Acoustic Comparison of Lower and Higher Belt Ranges in Professional Broadway Actresses

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Summary: Purpose. Current research on the female belt voice has generally been limited to the range of C5, which is not representative of the current requirements on Broadway. Additionally, much belt research uses voice teachers or college students. The goal of this study was to acoustically examine both higher and lower belt ranges in 10 women who have performed belt roles on Broadway during the last decade.

Method. We analyzed the long-term average spectrum of the middle stable portion of three belted pitches, one from a lower, more traditional belt song and two from a higher, more contemporary belt song. The dB levels of the first three peaks in the long-term average spectrum corresponding to the first three harmonics were extracted and compared across tasks. Age, professional roles played on Broadway, and self-perceived belt strategy were obtained via interview to find potential unifying factors in resonance strategies.

Results. Overall, the dB level of the peaks closest to the second and third harmonics were higher than the peak close to the fundamental frequency. The difference between peaks was statistically greater in the lower belt com-pared to both higher belt tasks, indicating these singers relied more on a single harmonic in the lower belt range than the higher belt range. In the higher belt range, there was less variability between peaks. No patterns emerged between resonance strategies and demographic information.

Conclusions. Elite female belters use varying resonance strategies to create commercially viable belt sounds in different belt ranges.

Key Words: Belt—Musical theatre—Broadway—Resonance strategy—Long term average spectrum.

INTRODUCTION

Belting has been the center of much debate and confusion in the voice community for many decades. Historically, it has been vilified as unhealthy due to varying aesthetics of sing-ing teachers and audiences, as well as vastly disparate self-perception of a singer's own function.1 Belting has been called “damaging,” “not legitimate,” “detrimental to health,” and an “abuse of the voice.”2-4 Much of the nega-tivity toward belting has come from the lack of agreement from both teachers and researchers about the definition of belting. Over the years, researchers have attempted to define belting with studies being conducted in acoustic and aerody-namic measures, perceptual findings, and vocal fold func-tion; however, much of the data is inconclusive.5

The most widely accepted acoustical definition of a belt involves a boosted second harmonic. Schutte and Miller concluded that acoustically, belting needs a raised first for-mant to match the second harmonic on open vowels.6 Titze also states that it is “well established” that a belt sound requires a strong second harmonic.7 However, Lebowitz and Baken found that a strengthened second harmonic was not universal. Many of the belters in their study displayed a weaker second harmonic relative to the fundamental.8 In

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another study comparing three singers, Dargin points out that Ethel Merman, who was once referred to as “Broad-way's biggest belter” by critics, does not use the typical belt strategy of tracking the first formant to the second har-monic, but rather tracks the second formant to the third harmonic.9 This opens the door for questions about what acoustically defines a belt and if there are multiple ways to create a belt sound.

It is well accepted in classical singing that there are a vari-ety of strategies for tenors singing in the G4-D5 range.10 Schutte, Miller, and Duijnstee analyzed 34 operatic tenors and found three prominent strategies, including raising the first formant to approximate and boost the third harmonic, the first formant approximating the first harmonic, and emphasizing the fifth and seventh harmonics.11 Henrich, Smith, and Wolfe investigated singers who often exhibited either a first formant tuned to the second harmonic or the first formant tuned to the third harmonic.12 Additionally, Neumann, Schunde, Hoth, and Euler found that the male singers in their study had a mean closed quotient of 47%-50% as they moved through their passaggio into their upper

range, and Lebowitz and Baken found that their female bel-ters had a mean closed quotient of 50% or below.8,13 With a

shared pitch range and similar closed quotient to tenors, it is safe to assume that female belters would exhibit a multi-plicity of successful acoustical strategies while belting.

Despite the disagreements in the voice community about the definition or safety of belting, women have been belting on Broadway stages since the 1920s.14 Not only have women been making these sounds successfully for almost 100 years, belting is now the dominant sound produced by women on the Broadway stage. In 2014, 63% of the casting notices for Broadway shows asked women to belt.15 Over

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the years, the range in which women are expected to pro-duce a belt sound has increased as well.15 In 2014, 20 of the Broadway show casting notices asked for belt sounds of their leading ladies, with 17 of the shows having belt notes

in the C#5-G5 range. Only three shows had a top belt note of B4 and C5.15

Even though the current demands of Broadway are clear, very little belt research has explored the higher belt range above the D5. Schutte and Miller compared a belted B4-flat to a belted E5-flat in a single subject study and found that there was a loss in the sharpness of the bandwidth of the harmonics as the singer sang in the higher belt range.6 This indicates that perhaps singers change their strategy as they ascend in pitch, yet no studies to date have explored what adjustments might take place.

The overall purpose of this study was to better under-stand the acoustic strategies used by professional musical theatre singers in the high belt range. Specifically, we inves-tigated the differences between the lower belt range (up to C5) compared to the higher belt range (above C#5). Our study used 10 elite female belters who have had success belt-ing on Broadway and in their recording careers. We com-pared their strategies of singing C5 to their strategies singing E-flat5 and F5 using samples from both the tradi-tional belt repertoire and contemporary belt repertoire.

MATERIALS AND METHODS

Subjects

Ten women (age range 28 to 65 years, mean = 38.2 years) who have played belt roles on Broadway within the last 10 years were recruited for this study. The subjects have per-formed in over 30 Broadway shows and one on the West End. The participants are featured on a total of 24 cast recordings and have released nine solo albums. They have received Olivier, MAC, New York Musical Festival, three Outer Critics, and Helen Hayes awards as well as two Tony Award, five Drama League, seven Drama Desk, and many regional award nominations. Information regarding



training, vocal health history, and self-perception of their belt was also gathered.

Vocal Tasks

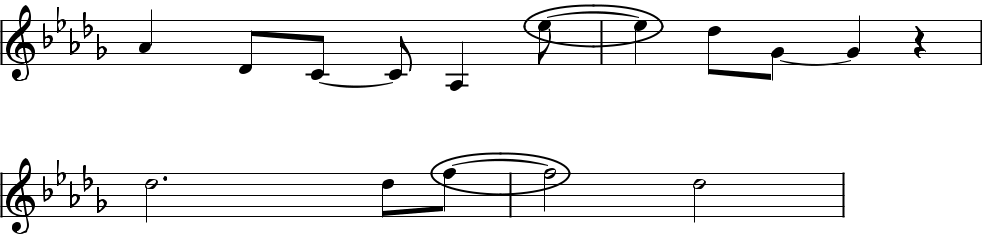
Each subject sang three excerpts that included representa-tive samples of different belt ranges ([Figure 1](#page1)). To represent a lower belt we chose “You Can't Get a Man With a Gun” from Annie Get Your Gun because the climactic pitch of a C5 on an open vowel is prototypical for many belt pieces from both the golden age and certain contemporary reper-toire. The other two samples came from phrases in “Defying Gravity” from Wicked, which exhibits the demand of belted, climactic notes in the Eb5 to F5 range now standard fare in many Broadway scores.

The singers were instructed to sing as though they were performing in the show. Both songs were sung in the origi-nal published keys. Singers were recorded at a distance of 16 cm with a Blue Yeti USB Microphone utilizing a cardi-oid pattern setting with a relative flat (§2 dB) frequency response between 200 and 10,000 Hz. Calibration for dB SPL was not performed because all acoustic measures were relative within each singer and within one recording session.

Acoustic Analysis

Three one-second samples were manually extracted from the two belted songs, a C5 from the traditional belt song and an E-flat5 and F5 from the contemporary belt song ([Figure 1](#page1)). Acoustic analysis of each extracted sample was performed automatically using a custom script in Praat.16 First, the script extracted the fundamental frequency (f0) and performed a long term average spectrum (LTAS) analy-sis of each sample using a 100 Hz bandwidth ([Figure 2](#page1)). From the resultant LTAS, the dB levels of the first three peaks (L1, L2, and L3) closest to each of the first three expected harmonics (f0, 2f0, and 3f0) were extracted. The peak with the maximum dB level was identified to examine whether a boosted 2f0 was consistent across tasks or singers.

With a gu - un

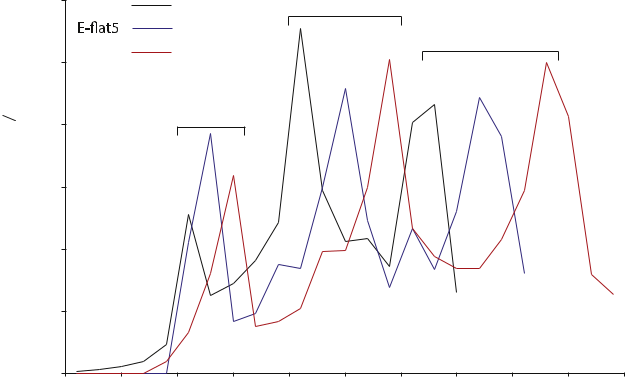


told me late- ly Ev’ - ry - one

high, de - fy - ing

FIGURE 1. Excerpts from “You Can't Get a Man With A Gun” from Annie Get Your Gun and “Defying Gravity” from Wicked. The belted C5 of “gUn” was representative of the lower belt range, while the belted E-flat5 of “Everyone” and the belted F5 of “deFYing” of “Defying Gravity” represented a higher belt range.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 412 |  |  |  |  |  |  |  |  |  |  |  |  | Journal of Voice, Vol. 34, No. 3, 2020 | | |  |
|  | 70 | C5 |  |  |  |  | Peak 2 |  |  |  |  |  | L3 as the maximum. Five singers relied on L2 in 2/3 of the | | |  |
|  |  | F5 |  |  |  |  |  |  | Peak 3 | |  |  | tasks and four singers relied on L3 in 2/3 of the tasks ([Table](#page1) | | |  |
|  | 60 |  |  |  |  |  |  |  |  |  |  | [1](#page1)). |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hz) |  |  | Peak 1 | |  |  |  |  |  |  |  |  | In both the low belt and high belt tasks, both L2 and L3 | | |  |
| (dB | 50 |  |  |  |  |  |  |  |  |  | were higher than L1 in all but three samples ([Figure 3](#page1)). | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | ANOVA revealed a main effect of task on the L2/L1 ratio, F | | |  |
| level |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 40 |  |  |  |  |  |  |  |  |  |  |  | (2,18) = 14.04, P < 0.001 ([Figure 4](#page1)). Post-hoc testing indi- | | |  |
| pressure |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | cated the L2/L1 ratio was greater in the lower belt C5 task | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sound | 30 |  |  |  |  |  |  |  |  |  |  |  | compared to both the E-flat5 and F5 high belt samples, | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  | P = 0.027 and P < 0.001, respectively. A similar main effect | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 20 |  |  |  |  |  |  |  |  |  |  |  | of task was found in the L3/L1 ratio, F(2,18) = 15.82, P < | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | 0.001, also driven by a greater ratio in the lower belt task | | |  |
|  | 10 | 250 | 500 | 750 | | 1000 | 1250 | 1500 | 1750 | 2000 | 2250 | 2500 | when compared to the higher belt tasks, P = 0.002 and | | |  |
|  | **0** |  |
|  |  |  |  |  |  | Frequency (Hz) | | |  |  |  |  | P = 0.009. Therefore, every singer relied on the peak near | | |  |
| FIGURE 2. Representative long-term average spectrum plots of | | | | | | | | | | | | | either the second or third harmonic to boost the overall | | |  |
| the three tasks from a single singer. | | | | | | | |  |  |  |  |  | sound level, and the degree to which the second or third | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | peak was boosted was greater in the low belt task. | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | In contrast to the L2/L1 and L3/L1 ratios, the L3/L2 ratio | | |  |
| To investigate the relative strength of each peak for each | | | | | | | | | | | | | was variable with no uniform strategy or clear difference | | |  |
| singer, the ratio of the dB levels between each pair of peaks | | | | | | | | | | | | | between tasks ([Figure 3](#page1)). ANOVA revealed no effect of | | |  |
| was calculated (L2/L1, L3/L1, and L3/L2). To investigate the | | | | | | | | | | | | | task on the L3/L2 ratio, F(2,18) = 0.02, P = 0.985. | | |  |
| extent to which singers relied on an individual peak versus | | | | | | | | | | | | | A main effect of task was found in the average absolute | | |  |
| evenly distributing the acoustic energy across peaks, the | | | | | | | | | | | | | level difference, F(2,18) = 12.33, P < 0.001. Post-hoc pair- | | |  |
| average absolute level difference was calculated using the | | | | | | | | | | | | | wise t tests revealed that task differences were consistent | | |  |
| following formula: | | | |  |  |  |  |  |  |  |  |  | with those found in the level ratios. The average absolute | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | level difference was higher in the belt C5, mean and stan- | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| L1 | L2 | L1 | L3 | L2 |  | L3 |  |  |  |  |  |  | dard deviation (SD) = 13.9 (4.8), compared to both the E- | | |  |
|  | þ |  | þ |  |  |  |  |  |  |  |  |  | flat5, mean (SD) = 9.0 (4.8), P = 0.039, and the F5, mean | | |  |
|  |  |  | 3 |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  | (SD) = 7.4 (4.2), P = 0.001. This finding indicates there was | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | a more evenly-distributed energy across the first three peaks | | |  |
| Statistical Analysis | | | | |  |  |  |  |  |  |  |  | in the high belt tasks relative to the lower belt. | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Descriptive statistics by task and by singer were calculated | | | | | | | | | | | | |  |  |  |  |
| for | the | maximum | | | peak. | | One-way | | repeated-measures | | | | DISCUSSION | | |  |
| ANOVA was used to test for differences between the three | | | | | | | | | | | | |  |
| Recent investigation into the female belt voice has chal- | | |  |
| tasks in the dB ratios and in the average absolute level dif- | | | | | | | | | | | | |  |
| lenged the concept that the second harmonic is always dom- | | |  |
| ference. If the ANOVA indicated a significant difference | | | | | | | | | | | | |  |
| inant in this vocal quality. | [8](#page1) | Additionally, most acoustic |  |
| between the three tasks (P < 0.05), post-hoc pairwise com- | | | | | | | | | | | | |  |  |
| studies of the belt quality have been limited to the lower belt | | |  |
| parisons were completed using two-tailed paired t tests with | | | | | | | | | | | | |  |
| range. In the current study, | | we investigated the relative |  |
| Bonferroni adjustment for multiple comparisons. | | | | | | | | | | |  |  |  |
|  |  | strength of spectral peaks in the LTAS of professional musi- | | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | cal theatre performers belting in both the lower (C5) belt | | |  |
| Demographic Analysis | | | | | | |  |  |  |  |  |  | range as well as in the higher belt range (E-flat5 and F5) | | |  |
|  |  |  |  |  |  |  |  |  |  |
| Qualitative comparisons of age, roles played, and self-per- | | | | | | | | | | | | |  |  |  |  |
| ception of belting strategy were made with the maximum | | | | | | | | | | | | | TABLE 1. |  |  |  |
| peak findings to find potential unifying factors in resonance | | | | | | | | | | | | |  |  |  |
| The 8 Possible Combinations of Maximum Peaks Across | | |  |
| strategies. To maintain anonymity, individual data are not | | | | | | | | | | | | |  |
| Tasks Summarized by Singer. | | |  |
| reported for these demographic measures. | | | | | | | | | |  |  |  |  |
|  |  |  |  |  |  |  |



C5 E-flat5 F5 Singer(s)

RESULTS

The maximum peak for each task was either L2 or L3, never L1. There was no consistency in which peak was the maxi-mum by task or by singer. In the C5 task, L2 was the maxi-mum peak in 6/10 productions. In the E-flat5 task, L2 was greatest in 5/10 productions. In the F5 task, L2 was greatest in 6/10 productions. Only one singer consistently used L2 as the maximum peak. All other singers had a mix of L2 and

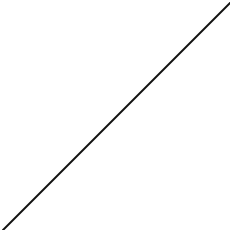
|  |  |  |  |
| --- | --- | --- | --- |
| 2 | 2 | 2 | H |
| 2 | 2 | 3 | F, J |
| 2 | 3 | 2 | A |
| 2 | 3 | 3 | C, D |
| 3 | 2 | 2 | B, G |
| 3 | 2 | 3 | - |
| 3 | 3 | 2 | E, I |
| 3 | 3 | 3 | - |
|  |  |  |  |

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**A**

|  |  |  |
| --- | --- | --- |
| (dB) | 60 |  |
| 50 |  |
|  |  |
| 1 | 40 |  |
| *L* |  |
|  | 30 |  |

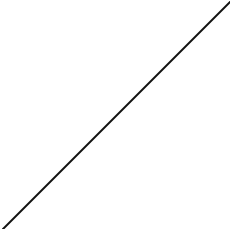
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | E Y | | |  | Y Y | |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | E | |  | Y | |  |  |
|  |  |  |  |  | Y E | |  | EYEE | | |  |  |
|  |  |  |  |  | Y | |  | GG YE | | |  |  |
|  |  |  |  |  | E G | | | | GY E | | |  |
|  |  |  |  |  |  |  |  | G | G | | G |  |
|  |  |  |  |  |  |  | G E | | | |  |  |
|  |  |  |  |  |  |  | G | | G | |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 30 | | 40 | | 50 | |  |  | 60 | |  |  |
|  |  |  | *L* | |  |  |  |  |  |  |  |  |



|  |
| --- |
| *L* |



**B**



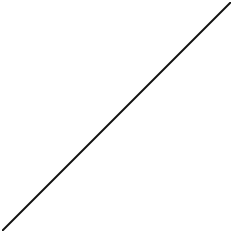
|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | C5: Gun | | | |  |  |  |  |  |
| 60 |  | F5: defYing | | | |  |  |  |  |  |
|  | Eb5: Everyone | | | | | |  |  |  |
| 50 |  |  |  |  |  | Y YYE | | | |  |
|  |  |  |  |  |  | YEYEEE | | |  |
|  |  |  |  |  |  |  | YE |  |  |  |
|  |  |  |  |  | E |  | YG | Y | |  |
|  |  |  |  |  |  |  | G | E | |  |
| 40 |  |  |  |  |  | E | | GGYY | |  |
|  |  |  |  |  |  |
|  |  |  |  |  | E |  | G G G | | |  |
|  |  |  |  |  |  | G |  |  |  |
| 30 |  |  |  |  |  |  | G | G | |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | 30 | | | 40 | | 50 | | 60 | |  |
|  |  |  |  | *L* | |  |  |  |  |  |



|  |
| --- |
| *L* |



**C**



|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | E | G | | |  |  |
| 60 |  |  |  |  | E |  | Y |  | EYY | |  |
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|  |  |  |  |  |  | G |  | G | |  |
|  |  |  |  |  | E | Y | G**Y** |  | E | |  |
|  |  |  |  |  | **G**EY | |  |
|  |  |  |  |  |  | G |  |
|  |  |  |  |  |  |  | G | GG | |  |  |
| 50 |  |  |  |  |  |  | Y E |  |  | E |  |
|  |  |  |  |  |  | E EY | | | |  |
|  |  |  |  |  |  |  | Y |  |  |  |  |
| 40 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
|  | |  |  |  |  |  |  |  |  | |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 30 | | | | 40 | | 50 | |  | 60 | |  |
|  |  |  |  | *L* | |  |  |  |  |  |  |



FIGURE 3. Plots of the relationships among L2/L1 (A), L3/L1 (B), and L3/L2 (C). Each letter represents measurements from a single singer (key in panel B). The dotted line indicates where values would be equal.

commonly found in contemporary musical theatre roles. Overall, we found the dB level of the peaks closest to the second and third harmonics were higher than the peak close to the fundamental frequency. The difference between peaks was more pronounced in the lower belt C5 task compared to both higher belt tasks (E-flat5 and F5), indicating these singers rely more on a single harmonic in the lower belt range than the higher belt range. In the higher belt range, there was less variability between peaks, in many cases including a relatively strong fundamental. Taken together, these results suggest there are multiple resonance strategies used by professional singers to produce a belt quality.

When looking at the ratio of L3 to L2, there was no clear pattern in resonant strategy across the tasks or sing-ers. L2 was strongest in 17/30 samples (all task com-bined), and L3 was strongest in the remaining thirteen samples. Additionally, only one singer utilized a boosted L2 across all three tasks. The other nine utilized a combi-nation of strategies across the three tasks. This finding is consistent with Dargin who found that three singers who played Annie Oakley in Annie Get Your Gun on Broad-way used a variety of either boosting H2 or H3 in their belting.9 Overall, we found a total of six maximum peak combinations ([Table 1](#page1)) among the 10 singers, demon-strating that each actress utilized a different acoustic

strategy, possibly to fit her own physiology or dramatic or musical intent when approaching the material. It appears that the production of commercially viable belt sounds is far more variable than previous acoustic studies have indicated.

When comparing biographical and interview data, we found no patterns across roles played, age, or self-percep-tion regarding the phenomenology of producing these vocal colors. Four of the subjects, B, E, F, and J, played Elphaba in Wicked, and only two of them overlapped in strategy across the three tasks ([Table 1](#page1)). Singers F and J used the same acoustic strategy across all three tasks. Singers B and E used the same strategy on the C5 and F5, and opposite strategies on the E-flat5. Interestingly, singers B and E used the opposite strategy of singers F and J on both the C5 and F5. The oldest and youngest singers, E and J, respectively, utilized the same strategy across all three tasks, indicating that age may not play a role in determining a particular strategy. The two who both focused on “maintaining a low larynx,” J and I, did not exhibit the same acoustic profile, nor did J and G, the two whose self-perception was largely focused on registration as they moved into their higher belt range. There was no clear, unifying biographical or percep-tual information that appeared to unify singers who used the same strategies.

1. 2.0

1.5



|  |  |  |
| --- | --- | --- |
| *L* | 1.0 |  |
| *L* |  |
|  |  |
|  | 0.5 |  |
|  | 0.0 |  |



|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **B** 2.0 | |  |  |  | **C** 2.0 | |  |  |  |
|  |  |  | 1.5 |  |  |  |  | 1.5 |  |  |  |
|  |  | *L* | 1.0 |  |  |  | *L* | 1.0 |  |  |  |
|  |  | *L* |  |  |  | *L* |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | 0.5 |  |  |  |  | 0.5 |  |  |  |
|  | flat5 |  | 0.0 |  | flat5 |  |  | 0.0 | flat5 |  |  |
| C5 | F5 |  | C5 | F5 |  | C5 | F5 |  |
|  | E- |  |  |  | E- |  |  |  | E- |  |  |

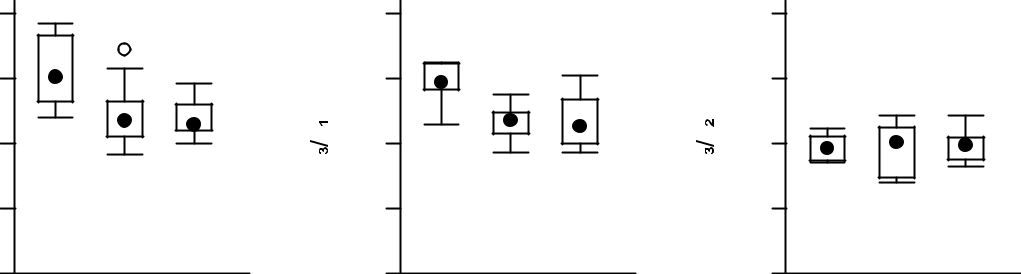


FIGURE 4. Box and whisker plots comparing the three level ratios by task. The L2/L1 (A) and L3/L1 (B) ratios were significantly greater in the lower belt compared with both higher belt tasks. No differences were found between tasks in the L3/L2 ratio (C).

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There were some unanimous agreements amongst these women about their belting. They all agreed that their belt changed in some way as they ascended in pitch from the lower belt range into the higher belt range, although they all had different perceptions of what changes were taking place. They also all agreed that their belt was connected to their speaking voice, and that there was a difference between their belt and their “mix.” Despite these agree-ments within all 10 subjects, we still saw varying acoustic strategies that appeared to be more individual and variable than their self-perception would indicate.

One limitation in this study is the vowel variability among the tasks. Because we utilized excerpts from spe-cific, widely sung pieces that are distinctly representative of the varied vocalism required in different belt ranges, the vowels did vary between the three tasks. However, we felt this approach provided more external validity for the tasks. Future studies may control for vowel across pitches to improve internal validity. Future studies involving electroglottography (EGG) would also assist with assessing the closed quotient during low and high belt production, undoubtedly providing more under-standing of the variability of belting across tasks and subject. Dynamic magnetic resonance imaging (MRI) would also be a methodology that could assist with understanding how the vocal tract shape specifically changes in the different belt ranges.

CONCLUSION

This study supports the few earlier studies that allude to the idea that there is more complexity and individual variability to belting than what much of the previous research has indi-cated. Further study in EGG, MRI, and vowel consistency across tasks is warranted to better recognize the differences in these strategies, as well as the pedagogical implications of each approach. Using elite-level singers with a proven track

record of success with belting is also essential to understand the variability of successful, sustainable belting. Addition-ally, further investigation into the variability of sounds that are considered “belt” by the industry would help to deepen our understanding of the term.

REFERENCES

1. [Sundberg J, Gramming P, Lovetri J. Comparisons of pharynx, source,](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0001) [formant, and pressure characteristics in operatic and musical theatre](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0001) [singing. J Voice. 1993;7:301–310.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0001)
2. Osborne CL. The Broadway voice: Part I, just singin' in the pain. High Fidelity. Vol 291979, 64.
3. [Reid C. A Dictionary of Vocal Terminology. New York: Joseph Patel-son Music House; 1983.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0002)
4. [Ruhl J. Is singing a dying art? NATS Bull. 1986;42:31–33.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0003)
5. [Roll C. The evolution of the female broadway belt voice: implications](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0004) [for teachers and singers. J Voice. 2016;30:639.e631–639.e639.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0004)
6. [Schutte HK, Miller DG. Belting and pop, nonclassical approaches to](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0005) [the female middle voice: some preliminary considerations. J Voice.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0005) [1993;7:142–150.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0005)
7. [Titze I. Can a belt or call timbre be achieved without a large closed](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0006) [quotient. J Sing. 2016;72:587–588.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0006)
8. [Lebowitz A, Baken RJ. Correlates of the belt voice: a broader exami-nation. J Voice. 2011;25:159–165.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0007)
9. [Dargin TC. Compared with Ethel: analyzing the singing styles of Reba](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0008) [McEntire and Bernadette Peters with Ethel Merman in Annie Get](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0008) [Your Gun. Voice Speech Rev. 2017;11:296–307.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0008)
10. [Popeil L. The multiplicity of belting. J Sing. 2007;64:77–80.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0009)
11. [Schutte HK, Miller DG, Duijnstee M. Resonance strategies revealed in](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0010) [recorded tenor high notes. Folia Phoniatr Logop. 2005;57:292–307.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0010)
12. [Henrich N, Smith J, Wolfe J. Vocal tract resonances in singing: Strate-gies used by sopranos, altos, tenors, and baritones. J Acoust Soc Am.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0011) [2011;129:1024–1035.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0011)
13. [Neumann K, Schunda P, Hoth S, Euler HA. The interplay between](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0012) [glottis and vocal tract during the male passaggio. Folia Phoniatr](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0012) [Logop. 2005;57:308–327.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0012)
14. [Jennings CA. Belting is Beautiful: Welcoming the Musical Theatre](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0013) [Singer into the Classical Voice Studio. University of Iowa; 2014.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0013)
15. [Freeman W, Green K, Sargent P. Deciphering vocal demands for](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0014) [today's broadway leading ladies. J Sing. 2015;71:491–495.](http://refhub.elsevier.com/S0892-1997(18)30399-0/sbref0014)
16. Boersma P, Weenink D. Praat: doing phonetics by computer [computer program]. Version 6.0.39, retrieved 8 May 2018 from <http://www.praat.org>.