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Technical note

Effects of perceived singing effort on classical singers' reverberation time preferences towards music practice rooms

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ABSTRACT

The purpose of this study is to investigate the effect of perceived singing effort on classical singers' reverberation time preferences in individual music practice rooms. The method has combined objective measurements (RT) and perceptual responses of participants. The participant group [N = 30] has consisted of five different backgrounds in vocal studies; early music education (EME) students, skilled amateurs, undergraduate singing students, graduate singing students, and professionals. Classical singers has been asked to sing with as high and as low as they could with melisma singing style (in opera singing technique) in three different room settings which had following reverberation times; around 0.6 s, 0.8 s, and 1.0 s. These were the values, which acoustical standards for music schools recommended. The participants have also been asked to sing with three different singing volumes in each room setting. The findings have been analysed statistically. The results showed that classical singers have preferred the room setting with 0.8 s reverberation time considering their overall experience in these room settings. Classical singers' perceived singing effort had a statistically significant relationship with preferred room setting. Furthermore, it has been found that there is a relationship between preference and background in vocal studies.

1. Introduction

Throughout the years, room acoustics regarding music was studied mainly in concert halls. The focus was on objective measurements and listeners' perceptions. However, very few studies considered musicians' perception, particularly the singer's [1]. Setting the foundation of a musical activity, music practice rooms come to the forefront. Every musician, before each concert or recital, spends a considerable amount of time practising his or her instrument. According to Lamberty, music students might spend up to 40 h per week in practice rooms [2]. Considering the time spent, these rooms require significantly more attention to indoor sound quality, nearly as much as concert halls, because these rooms are where musicians are learning and improving their skills by listening to their own instruments.

As singers are working with their own physiology instead of an extrinsic instrument, protecting their vocal instrument against damage is their upmost priority [3]. Many singers taking singing lessons are taught strictly about vocal comfort first. There are several techniques taught in singing education that focus primarily on vocal comfort in order to eliminate the vocal strain. Particularly when singing notes in higher and lower parts of their range, singers often have difficulties and if the voice is forced, *vocal folds* (sometimes misleadingly called *vocal cords*) may permanently be damaged [3]. Such problems may easily occur when practising in a room with poor acoustics. In case the room is too absorbent, then singers may force their voice to be able to properly hear themselves. Considering the time they usually spend, this may result in vocal strain and even permanent vocal damage if maintained.

Most singers are learning and improving their singing techniques in music practice rooms on their own. Learnt technique is expected to be maintained and improved throughout the development process. If incorrect technique is worked into muscle memory, it requires a lot of time and effort to correct afterwards. Therefore, poor acoustical conditions may also affect the development of basic musical skills of singing students negatively [4]. Such concerns are among the most probable reasons of having poor performances in concerts and recitals. For these reasons, the reserved rooms for singers should be efficiently and suitably designed in total absorption amount to provide for a vocal comfort zone.

Since singers in music practice rooms practice their singing voices individually, their own perceptions should be considered. Acoustical perceptions towards music practice rooms can be estimated by objective acoustical parameters. Consequently, reverberation time comes to the forefront.

Reverberation time (RT) is the primary and widely used objective

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acoustical parameter to design and evaluate room acoustics. Optimum reverberation time may differ from one singer to another. Accordingly, perceived singing effort might be a determinant factor to estimate what should be regarded as the optimum reverberation time in music practice rooms. To this date, perceived singing effort has not yet been tested in literature with classical singing trainees' RT preferences.

The aim of this study is to focus on how the perceived singing effort influences the RT preference of classical singers upon individual singing practice rooms exploring possible correlations between room conditions and singer responses. Furthermore, a potential contribution is aimed to be made to the current design standards and guidelines suggesting an optimum RT (for octave band frequencies between 250 Hz and 2000 Hz) for music practice rooms, with the differences of subjective and perceptual responses of classical singers from different backgrounds in vocal studies.

It is hypothesised that classical singers would like to exert a considerable amount of singing effort in order to amplify their voices in preparation for stage performances and thus prefer around 0.6 s (average value of octave band frequencies between 250 Hz and 2000 Hz). Additionally, strong correlations between perceived exerted singing effort and preference of RT are expected; as well as between classical singers' perceived exerted singing effort and their background in vocal studies in music. Ultimately, classical singers' background in vocal studies and preference of RT in a practice room are expected to be relate each other.

2. Method

2.1. Room settings

Two identical singing practice rooms were determined. Their plan and elevation drawings are given in Fig. 1. Their dimensions were 7.3 m ∗ 5.4 m ∗ 3.2 m (L ∗ W ∗ H) and their volumes were 128 m^3. There were absorbent panels (N = 23) with dimensions of 1.4 m ∗ 0.60 m ∗ 0.03 m (L ∗ W ∗ H) on the walls. Additionally, there was a single window of (L ∗ W) 0.9 m ∗ 1.2 m, a wooden door of (L ∗ W) 2.1 m ∗ 0.9 m, and some furniture consisting of a cabinet, table & chairs, and a piano along with a piano stool. The only difference between these two identical rooms was the floor finish material. The one had a carpeted floor while the other had parquet flooring.

At this stage, acoustical standards and design guidelines for music practice rooms were examined. According to the specified guidelines in Table 1, optimum reverberation times (RT) should be around 0.6–1.0 s range [5–7].

After measuring the present room settings, which were around 0.6 s and 0.8 s, an additional room setting was created which had RT of 1.0 s by changing the distribution and the number of absorbers on the walls of the room with RT of 0.8 s. From sidewalls, absorbent panels (N = 7) have been homogeneously removed and set to be staggered. Rear wall was left to be absorbent. Therefore, three different room settings were arranged (Fig. 2). Their RTs were set to be different, from "dead space" condition to "live space" condition respectively. Room setting 1 (RS1), the "dead" setting, had carpeted floor with 23 absorbent panels on the walls. Room setting 2 (RS2), the midway setting, had parquet flooring with the same number and distribution of absorbent panels. Lastly for room setting 3 (RS3), the "live" setting, had parquet floor with 16 absorbent panels on the walls (see Fig. 3.).

As mentioned previously, reverberation time (RT) is a primary acoustical parameter in room acoustics. However, for small volumes, it may not be the dominant criterion. Even if the correct RT for the purpose of the room is provided; lack of scattering surfaces, undesirable reflections (flutter echoes) and room resonances may pose basic acoustical problems such as loudness at particular lower frequencies [8]. In addition, depending on RT, sound levels may significantly change in small rooms. Therefore it is worth mentioning that in this study, reverberation time is only a controlling factor for perceiving singing effort rather than a subject of assessment.

Room settings were assessed to be free from flutter echoes as much as possible (in room setting 1 and 2 vertical flutter echo might still pose a risk) while keeping the current acoustical condition unchanged.

2.2. Measurements and instruments

2.2.1. Objective measurements

Room settings were evaluated in their geometry and size in order to make estimations about their modal characteristics. Since the volume of each room is adequately large, there were neither axial modes found multiple within 5%, nor tangential and oblique modes overlapped in one particular frequency. Each room setting's dimensional ratios were 1:1.68:2.28. Nearest known ratio, to indicate that the room modes are well distributed is Sepmeyer's [9], 1:1.60:2.33. Nevertheless, there were no certain criteria for the best room concerning well-distributed room modes. Accordingly, room modes were not taken into consideration in this study. Instead, Schroeder's widely used cut-off formula was used to determine the lowest frequency [10]. Relevant Schroeder Frequencies of each room setting are given in Table 2.

The position and facing direction of participants were fixed (see Fig. 1). In each room setting, reverberation time was measured according to ISO 3382-2:2008 [11] using DIRAC 3.0 Room Acoustics Software Type 7841.

2.2.2. Subjective evaluations

Thirty classical singers participated in this study. Gender distribution of the participants was as follows: 18 female, 12 male. The age range was between 15 and 30 years ($M = 23.2$, $SD = 5.11$). Participants' backgrounds in vocal studies were distributed from elementary to professional. Voices of participants were classified as bass (N = 1), baritone (N = 4), tenor (N = 5), countertenor (N = 2) contralto (N = 2), mezzo-soprano (N = 4), and soprano (N = 12). Participants were asked to perform a vocal warm-up exercise, singing from the lowest to the highest parts of their range in each room setting in melisma singing style (singing of a single syllable of text while moving between several different notes in succession) with classical singing technique. A graduate singing student from Bilkent University Faculty of Music re-composed a generic warm-up exercise which consisted of legato (joined) five notes that changed according to a reference tone. The final exercise became more complex with conjoined nine notes. The same participants were also asked to sing with different volumes from pianissimo (softest) to fortissimo (loudest). Reference tones were presented by the piano shortly before the production each vocal sound. Each session was completed in around 5 min per singer so that they could test their perceptions in the room settings better.

In order to eliminate order and learning effect, the participants were asked to perform in random rooms every other day. Therefore, preconceived opinions towards room settings were prevented considerably. All participants reported that they had been classically singing for at least 3 years and had no hearing problems.

2.2.3. Questionnaire

Subjective evaluations of participants towards each room setting were obtained through a questionnaire. Participants signed an informed consent form prior to data collection for the sake of procedure. The questionnaire was designed using tick boxes to make it more user-friendly along with a Likert scale.

The questionnaire consisted of four parts in total. In the first two parts, before their first session, participants were asked to fill the relevant questions to collect data about their background in vocal studies, age, and gender along with their practising routine, concert schedule in a year, and any previous problems they had in music practice rooms. After each singing session, participants were asked to fill the remaining two parts. In those last two parts, questions were about their experiences in practice rooms and mainly about their perceived exerted

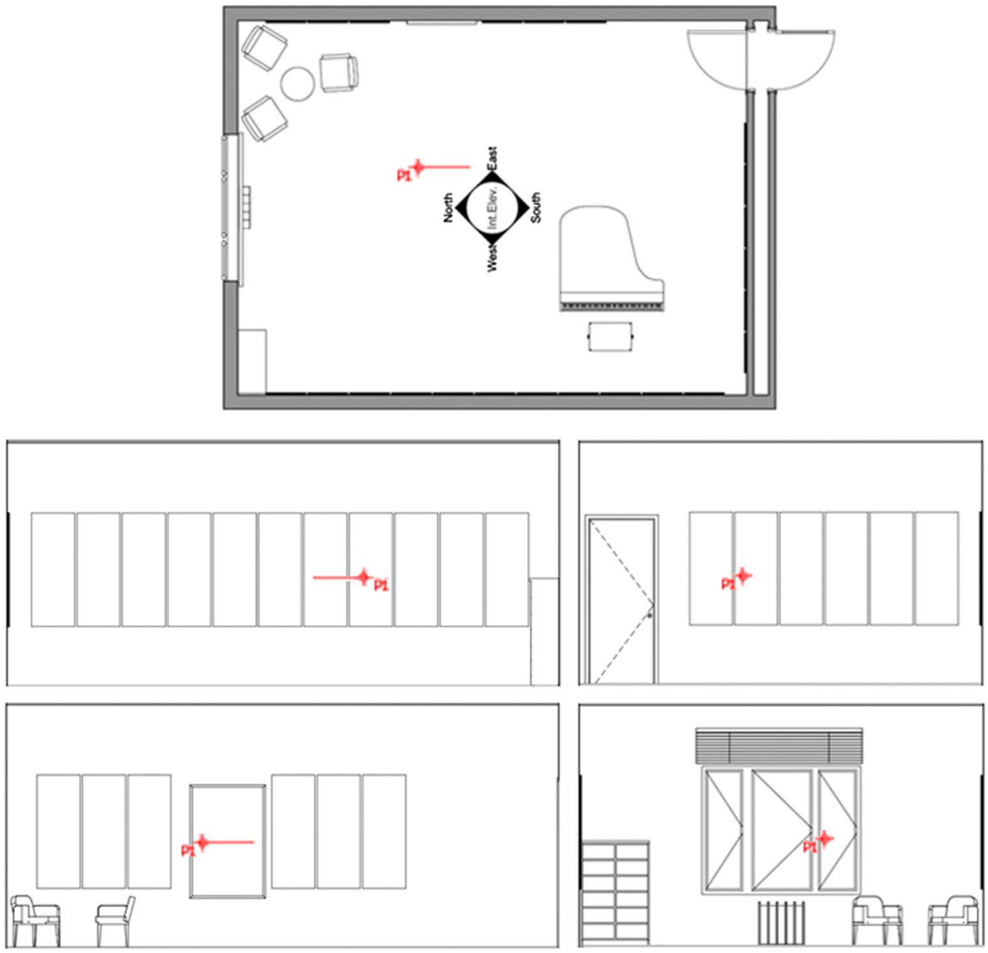


Fig. 1. Room Setting 1 and 2, plan and elevations (red mark represents the sound source and its direction). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Optimum RT for music practice rooms.

Standards	Volume (m^3)	RT (s)
AS/NZS 2107 [5]	Not specified	0.5–0.7
ANSI S12.60 [6]	< 283	< 0.6
BB93 [7]	≤30	≤0.6*–≤0.8**
	> 30	≤0.8*–≤1.0**

* Suggested RT value for newly built music practice rooms.
** Suggested RT values for refurbished music practice rooms.

singing effort, satisfaction levels, and preferences towards rooms considering their overall experience. Subjective evaluations were also collected through open-ended comments about their experiences at the end.

In order to test the hypotheses drawn for this study, the aim was to control reverberation time with three different values according to what acoustical guidelines suggested, by eliminating the influential factors as far as possible such as standing waves and horizontal flutter echoes. The obtained data was analysed via IBM SPSS (Statistical Package for the Social Sciences) Statistics Software, version 21. Depending on the variable types, following statistical tests were run: One Way ANOVA test, Kruskal-Wallis (K-W) H test, Tukey post hoc test; Rank Biserial correlation test, Spearman's rank order correlation test and Chi-Square test of independence.

3. Results

3.1. Sample group

Data taken from 30 classical singers according to their experience in each room settings were analysed to provide a reasonable conclusion to study. Majority of the participants (N = 19, 53.3%) spends at least 10 h in music practice rooms per week. For four of them, the duration can be as long 20 or more hours.

All participants stated that they had no permanent hearing loss to

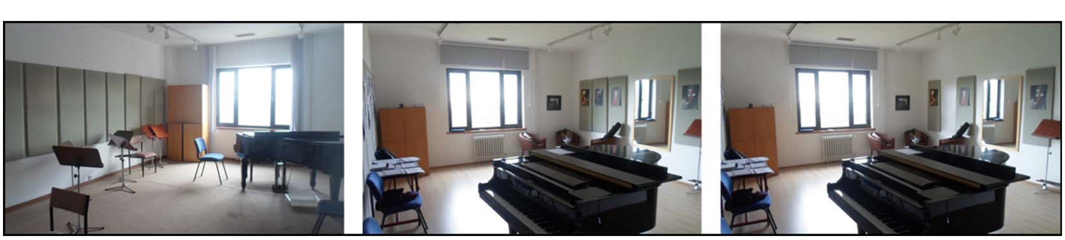


Fig. 2. Photographs of room setting 1, 2, and 3 respectively.

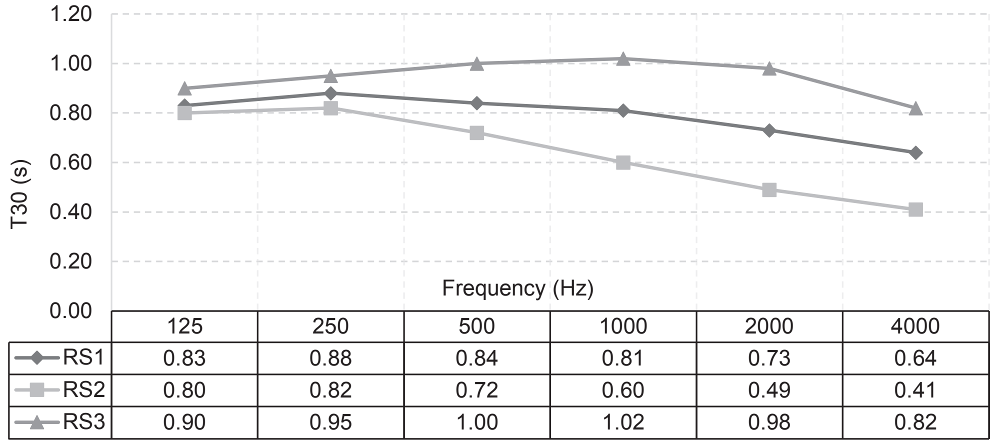


Fig. 3. Measured RT values for each room setting.

Table 2
Calculated Schroeder frequency values for each room setting.

Room settings	Approximate RT values (s)	Schroeder frequency (Hz)
1	0.6 s	136
2	0.8 s	158
3	1.0 s	176

date. All participants grasped the basic concept of reverberation time (RT) and they agreed that RT (and sound levels depending on it) had a big influence on their vocal effort. The majority (N = 20, 66.6%) have suffered from vocal strain during a daily practice at some point in their lives.

3.2. Room perceptions

Following questions were shortlisted and addressed to the participants to find out how they perceive (1) *their singing effort*, (2) *their lower and higher notes*, and (3) *three major singing volumes* in each room settings. Since dependent variables in this part of the questionnaire were designed to be ordinal, Kruskal-Wallis (K-W) H test was run to see if there is any statistically significant difference between them in each room setting. At this point, it is worth mentioning that the Kruskal-Wallis H test does not give results about which specific groups of the independent variable are statistically significantly different from each other. For this reason, if there was a significant difference found with K-W, Tukey post hoc test was applied to see which of these groups differ from each other.

Participants were asked to indicate how they perceived their exerted singing effort in each room setting in order to analyse how RT influences their perceived singing effort. The question offered the following responses along a Likert-type scale: (1) *much more than normal*, (2) *more than normal* (3) *normal*, (4) *less than normal*, (5) *much less than normal*.

Even though the term *perceived singing effort* may not have been easy to explain, all participants were already familiar with the term. In Fig. 4, related frequencies are given. Their means and standard deviations are as follows according to each room setting: $\mu_1 = 2.27$, SD = .828; $\mu_2 = 3.40$, SD = .814; $\mu_3 = 4.67$, SD = .661. Kruskal-Wallis H test results a statistically significant difference between perceived exerted singing efforts in room settings, $\chi2(2) = 59.22$, $p = 0.0001$, with a mean rank perceived singing effort level of 21.47 for RS1, 43.30 for RS2 and 71.73 for RS3. A Tukey post hoc test revealed that the perceived singing effort was statistically significantly different in each room setting at $p < 0.01$ (p_1, p_2, $p_3 = 0.0001$).

Participants were also asked to indicate how they perceived their lower and higher notes in each room setting. The question offered the following responses along a Likert-type scale: (1) *very unclear,* (2)

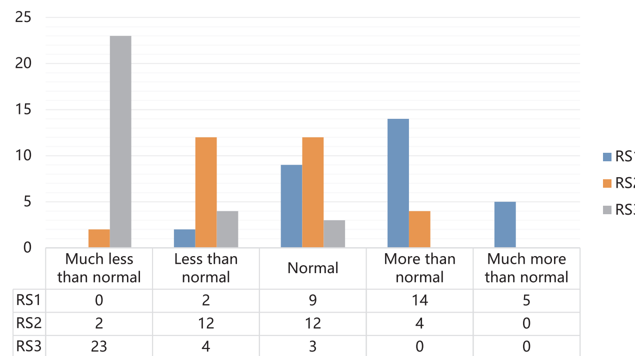


Fig. 4. Perceived singing effort in each room setting.

unclear, (3) *neutral,* (4) *clear*, (5) *very clear*. The purpose of this question was to acquire insight on participants' perception about the sound quality in these room settings. Since low frequencies are critical in such small music rooms, in case there were any statistically significant difference between room settings related to perceived lower notes, this means that modal behaviour of the room could not be set properly in the room settings. Perception of high notes, on the other hand, worked as a manipulative factor here. If there were statistically significant difference detected, then the actual questions posed for this study would have biased answers from the participants.

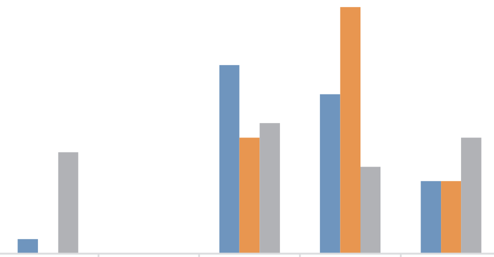
However, there was no statistically significant difference between perceived low notes, $\chi2(2) = 2.734$, $p = 0.255$); and high notes, $\chi2(2) = 1.584$, $p = 0.453$, in each room setting. Frequencies regarding answers given to this question are presented in Fig. 5.

Participants were also asked to indicate how they perceived three major singing volumes in each room setting. The purpose of this question was to acquire participants' perceptions about how they hear their own voices with different singing volumes in each room setting. Furthermore, in order to check the validity of given answers, regarding reverberation time preferences (see following title), questioning the influence of three different singing volumes was required. The question offered the same following responses along a Likert-type 1 to 5 scale: (1) *very unclear,* (2) *unclear,* (3) *neutral,* (4) *clear*, (5) *very clear*.

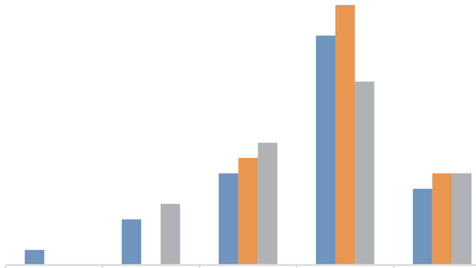
There was no statistically significant difference between perceived pianissimo, $\chi2(2) = 3.60$, $p = 0.165$; mezzo forte, $\chi2(2) = 1.45$, $p = 0.485$; and fortissimo parts, $\chi2(2) = 1.74$, $p = 0.418$, of the exercise in each room setting. Frequencies regarding answers given to this question are presented in Fig. 6.

3.2.1. *Preference of room settings*

Considering their overall experience, participants chose which room setting they would prefer for practising. The question offered the



	Very unclear	Unclear	Neutral	Clear	Very clear
RS1	1	0	13	11	5
RS2	0	0	8	17	5
RS3	7	0	9	6	8



	Very unclear	Unclear	Neutral	Clear	Very clear
RS1	1	3	6	15	5
RS2	0	0	7	17	6
RS3	0	4	8	12	6

Fig. 5. Perception of low and high notes (respectively) in each room setting.

following responses: (1) Room setting 1 (RS1), (2) Room setting 2 (RS2), (3) Room setting 3 (RS3).

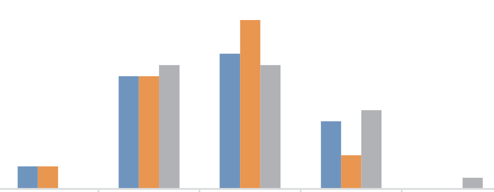
According to results, the most preferable room setting to practice was RS2 (N = 16, RT = 0.8 s) over RS1 (N = 8, RT = 0.6 s), and RS3 (N = 6, RT = 1.0 s). Most of the participants also (n = 23) indicated why they preferred practising in the room setting they have chosen [12]. Most common two of which for RS1 are, "I always prefer to practice in absorbent conditions to keep my vocal strength", "I can realize my mistakes easier in this room setting, so I prefer practicing in this room setting". For RS2, "This room setting is neither unresponsive nor too reverberant", "My vocal coach suggested I practice in a room like this". For RS3, "I can hear myself properly with less effort", "Acoustics in this setting is better than others".

3.2.2. Statistical analyses

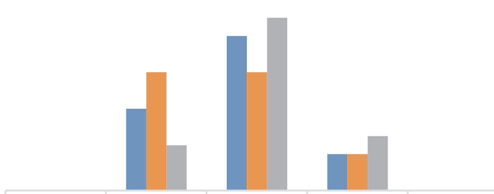
Relationship between perceived exerted singing effort of the classical singers and their RT preferences was questioned. If any, how the perceived exerted singing effort influenced the RT preference among 0.6 s, 0.8 s and 1.0 s could be revealed. A Rank-Biserial correlation was run to explore the relationship between RT of room settings and perceived singing effort. There was a moderate, negative correlation between them, which was significant at $p < 0.01$, [$r_{rb}(30) = -.614$, $p = 0.0001$].

Relationship between perceived exerted singing effort of the classical singers in each room setting and their background in vocal studies was questioned as well. A Spearman's rank-order correlation was run to examine the relationship between perceived exerted singing effort of the classical singers in each room setting and their background in vocal studies. According to this analysis, there was no correlation between perceived exerted singing effort of the participants and their background in vocal studies at $p < 0.01$ and $p < 0.05$ [$r_s(30) = .392$, $p = -0.162$]. Nevertheless, five variables of background in vocal studies were recoded as two variables as unexperienced classical singers (early music education students, skilled amateurs, undergraduate students) and experienced classical singers (graduate students, professionals) a different result was found. In order to achieve further results, a chi-square test of independence indicated that perceived singing effort of the participants was associated with background in participants' vocal studies, χ (2, N = 30) = .520, $p < 0.001$, Cramér's V = .017.

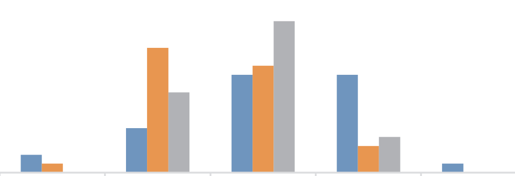
Relationship between participants' background in vocal studies and their RT preferences was also questioned. If any, how their backgrounds in vocal studies influenced their RT preference among 0.6 s, 0.8 s and



	Very unclear	Unclear	Neutral	Clear	Very clear
RS1	2	10	12	6	0
RS2	2	10	15	3	0
RS3	0	11	11	7	1



	Very unclear	Unclear	Neutral	Clear	Very clear
RS1	0	9	17	4	0
RS2	0	13	13	4	0
RS3	0	5	19	6	0



	Very unclear	Unclear	Neutral	Clear	Very clear
RS1	2	5	11	11	1
RS2	1	14	12	3	0
RS3	0	9	17	4	0

Fig. 6. Perception of each singing volume in each room setting (pianissimo to fortissimo respectively).

1.0 s could be revealed. Once more, Rank-Biserial correlation was run to determine the relationship between aforementioned variables. There was a negative correlation found between them, which was statistically significant at $p < 0.01$ [$r_{rb}(30) = -.594$, $p = 0.001$].

4. Discussion

4.1. Relationship between perceived singing effort and RT preference

A change in acoustical condition regarding reverberation time (RT) could affect classical singers in unamplified conditions. Classical singers might change and compensate their vocal technique according to the room absorption as Skirlis, Cabrera & Connolly stated [13]. Skirlis et al. found that classical singers produced greater sound levels in large hall renditions (higher RT) compared to smaller halls (lower RT). Controlling RT and changing the room size, Hom [14] found that choristers exerted more singing effort in large performance halls (smaller RT) and smaller rehearsal rooms (higher RT). It means that regardless of room volume, there is a strong and direct connection between RT and singing effort. Another study testing choristers' singing effort with changing RT was performed by Ternström [15] and in absorbent conditions exerted singing effort increased. Therefore, a negative relationship expected to be found between perceived singing effort and preference of RT. As a result of statistical analysis, it was found that singing effort had an influence on RT preference of classical singers. Such that, as perceived singing effort decreases, preference of singers tends towards higher reverberation times among 0.6 s, 0.8 s, and 1.0 s.

Similarly, background in vocal studies had an influence on perceived singing effort. As the background in vocal studies increased from early music education level to professional level, perceived singing effort decreased considerably. It may have stemmed from the experience in music practice rooms and the singing techniques developed over several years. It seems that, background in vocal studies was also correlated with RT preferences [8,12].

These results also indicated that, professional classical singers preferred to practice in more dead conditions over live conditions while amateur classical singers preferred more live conditions to dead conditions. Overall, the most preferable room condition was the midway between live and dead conditions with a reverberation time of 0.8 s. However, although a moderate correlation was found between perceived singing effort and preference of RT, unexpectedly the most preferable practice room setting had 0.8 s RT instead of 1.0 s. In this regard, Beranek [16] stated that reverberation provides musicians with "fullness-of-tone" in rooms for music. Most of the studies within literature addressed that reverberation time has a strong influence on classical singers' preference. Furthermore, according to Stetson & Braasch [17], there is a strong connection between increasing preference and increasing reverberation time. As this study shows, however, too much reverberation in music practice rooms is not preferred by classical singers. It appears that in individual music practice rooms, classical singers do not prefer to practice in neither dead nor live conditions. Classical singers' comments towards their preferences also showed that although they are satisfied with live conditions since they can hear their own voices properly, they would like to practice in optimum conditions to both hear their voices clearly and exert some effort to prepare better for stage performances.

4.2. Methods on classical singers

Graduate students (n = 2) from Bilkent University and professional opera singers, graduated from Bilkent University (n = 2) were consulted before the study in order to discuss possible limitations and imperfections of the preliminary research method of the present study. Judging by their experiences, they agreed upon the idea that a classical singer may sing with a greater sound pressure level one day, and may sing with a lower sound pressure level the other day. Therefore, a change in SPL of a classical singer might be influenced by their moods along with their warm-up routines. Regarding this influence, evaluation of perceived singing effort obtained through questionnaire might give reasonable results.

One of the factors, which might influence the responses of classical singers as well, was the song choice for such studies. Beranek [16] indicated that preferred values of acoustical parameters depend on repertoire in concert halls. Beranek also specified different values for symphonic music, chamber music, and opera. Skirlis et al. [13] indicated that preferred values might chance according to the genre. Noson, Sato, Sakai & Ando [18] asked performers to sing two short passages of the same song for a study. After two years, same researchers [19] tried a different singing style melisma singing with and without lyrics as research method. For such studies, melisma singing was found to be a reasonable method to take song choice as a determining factor. For this reason, in this study, melisma singing with one particular syllable word was determined and applied to participants. Nonetheless, to control the influence of genre, classical singers were asked to sing with melisma singing style as long as it was sung using classical technique.

One last strength under discussion is on distinctions between the applied methods; using an anechoic chamber and a real environment in research field, concerning perceptions of musicians was that anechoic conditions were found to be unrealistic and artificial. Even if they provide variety of options and are more efficient, which are accepted worldwide and widely used for such studies, perceptions of classical singers might be influenced while both experiencing the environment and evaluating the recordings in digital platforms. In the study, performed by Gunnlaugsdóttir [20], participant musicians stated that the surroundings in the anechoic chambers were unnatural to them. Graduate students and professional opera singers, who were unofficially interviewed before the study, indicated that they would prefer to be examined in their own practising environments rather than artificial environments. They also emphasized the importance of feeling and perceiving the room simultaneously over hearing and evaluating a digital sound from headphones or any other amplifiers. For this reason, the study was conducted in real music practice rooms.

One of the starting points of this study was to test the reliability of design recommendations indicated in standards for music practice rooms. Along with aforementioned standards, Wenger Corporation [21] also published a planning guide for school music facilities. In the related planning guide, it was indicated that untreated music practice rooms should be treated with absorber panels located on the wall surfaces in order to eliminate flutter echoes and undesirable loudness. Nonetheless, the presence of diffuser panels would also create a more acoustically balanced environment, which would enable clear communication between teachers and students along with communication within an ensemble. The room settings, which were designed for this study, did not have diffuser panels where necessary. Since the investigation was to test primarily the perceived singing effort and classical singers' RT preferences in music practice rooms for individual purposes, presence of diffuser panels were considered to be unnecessary. However, considering the classical singers' overall evaluations towards sound quality in room settings, the absence of diffuser panels might have influenced these results.

In Marshall & Meyer's [22] study, performers preferred parquet floor selection to carpet flooring. Considering the absorption properties of aforementioned materials, it is known that unlike parquet flooring, carpet has a tendency to absorb high frequency sound energy. This distinction might be the reason behind practice room preferences. Researchers affirmed the fact and concluded that carpet as stage floor finish should not be used. In this study, one of the three room settings had carpet floor. For this reason, results might be influenced by the floor material selection as well.

5. Conclusion

Primarily, this study has questioned the most preferable RT for classical singers in music practice room (in around 130 m^3 volume) among 0.6 s, 0.8 s, and 1.0 s which are the among the RT values recommended in standards. Results have shown that for classical singers neither a dead nor a live condition is preferable. Classical singers would like to practice in a room with a RT of 0.8 s in which they can hear their voices while slightly exerting an above average singing effort. Therefore, the first hypothesis, stating that the optimum RT was 0.6 s, was rejected.

Secondly, perceived singing effort was questioned regarding its influence on preference. Results indicated that there is a significant connection between perceived singing effort and classical singers' perceptions towards their exerted singing effort. It was found that as perceived singing effort increases, the room condition becomes absorbent. According to classical singers' overall tendency, preference increases where perceived singing effort decreases. Thus, the second hypothesis was not rejected.

Thirdly, the relationship between perceived singing effort and background in vocal studies was investigated to understand how education level influences perceived singing effort. Results indicated that a background in vocal studies has no correlation with perceived singing effort. However, further results showed that experienced classical singers who have completed their higher education in singing usually exert less effort than ones who are currently being trained. Although there is a significant relationship between perceived singing effort and education level of classical singers, third hypothesis was rejected in accordance with these results.

Lastly, the relationship between RT preference and classical singers' background in vocal studies was questioned to understand how education level influenced preferred RT. Results indicated that there is a connection between classical singers' background in vocal studies and preference. As their background in vocal studies increased in duration, their preferences tended towards lower reverberation times. In contrast, preferences tended towards higher reverberation times as background in vocal studies decreased. Accordingly, fourth hypothesis was not rejected.

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