (2000) *Principles of Voice Production*. Third Printing. Iowa City, IA: National Center for Voice and Speech.

Titze, I. R. (2006). Voice Training and Therapy With a Semi-Occluded Vocal Tract: Rationale and Scientific Underpinnings. *Journal of Speech, Language, and Hearing Research*, 49(2), pp. 448 - 459. [https://doi.org/10.1044/1092-4388\(2006/035\)](https://doi.org/10.1044/1092-4388(2006/035)).

Titze, I. R. (2020) "Inertagrams for a Variety of Semi-Occluded Vocal Tracts", *Journal of Speech, Language, and Hearing Research*, 63(8), pp. 2589 - 2596. Available at: https://doi.org/10.1044/2020_JSLHR-20-00060.

Titze, I. R. and Laukkanen, A.-M. (2007) "Can vocal economy in phonation be increased with an artificially lengthened vocal tract? A computer modeling study", *Logopedics Phoniatrics Vocology*, 32(4), pp. 147 - 156. Available at: <https://doi.org/10.1080/14015430701439765>.

Titze, I. R. and Story, B. H. (1997) "Acoustic interactions of the voice source with the lower vocal tract", *Journal of the Acoustical Society of America*, 101(4), pp. 2234 - 2243. Available at <https://doi.org/10.1121/1.418246>.

Titze, I. R. and Verdolini Abbott, K. (2012) *Vocology: The Science and Practice of Voice Habilitation*. Salt Lake City, UT: National Center for Voice and Speech.

Titze, I. R. et al. (2021) "Vocalization with semi-occluded airways is favorable for optimizing sound production", *PLoS Computational Biology*, 17(3), pp. 1 - 21. Available at: <https://doi.org/10.1371/journal.pcbi.1008744>.

Ülvan, E. *et al.* (2024) "Effects of a Short-Term Vocal Loading Task and Different Restoration Strategies on Voice", *Journal of Voice* [Preprint]. Available at: <https://doi.org/10.1016/j.jvoice.2024.11.046>.

van Leer, E. and van Mersbergen, M. (2017) "Using the Borg CR10 Physical Exertion Scale to Measure Patient-perceived Vocal Effort Pre and Post Treatment", *Journal of Voice*, 31(3), pp. 389.e19 - 389.e25. Available at: <http://dx.doi.org/10.1016/j.jvoice.2016.09.023>.

Vocal Straw Exercise (2010). National Center for Voice and Speech. 14 June. Available at: <https://www.youtube.com/watch?v=0xYDvwvmBIM>.

Wu, C.-H. and Chan, R.W. (2020) "Effects of a 6-Week Straw Phonation in Water Exercise Program on the Aging Voice", *Journal of Speech, Language, and Hearing Research*, 63(4), pp. 1018 - 1032. Available at: https://doi.org/10.1044/2020_JSLHR-19-00124.

Appendices

Appendix 1 - Quartet Participant Informed Consent Form

Page 1 of 2

Acoustic and Perceptual Impacts of Straw Phonation Exercises on Barbershop Quartets: A Pilot Study

Informed Consent - Quartet Participants

As part of his MA Voice Pedagogy coursework, Josh Gongaware is investigating the acoustic and perceptual impacts of straw phonation exercises on barbershop quartets through the University of Wales Trinity St. David (UWTSD) and the Voice Study Centre (VSC), under the guidance of Joshua Lee-Cummins. Your participation will help to reveal the impacts that straw phonation has on the acoustic output of barbershop quartets, barbershop quartet singers' perceptions of their own singing, and outside listeners' perceptions of barbershop quartet singing, which will serve as pilot data on the efficacy of straw phonation as an exercise for barbershop quartet singers.

Quartet participation is open to established North American barbershop quartets of any organizational affiliation(s) or no organizational affiliation, whose members are all 18 years of age or older and are in good vocal health/not currently experiencing any vocal discomfort or pain. All quartet participants will be required to provide informed consent prior to participating in this study. The data collection process will take approximately one hour and will be conducted at a mutually-agreeable location and time on or before August 16, 2026. Participating in this study as a Quartet Participant will involve singing a song/arrangement of your choosing multiple times, completing a prescribed vocal exercise regimen, and completing an individual questionnaire about your experience. Your performances will be audio recorded, and these recordings will be acoustically analyzed and adjudicated by certified Barbershop Harmony Society (BHS) Singing Judges according to their standard scoring system.

The researcher attained ethical approval from UWTSD and is committed to following ethical guidelines, minimizing risk, and ensuring participant confidentiality. Participating in this study is voluntary and you are free to change your mind and stop at any point. There is a small risk that you may find some of the questions sensitive and they may cause emotional discomfort, and/or that you will sustain vocal fatigue, discomfort, or injury during the experimental process. Participants may opt out of answering any questions causing emotional discomfort. Participants may also take time to rest if needed, and should not continue with the experiment if they experience vocal discomfort or a vocal injury.

All participants will be given a unique identifier to ensure confidentiality and all data containing personally-identifiable information will be kept in password-protected cloud storage only accessible to the researcher. Pseudonymized recordings of quartet performances will be securely shared as needed with expert listener participants for adjudication. All data files will be deleted following completion of the UWTSD/VSC grading and moderation process.

This research is not sponsored by, endorsed by, or affiliated in any way with BHS or the Society Committee for Contest and Judging (SCJC). The researcher and all participants are volunteers and are not official representatives of BHS or SCJC.

By signing below, you hereby acknowledge the following:

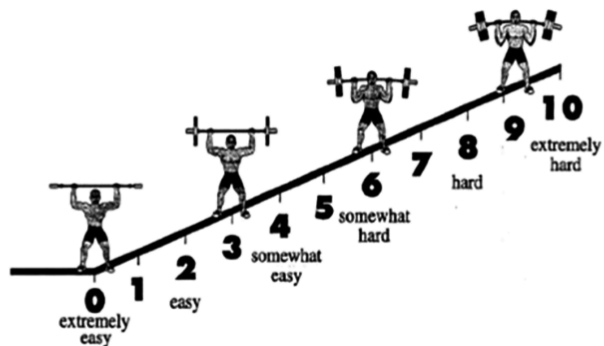
- I attest that I am 18 years of age or older.
- I attest that, to the best of my knowledge, I am in good vocal health.
- I attest that I am not currently experiencing vocal pain or discomfort.
- I voluntarily agree to participate in this research study.
- I understand that even if I agree to participate now, I can withdraw at any time.
- I understand that I can refuse to answer questions without any consequence other than my answers will no longer contribute to the results.
- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
- I understand that participating in this study as a Quartet Participant involves performing a song multiple times, completing a vocal exercise regimen, and completing an individual questionnaire about my experience.
- I understand that I will not benefit directly from participating in this study.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this study my identity will remain anonymous.
- I understand that I have the right to request access to my personal data, in accordance with applicable data protection legislation.
- I understand that once data has been fully anonymized, it may not be possible to identify, retrieve, or withdraw my individual data.
- I understand that I am free to contact the researcher to seek further clarification and information.

Full Name (Printed)	
Full Name (Signature)	
Date	

Appendix 2 - Quartet Participant Questionnaire

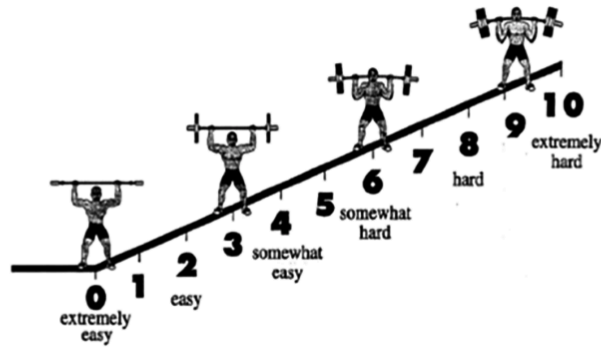
Participant ID _____

1. Based on the scale below, circle the number (0-10) that indicates how much effort, strain, discomfort, and/or fatigue you perceived when using your voice during your first performance?



2. Please describe how you warmed up before your first performance.

3. Based on the scale below, circle the number (0-10) that indicates how much effort, strain, discomfort, and/or fatigue you perceived when using your voice during your second performance?



4. In terms of overall quartet sound, how do you think your first performance compared to your second performance? Circle your response below.
- The overall quartet sound was better during the first performance than during the second performance.
 - The overall quartet sound was better during the second performance than during the first performance.
 - I did not notice a difference in the overall quartet sound between the first and second performances.
5. Did you observe any differences between your first and second performances? If so, please explain what you observed and what you think may have contributed to these differences.

6. Please rate how much you think the straw exercise regimen impacted each of the following:

Not at all ←————→ **Very much**

The overall quartet sound	0	1	2	3	4	5	6	7	8	9	10
The sound of your individual singing	0	1	2	3	4	5	6	7	8	9	10
The feeling of your individual singing	0	1	2	3	4	5	6	7	8	9	10

7. If you perceived changes in the overall quartet sound after the straw exercise regimen, please describe the changes you perceived.

8. If you perceived changes in your individual singing after the straw exercise regimen, please describe the changes you perceived.

9. Have you done straw-based vocal exercises before participating in this experiment? Circle your response below.

- a. Yes
- b. No
- c. I am not sure

Appendix 3 - Expert Listener Participant Informed Consent Form and Questionnaire

Acoustic and Perceptual Impacts of Straw Phonation Exercises on Barbershop Quartets: A Pilot Study

As part of his MA Voice Pedagogy coursework, Josh Gongaware is investigating the acoustic and perceptual impacts of straw phonation exercises on barbershop quartets through the University of Wales Trinity St. David (UWTSD) and the Voice Study Centre (VSC), under the guidance of Joshua Lee-Cummins. Your participation will help to reveal the impacts that straw phonation has on the acoustic output of barbershop quartets, barbershop quartet singers' perceptions of their own singing, and outside listeners' perceptions of barbershop quartet singing, which will serve as pilot data on the efficacy of straw phonation as an exercise for barbershop quartet singers.

Expert Listener participation is open to certified Barbershop Harmony Society (BHS) Singing Judges who are 18 years of age or older, and all Expert Listener participants will be required to provide informed consent before participating in this study. Participating in this study as an Expert Listener participant will involve listening to a set of 10 audio recordings of quartet performances and adjudicating them according to the standard BHS scoring system. This data collection should take approximately 40 minutes.

Participating in this study is voluntary and you are free to change your mind and stop at any point. The researcher attained ethical approval from UWTSD and is committed to following ethical guidelines, minimizing risk, and ensuring participant confidentiality. There is a small risk that by listening to the quartet recordings, you may experience auditory and/or emotional discomfort. You may opt out of questions that cause you emotional discomfort.

All Expert Listener participants will be given a unique identifier to ensure confidentiality. All data containing personally-identifiable information will be kept in password-protected cloud storage only accessible to the researcher. Pseudonymized recordings of quartet performances will be securely shared as needed with expert listener participants for adjudication. All data files will be deleted following completion of the UWTSD/VSC grading and moderation process.

This research is not sponsored by, endorsed by, or affiliated in any way with BHS or the Society Committee for Contest and Judging (SCJC). The researcher and all participants are volunteers and are not official representatives of BHS or SCJC.

By submitting this form below, you hereby acknowledge the following:

- I voluntarily agree to participate in this research study.
- I attest that I am 18 years of age or older.
- I attest that I am a certified Barbershop Harmony Society Singing Judge.
- I understand that even if I agree to participate now, I can withdraw at any time.
- I understand that I can refuse to answer questions without any consequence other than my answers will no longer contribute to the results.
- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
- I understand that participating in this study as an Expert Listener Participant involves listening to a set of quartet audio recordings and adjudicating them according to the standard BHS scoring system.
- I understand that I will not benefit directly from participating in this study.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this study my identity will remain anonymous.
- I understand that I have the right to request access to my personal data, in accordance with applicable data protection legislation
- I understand that once data has been fully anonymized, it may not be possible to identify, retrieve, or withdraw my individual data.
- I understand that I am free to contact the researcher to seek further clarification and information.

* Indicates required question

In order to continue with participating in this study, please complete the required items below:

Please confirm that you have read and understand all information provided above * and that you consent to participate in this research study.

☐ I have read and understand all information provided above and I consent to participate in this research study.

Please confirm that you are a member of the target population for this study. *

☐ I am at least 18 years old and am currently a certified Barbershop Harmony Society Singing Judge.

Please enter your full name. *

Your answer

Next

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Acoustic and Perceptual Impacts of Straw Phonation Exercises on Barbershop Quartets: A Pilot Study

* Indicates required question

Recordings

Please click the links below to listen to each of the following audio recordings. A new tab will open with a media player.

Please adjudicate each recording according to the standard BHS scoring system and select your score for each in the corresponding dropdown list below.

Please listen to [Recording 1](#) and select your score below. *

Choose

Please listen to [Recording 2](#) and select your score below. *

Choose

Please listen to [Recording 3](#) and select your score below. *

Choose

Please listen to [Recording 4](#) and select your score below. *

Choose

Please listen to [Recording 5](#) and select your score below. *

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Please listen to [Recording 6](#) and select your score below. *

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Please listen to [Recording 7](#) and select your score below. *

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Please listen to [Recording 8](#) and select your score below. *

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Please listen to [Recording 9](#) and select your score below. *

Choose

Please listen to [Recording 10](#) and select your score below. *

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Appendix 4 - Experimental Protocol

Introduction (~ 5 minutes):

Hello. Thank you for your participation in today's experiment. My name is Josh Gongaware, and I am a Masters Student in Voice Pedagogy through the Voice Study Centre and the University of Wales Trinity St. David, under the guidance of Joshua Lee-Cummins. For the final research project of my program, I am investigating the acoustic and perceptual impacts of straw phonation exercises on barbershop quartets. Your participation in this study will help to reveal the impacts that straw phonation has on the acoustic output of barbershop quartets, barbershop quartet singers' perceptions of their own singing, and outside listeners' perceptions of barbershop quartet singing, which will serve as pilot data on the efficacy of straw phonation as an exercise for barbershop quartets.

Before we begin the data collection process, I will summarize the experimental methodology, what your participation will involve, and your rights as a participant, and also ask if there are any questions. If you agree to participate, I will then ask you to sign an informed consent form attesting that I provided information on the study to you and that you consent to participate in it. Please note that participating in this study is voluntary and you are free to change your mind and stop at any point.

If you choose to do so, you will be participating in this study as a quartet singer participant. The data collection process will flow as follows:

1. **~15 min** - First, participants will have up to 15 minutes to warm up - individually or collectively - in whatever way you see fit.
2. **~3 min** Next, participants will stand in front of the recording device and I will ask you to sing brief passages of a song to help me test the recorder and ensure the levels are set appropriately.
3. **~3 min** - Next, participants will be asked to perform a barbershop arrangement of their choosing with duration of approximately 2-3 minutes in duration. This performance will be audio-recorded.
4. **~3 min** - Following the performance, participants will then be asked to complete a brief questionnaire about their personal experience in this first performance.
5. **~8 min** - Following completion of the questionnaire, I will demonstrate a vocal exercise you will be asked to perform and describe an approximately 5-minute long vocal exercise protocol that you will be asked to complete. You will have the opportunity to ask questions before we begin the protocol.
6. **~5 min** - I will then guide you through the 5-minute long vocal exercise protocol while you complete the vocal exercises.
7. **~3 min** - Immediately following completion of the vocal exercise protocol, participants will again be asked to perform the same arrangement as you performed in step 2. This performance will again be audio-recorded.
8. **~5 min** - Participants will then be asked to complete another brief questionnaire on their experience with their personal experience in the second performance.

After data collection, the recordings of your performances will be acoustically analyzed and adjudicated by Certified Barbershop Harmony Society Singing Judges according to the standard Barbershop Harmony Society scoring system. Please note that this research is not in any way affiliated with, sponsored by, or endorsed by the Barbershop Harmony Society or the Society Committee for Contest and Judging. All recordings will be pseudonymized (i.e. not attributed to any individual participant or quartet names) prior to sharing, and in any report on the results of this study individual quartet singers and quartet participant identities will remain anonymous.

Informed Consent (~5 minutes): Your rights as a participant are summarized on your informed consent form. Please review thoroughly and let me know if you have any questions.
[Allow time to review]

Do you have any questions at this time?

[answer questions]

If you agree to participate in the experiment, please print your full name and today's date, sign, and return the informed consent form to me at this time.
Thank you!

Data Collection Process (~50 minutes):

At this time, we will begin the data collection process. Please take the next 15 minutes to warm up - individually or collectively - in whatever way you see fit.

[Set timer for 15 minutes, and proceed at end of 15 minute period]

Thank you, your warm up period has concluded. To assist with microphone leveling, please sing a small passage at around the quietest volume you will sing in your song today, followed by a small passage at around the loudest volume you will sing in your song today.

[Allow time for microphone leveling exercise]

Thank you. Please now perform the barbershop arrangement of your choosing, with a duration of approximately 2-3 minutes.

[Allow time for quartet to sing for take 1]

Thank you. You will now be asked to complete a brief questionnaire regarding your experience in the experiment thus far. Please read the questions carefully, answer them to the best of your ability, and submit your completed questionnaire when you are done. Let me know if you have any questions.

[Allow time for singers to complete questionnaire]

Thank you. We will now go over a vocal exercise protocol that you will be asked to complete shortly.

- You will be vocalizing through a drinking straw. Place one end of the straw in your mouth as you would when drinking and hold the free end of the straw with one hand.
- While vocalizing, continue holding the straw with your hand - do not simply allow it to rest between your teeth.
- Maintain a tight seal and do not allow air to escape around the straw through your lips or through your nose.
 - If you pinch your nose, the sound shouldn't change.
- Use abdominal muscle support to keep your tone as smooth and steady as possible.

- Your level of effort in this exercise should be as though you are making a normal singing sound, even though the sound coming through the straw will likely be much smaller than in normal singing.
- When you are asked to add accents/hills, do this through abdominal support rather than neck muscle tension.
- Avoid pulses or rearticulation in the last exercise. Keep it as smooth and connected as possible.

The exercises will be as follows.

- 6 straw glides from lowest to highest note and back down (encourage use breath energy and as little neck tension as possible)
- Glides with accents/hills (encourage to add accents with abdominal support with as little neck tension as possible)
 - 3 accents
 - 4 accents
 - 5 accents
 - 6 accents
 - 7 accents
- Sing star spangled banner in unison (key of A major) through straw (encourage to use breath energy and abdominal support with as little neck tension as possible)

As a reminder, immediately following this exercise - with as little time after completion of the vocal exercise regimen as possible - you will be asked to sing the same arrangement you sang previously.

Do you have any questions before we begin the vocal exercise protocol?

[answer questions]

We will now begin the vocal exercise protocol.

[Go through vocal exercise protocol]

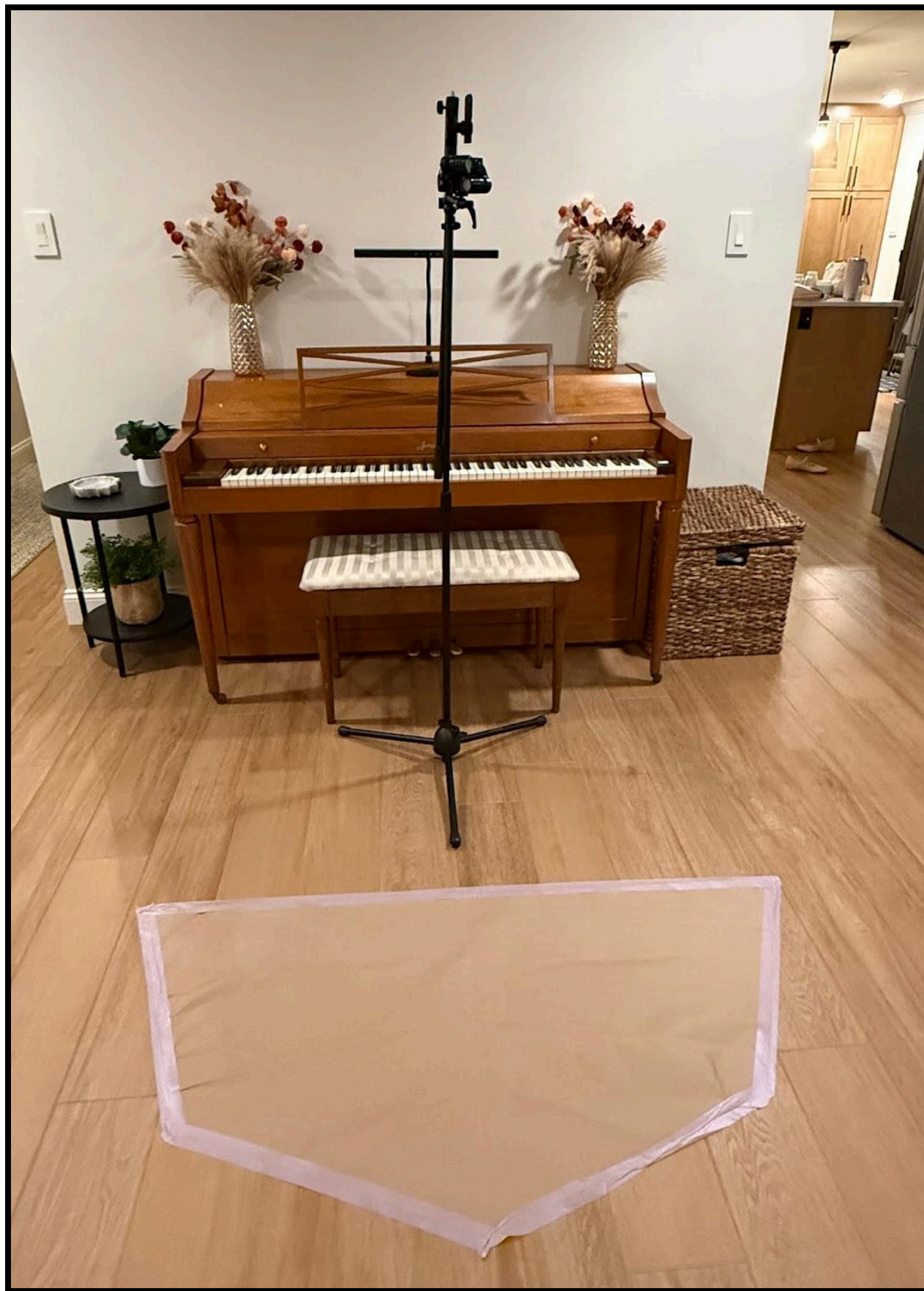
Thank you. This concludes the vocal exercise protocol. Please sing the same arrangement again that you sang earlier.

[Allow quartet to sing]

Thank you. You will now be asked to complete a brief questionnaire regarding your experience in the second performance. Please read the questions carefully, answer them to the best of your ability, and submit your completed questionnaire when you are done. Let me know if you have any questions.

This concludes this phase of the experiment. Thank you again for your cooperation and participation. If you have any questions about the study, or wish to withdraw from the study at any time, please reach out to me via email.

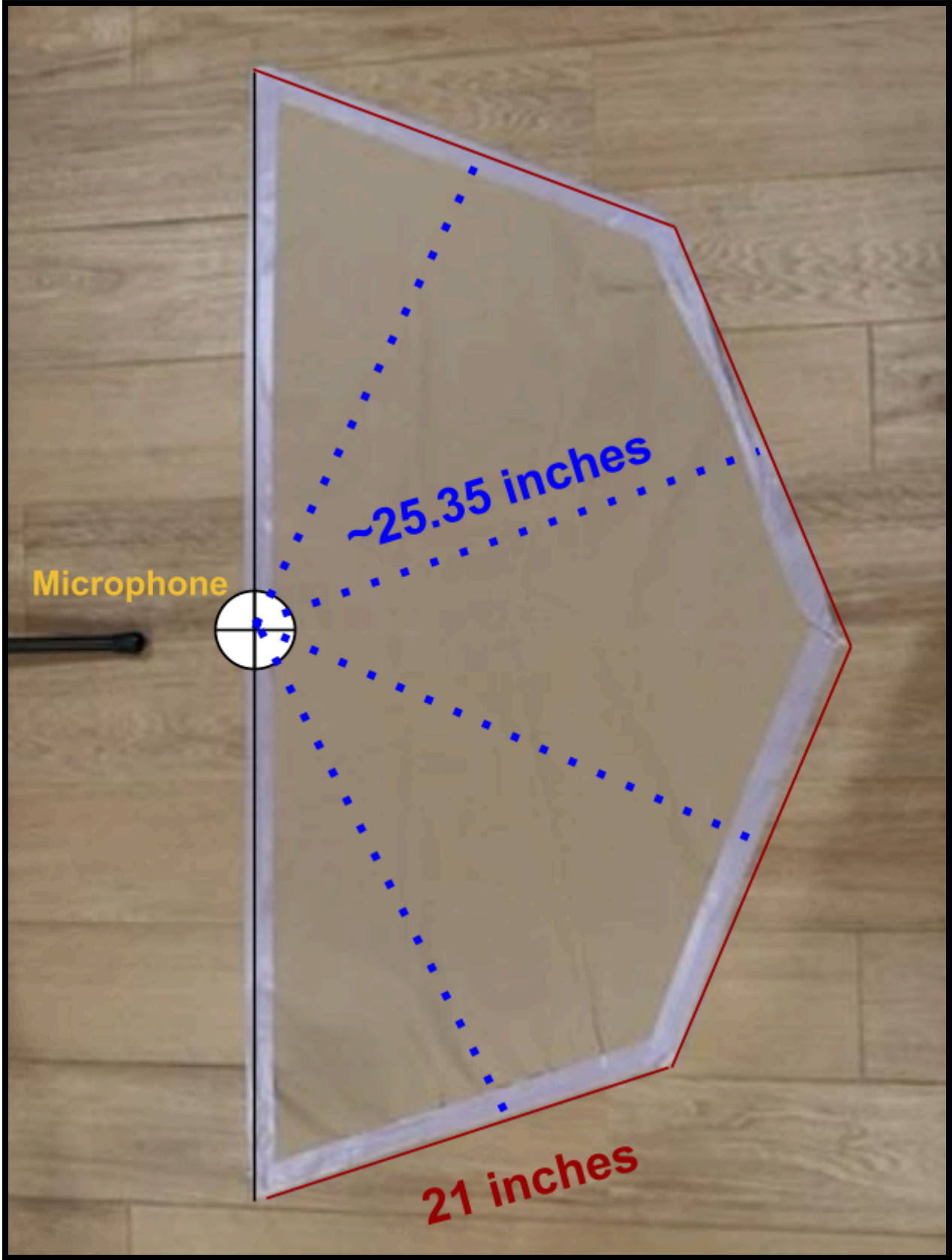
Appendix 5 - Example Quartet Participant Recording Setup (Front View)



Appendix 6 - Example Quartet Participant Recording Setup (Profile View)



Appendix 7 -Quartet Spacing Dimensions



Appendix 8 -Essential Everyday Flexible Plastic Straw Length



Appendix 9 -Essential Everyday Flexible Plastic Straw Diameter



Appendix 10 - ZOOM H6 Studio with 19.4 mm large diameter stereo X-Y microphones



Appendix 11 - Triplet SLM600 Sound Level Meter



Appendix 12 - Quartet 2 Long-Term Average Spectrum - Final Chord Removed

