ACOUSTIC SPECTROGRAM FOR EVALUATING THE EFFECTIVENESS OF ACCEPTANCE AND COMMITMENT TRAINING (ACT) AS A MUSIC PERFORMANCE ANXIETY MANAGEMENT METHOD IN PROFESSIONAL SINGERS

G Kutsal   Sounteria Ltd, United Kingdom
D Winter   Voice Study Centre, United Kingdom
D Juncos   Hornstein, Platt & Associates, Philadelphia, United States

1   INTRODUCTION

Music performance anxiety (MPA) refers to the ongoing and distressing worries about, or actual hindrance of, performance abilities in public settings, which is disproportionate to the musician's skill, training, and preparation.[1] MPA symptoms range from physical (shaky hands, irregular or quicker heartbeat, secretion of adrenaline), cognitive (negative thoughts and worries), behavioural (avoidance or less than optimal performance in evaluative situations) and psychological (perception of the musician affecting their responses)[1]. The estimated prevalence of MPA in professional musicians is between 15-25%[2] but a more recent study suggests it can be as high as 78%[3].

There are numerous management techniques for MPA, including beta-blockers, meditation, mindfulness, hypnosis, biofeedback, Cognitive and Behavioural Therapy (CBT) and Acceptance and Commitment Training (ACT)[4]. The ACT model is a relatively novel approach with a limited number of studies on MPA applications. However, it is based on promoting psychological flexibility as a way of managing unwanted thoughts, feelings and other symptoms[1]. This is achieved through mindfulness and being present, non-judgementally observing and accepting unwanted thoughts and feelings, and taking committed actions towards one's values instead of suppressing or avoiding the unwanted thoughts and feelings[5]. As an empirically supported evidence-based model, Acceptance and Commitment Therapy (ACT) has the goal of increasing psychological flexibility, which should result in improved performances through present moment awareness, acceptance of thoughts, emotions and experiences, and taking committed action towards values of the individual[1,5]. While reduction or elimination of MPA symptoms is not an explicit focal point of ACT, changes in symptoms can occur following an increase in psychological flexibility[1,6].

A coaching model based on the principles of Acceptance and Commitment Therapy is offered as Acceptance and Commitment Coaching (ACC), or Acceptance and Commitment Training (ACT) outside clinical settings[7]. ACT has been successfully trialled with singers and musicians experiencing MPA in the recent years [1,2,8]. However, the effectiveness of MPA management methods such as ACT has been mainly studied with a subjective and qualitative approach using self-report questionnaires in the existing literature.

2   LITERATURE REVIEW

The voice is generated as a buzz at the larynx, a complex sound with a fundamental frequency (f_0) and higher harmonic components at numerous frequencies, which is then shaped by the vocal tract[9]. During phonation, vocal folds generate not only the fundamental frequency but also every harmonic above it. The relative strength of these harmonics influence our perception of tone quality and colour[10]. When the shape and configuration of the vocal tract amplifies a certain harmonic, is it called a formant[11]. It is possible to visualise and distinguish between different vocal qualities using a spectrogram[12]. In fact, spectrographic analysis has been utilised for voice research for decades[13,14,15].

Even though most research on spectrograms have been on formant tuning, there is much more than formants alone. In addition to spectral energy of formants, spectrographic analysis parameters relevant to MPA research might include pitch stability, legato and vibrato qualities[10]. These allow a rather objective comparison between different recordings, albeit by the researcher's visual inspection. For example, most spectrograms provide pitch tuning information at a given point in the recording using scientific pitch notation. This enables comparison of pitch accuracy between recordings. Additionally, pitch stability can be evaluated visually via the fundamental frequency line[15]. Regarding vibrato, spectrographic analysis might show the consistency, stability, and the pitch range of vibrato as the fundamental frequency chances over a held note.

3   METHODS

3.1   Participants

Four professional singers who experience MPA were recruited via purposive sampling (n=4). Two participants specialised in Western classical and opera whereas the other two were in popular music, also known as Contemporary Commercial Music (CCM). The age range was 28-36 years old with a mean of 33.75 and all participants were female. All participants held Bachelor's and/or Master's degrees a relevant field, and they had performing experience between 9 and 10 years. They were screened for clinically significant levels of MPA using KMPAI-r[16] where all four potential participants scored above the cutoff of 105 for problematic MPA, and were consequently recruited[17]. Attendance to individual sessions and live performances were 100%. However, one of the participants (PS2) could not complete 1-month follow up surveys.

3.2   Coaching Programme

A six-week coaching programme was designed with weekly 75-minute sessions[7]. The programme was delivered fully online over Zoom, between live pre- and post-coaching performances. Handout PDFs and pre-recorded audio files of mindfulness exercises were also provided between sessions.

3.3   Self-Assessment Surveys

Participants were asked to complete seven self-report questionnaires before the pre-coaching performance, after the third session, before the post-coaching performance, and at one month following the completion of the study. These questionnaires comprised of the following:
- Anxiety Control Questionnaire (ACQ)[18]
- The Believability of Anxious Feelings and Thoughts (BAFT)[19]
- Experiential Shame Scale (ESS)[20]
- Kenny Music Performance Anxiety Inventory (K-MPAI)[16]
- Musician's Action and Acceptance Questionnaire (MAAQ)[21]
- Philadelphia Mindfulness Scale (PHLMS)[22]
- Valuing Questionnaire (VQ)[23]

3.4   Live Performances and Adjudication Process

Pre- and post-coaching performances over Zoom were arranged where all participants attended live. Participants were asked to choose songs from their existing repertoire that demonstrated their singing abilities[24]. Additionally, due to consonants often appearing as noise, they were asked to choose songs with long held vowels so that these could be analysed with a spectrogram.

Videos recorded over Zoom were randomised and sent to an adjudication panel of 8 singing teachers for scoring. Their teaching experience ranged from 5 years to 25 years. The scoring sheet was adapted from items and definitions on the Associated Board of the Royal Schools of Music (ABRSM) singing scoring criteria[25]. Each item was scored on a Likert scale from 1 (Poor) to 10 (Excellent) in the following domains:

- Pitch and intonation,
- Timing, tempo, and rhythm,
- Tonal awareness, control, and projection,
- Musical shaping, dynamics, and vocal expression,
- Communication of character and style, storytelling, involvement, and musical conviction,
- Confidence, assuredness, control, and stage presence.

3.5 Acoustic Spectrogram Analysis

Participants were asked to record the sound of their voice without the accompaniment using their own smartphones during both live performances in addition to a relaxed-state recording without an audience. For spectrographic analysis, 4 different vowels from each song were selected for each participant. Afterwards, screenshots were taken from all recordings to compare relaxed-state, pre- and post-coaching snippets. The software used was VoceVista Video Pro by Sygyt Software in Version 5.4.2.

4 FINDINGS AND DISCUSSION

4.1 Self-Assessment Surveys

Survey results were statistically analysed using Reliable Change Index, Paired-Samples T-Test, Clinical Significance and Two-Way ANOVA. Findings are presented in Figure 1 and 2 below.

Measures	Pre	Mid	Post	Follow Up	Functional Population
ACQ *	M = 76.75	M = 92.75	M = 92.7	M = 90.67	M = 96.1 [18]
BAFT *	M = 76	M = 75.5	M = 52.5	M = 61	M = 50.1 [19]
ESS *	M = 5.75	-	M = 2.68	-	M = 3.9 [20]
KMPAI *	M = 163.75	M = 145.75	M = 120.5	M = 128	M = 93.5 [15]
MAAQ *	M = 22.25	M = 23.5	M = 32.25	M = 31.67	M = 29.6 [21]
PHLMS Awareness	M = 42.25	M = 41	M = 39	M = 36.34	M = 34.7 [22]
PHLMS Acceptance *	M = 20.25	M = 23.5	M = 29.25	M = 27.3	M = 30.7 [22]
VQ Progress *	M = 23.5	M = 25.5	M = 31.25	M = 27.34	M = 17.2 [23]
VQ Obstruction	M = 21.25	M = 20	M = 14	M = 16.67	M = 12.1 [23]
* indicates statistically significant changes at $p < 0.05$ between pre- and post-coaching scores					

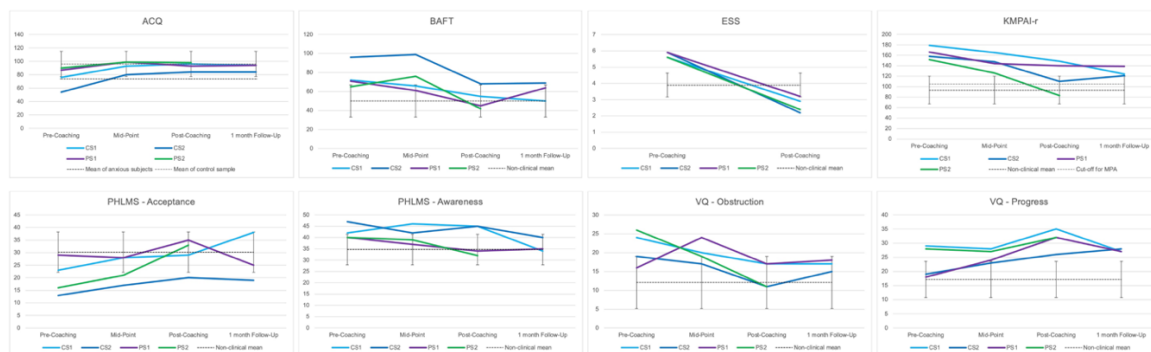Figure 1. Statistical analysis of self-assessment survey scores

Figure 2. Survey scores of each participant at pre-coaching, mid-point, post-coaching and follow-up

4.2 Adjudication of Singing Performance Quality (SPQ)

Results were statistically analysed using Two-Way ANOVA and Interrater Reliability. Findings of adjudication data are presented in Figure 3.

SPQ	Musical shaping, dynamics, and vocal expression	Communication of character and style, storytelling, involvement, and musical conviction	Confidence, assuredness, control, and stage presence
All Singers (n = 4)	No significant difference (F = 0.769, p = 0.445)	No significant difference (F = 1.256, p = 0.344)	No significant difference (F = 3.902, p = 0.143)
CCM Singers (n = 2)	Significant difference (F = 361.000, p = 0.033)	No significant difference (F = 25.000, p = 0.126)	Significant difference (F = 196.000, p = 0.045)

ICC	Musical shaping, dynamics, and vocal expression	Communication of character and style, storytelling, involvement, and musical conviction	Confidence, assuredness, control, and stage presence
Absolute Agreement	Moderate (0.599)	Good (0.774)	Good (0.855)
Consistency	Moderate (0.712)	Good (0.834)	Excellent (0.936)

Figure 3. Statistical analysis of Singing Performance Quality (SPQ) scores on the left, Intraclass Correlation Coefficient (ICC) results for interrater reliability on the right[26]

4.3 Discussion of Subjective Measure Findings

Some findings from this study are consistent with previous research in terms of improvements in ACT skills and MPA experiences. Firstly, participants showed a significant change in their ability to defuse from MPA-related thoughts and feelings in the BAFT questionnaire. This is similar to findings in previous studies with a university violinist[4], a professional drummer[27], and college vocalists[28]. Secondly, their ACQ scores indicate a significant increase in their acceptance of unwanted experiences, their ability to defuse from them and their willingness to take valued action despite these experiences, indicating greater psychological flexibility, which are consistent with literature as well[4,28].

Defusion work is noted to have a natural consequence of acceptance[5]. While the expectation was for PHLMS Acceptance subscale scores to increase, indicating greater present moment awareness, there was no significant change in participants' scores. This might be expected as two participants were in the normal range and two were already above in the pre- assessment. Similarly, the VQ Obstruction subscale scores were expected to decrease to demonstrate an increase in psychological flexibility, however this was not evidenced in analyses. This might have been different if the study was conducted over a longer period.

Another positive indicator is KMPAI scores in which all participants were above the MPA cut-off at the beginning and lowered their scores towards the end. One participant even completed the study below the cut-off in the post-coaching assessment, which is backed by the literature[4,28].

While all participants reported increased psychological flexibility and valued action taking in self-report questionnaires, this was not reflected in their Singing Performance Quality scores equally. Analysis of the 3 categories revealed no significant difference in any of these. However, when means of scores by all judges were plotted, an interesting pattern emerged. Both popular singers appeared to have a

significant change between their pre- and post-coaching performances in which the latter was scored higher. In contrast, there was little change in both classical singers' scores and some scores were lower in the post-coaching performance. With this insight, an analysis with only popular singers' scores was conducted. These indicated a significant improvement in musical shaping, dynamics, and vocal expression, and confidence, assuredness, control, and stage presence categories.

There might be different explanations for these findings. One possible explanation is related to the values they chose to express during sessions and performance. The most significant values CS1 selected were to be a bold and daring performer, and staying connected to her true self. For CS2, this was executing proper technique. It is possible that these values, while valid and useful, did not have a significant impact on their performances. In fact, focusing on executing proper technique might have reduced their presence, communication of character, and their engagement with the audience, resulting in lower scores. For popular singers, chosen values were fully engaging with the performance and connecting with the audience. These values are arguably easier to notice during a performance as a judge or audience member than those selected by classical singers.

Secondly, popular styles might allow for more artistic freedom and self-expression than classical, with classical singers possibly being held to higher standards[28]. Therefore, improvements in PS1 and PS2's scores would be even more significant. Taking these into consideration, changes in both popular singers' scores are consistent with previous literature on ACT[28,29].

Another finding worth noting is the reduction in shame over MPA in the post-coaching performance. In the pre-coaching performance, all participants were above the normal range. One participant completed the study right at the lower end of the normal range whereas others were well below, indicating significantly lower levels of shame. It is possible to assume that ACT and self-compassion had a direct or indirect influence on their experiences of shame.

4.4   Acoustic Spectrogram Analysis

For spectrographic analysis, 4 different vowels from each song were selected for each participant for a total of 48 snippets. Screenshots were taken from all recordings to compare pitch, strength of harmonics, consistency, and vibrato. Previous studies on perception suggest a variation by ±25 cents in singing is acceptable due to "vocal generosity effect" especially in the presence of vibrato[30,31]. Based on this finding, pitch consistency was found to be comparable across all recordings for all participants without any major deviations.

Samples of spectrogram views are presented below in Figures 5, 6, 7 and 8.
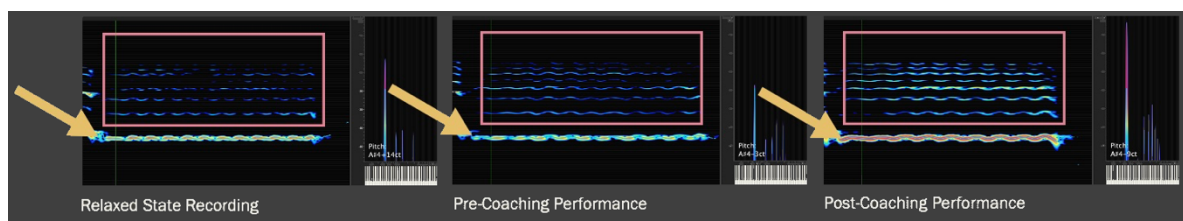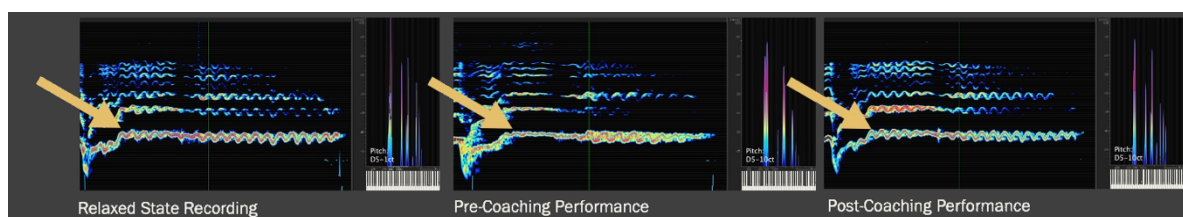

Figure 5. Classical Singer 1 (CS1), "Deer" (/ɪ/)

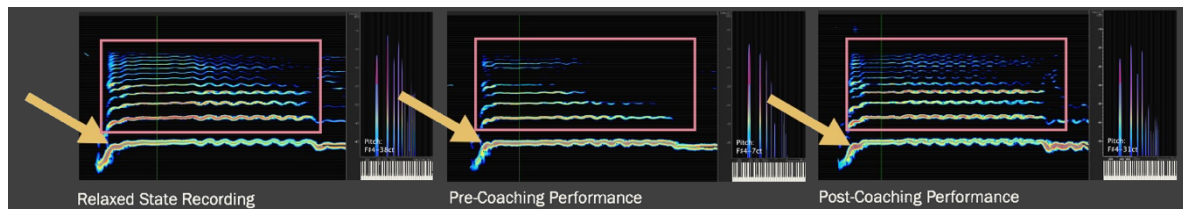

Figure 6. Classical Singer 2 (CS2), "Lel" (/ɛ/)
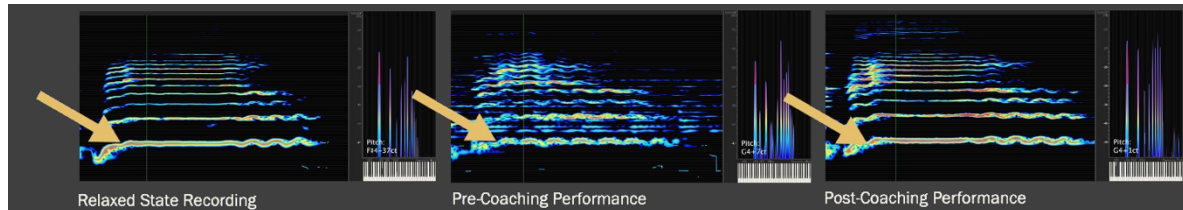
Figure 7. Popular Singer 1 (PS1), "Now" (/ɐ/)

Figure 8. Popular Singer 2 (PS2), "Thrill" (/ɪ/)

Spectrographic analysis does appear to have valid applications in comparing recordings for MPA symptoms. This is especially visible in recordings of CS2 and PS1. The bleeding music in PS2's pre-audio makes it challenging to discern her voice from the backing track, and CS1's recordings do not appear to differ significantly between performances.

Upon comparing these findings with SPQ scores, it is possible to infer that there was no significant difference in CS1's SPQ after coaching. Even though her scores in ACQ, KMPAI, MAAQ, PHLMS Acceptance and ESS imply a change in her subjective experience of MPA, there was no reliable change in her SPQ scores and spectrogram.

CS2 appears to have the most significant improvements in spectrogram view in terms of vibrato quality, spectral energy, and pitch accuracy, however, this is not also reflected in her SPQ scores. While the acoustic analysis and reliable changes in her ACQ, BAFT, MAAQ, KMPAI, VQ Progress and ESS scores would indicate a significant improvement in her vocal quality, her musicality and expressions scores appear to be lower in the post-coaching performance whereas her musical conviction and confidence remain the same. As discussed above, it is possible that her focus on executing proper technique resulted in a more consistent vocal quality but lessened presence and musical conviction, causing the discrepancy between her SPQ scores.

Recordings of PS1 indicate that her vocal quality was closer to her relaxed state recording in the post-coaching performance than pre-coaching. Her SPQ scores were significantly higher in the post-coaching performance as well. This is quite interesting, as she displays the least number of reliable changes in self-report surveys. The only significant differences were in ESS, VQ Progress, KMPAI and MAAQ. Hence, KMPAI and MAAQ might be stronger indicators of performance quality in singers.

Finally, PS2 appears to have made the most progress in terms of her BAFT, KMPAI, MAAQ, PHLMS Acceptance, VQ Obstruction and ESS scores. These changes are reflected in her SPQ scores as well. It is unfortunate that her pre-coaching audio was suboptimal to properly compare with others. However, based on the spectral energy and vibrato data present in these recordings, it is possible to deduce that her performance in the post- performance was closer to her relaxed state recording. As she was the only singer to complete the study below the KMPAI cut-off, it is also possible to argue she showed the most significant improvements in the project.

4.5 Limitations

Despite all efforts to ensure comparable and high-quality recordings, there were several limitations of this study. These include instrumental bleed in some recordings, as well as room effect, audio quality and non-standardised recording equipment. Additionally, the sample size was small and

homogenous. Future studies should aim for a more diverse sample to ensure findings are applicable to a broader population. Lastly, while on the objective side, spectrographic analysis still requires a researcher to analyse the data via visual inspection. It is possible to argue this is not 100% objective. Therefore, future studies can benefit from a specialised acoustic analysis software, such as Praat, for added objectivity.

5   CONCLUSION

As in previous studies, findings of this study also showed significant changes in subjective and objective measures. ACT coaching appears to be a promising approach for musicians experiencing problematic MPA. Additionally, this study has shown that acoustic spectrogram can be utilised effectively for comparing audio data from singers.

6   REFERENCES

1.   Juncos, D. G. and de Paiva e Pona, E. (2018) 'Acceptance and commitment therapy as a clinical anxiety treatment and performance enhancement program for musicians', *Music & Science*, 1, p. 205920431774880.
2.   Shaw, T. A., Juncos, D. G. and Winter, D. (2020) 'Piloting a New Model for Treating Music Performance Anxiety: Training a Singing Teacher to Use Acceptance and Commitment Coaching With a Student', *Frontiers in Psychology*, 11(May), pp. 1–14.
3.   Ryan, C. and Andrews, N. (2009) 'An investigation into the choral singer's experience of music performance anxiety', *Journal of Research in Music Education*, 57(2), pp. 108–126.
4.   Juncos, D. G. and Markman, E. J. (2015) 'Acceptance and Commitment Therapy for the treatment of music performance anxiety: A single subject design with a university student', *Psychology of Music*, 44(5), pp. 935–952.
5.   Hayes, S. C., Strosahl, K. D. and Wilson, K. G. (2012) *Acceptance and Commitment Therapy: The Process and Practice of Mindful Change.* 2nd edition. New York: The Guilford Press.
6.   Juncos, D. G. and Markman, E. J. (2015) 'Acceptance and Commitment Therapy for the treatment of music performance anxiety: A single subject design with a university student', *Psychology of Music*, 44(5), pp. 935–952.
7.   Hill, J. and Oliver, J. (2018) *Acceptance and commitment coaching: Distinctive features*, *Acceptance and Commitment Coaching: Distinctive Features*.
8.   Clarke, L. K., Osborne, M. S. and Baranoff, J. A. (2020) 'Examining a Group Acceptance and Commitment Therapy Intervention for Music Performance Anxiety in Student Vocalists', *Frontiers in Psychology*, 11(May), pp. 1–11.
9.   Titze, I. R. (2016) 'Some Consensus has been Reached on the Labeling of Harmonics, Formants, and Resonances', *Journal of Voice*, 30(2), p. 129.
10.   Bozeman, K. (2014) *Practical Vocal Acoustics: Pedagogic Applications for Teachers and Singers*. 1st edn. Pendragon Press.
11.   Guzman, M. *et al.* (2014) 'Resonance Strategies Revealed in Rock Singers during Production of High Notes', *Journal of Singing*, 71(2), p. 183.
12.   Obert, K. (2019) *New Twang and Ring Lecture for Get Vocal*. Available at: https://www.youtube.com/watch?v=pT6-g4QKMbc (Accessed: 25 April 2020).
13.   Schutte, H. K. and Miller, D. G. (1993) 'Belting and pop, nonclassical approaches to the female middle voice: Some preliminary considerations', *Journal of Voice*, 7(2), pp. 142–150.
14.   Bozeman, K. (2007) 'A Case for Voice Science in the Voice Studio', *Journal of Singing*, 63(3), p. 265.
15.   Erickson, H. M. (2021) 'Mobile Apps and Biofeedback in Voice Pedagogy', *Journal of Singing*, 77(4), pp. 485–500.

16. Kenny, D. T. (2016) 'Kenny Music Performance Anxiety Inventory (K-MPAI) and scoring form', (March). Available at: https://www.researchgate.net/publication/299461895.

17. Ackermann, B. J. *et al.* (2014) 'Sound Practice- Improving occupational health and safety for professional orchestral musicians in Australia', *Frontiers in Psychology*, 5(AUG), pp. 1–11.

18. Rapee, R. M. *et al.* (1996) 'Measurement of perceived control over anxiety-related events', *Behavior Therapy*, 27(2), pp. 279–293.

19. Herzberg, K. N. *et al.* (2012) 'The believability of anxious feelings and thoughts questionnaire (BAFT): A psychometric evaluation of cognitive fusion in a nonclinical and highly anxious community sample', *Psychological Assessment*, 24(4), pp. 877–891.

20. Turner, J. E. (2014) 'Researching state shame with the experiential shame scale', *Journal of Psychology: Interdisciplinary and Applied*, 148(5), pp. 577–601.

21. Juncos, D. G., Osborne, M. S., Taylor, J., & Zenobi, D. (2023, 17 August). *Continued explorations of the psychometric properties of the Musician's Acceptance and Action Questionnaire (MAAQ).* Paper presented at the International Symposium on Performance Science 2023.

22. Cardaciotto, L. *et al.* (2008) 'The assessment of present-moment awareness and acceptance: The philadelphia mindfulness scale', *Assessment*, 15(2), pp. 204–223.

23. Smout, M. *et al.* (2013) 'Development of the Valuing Questionnaire (VQ)', *Journal of Contextual Behavioral Science*. Elsevier, 3(3), pp. 164–172.

24. Osborne, M. S., Kenny, D. T. and Cooksey, J. (2007) 'Impact of a Cognitive-Behavioural Treatment Program on Music Performance Anxiety in Secondary School Music Students: A Pilot Study', *Musicae Scientiae*, 11(5), pp. 53–84.

25. The Associated Board of the Royal Schools of Music (2017) *Abrsm marking criteria*. Available at: https://gb.abrsm.org/media/12047/marking_criteria_2018__a4_website__singing.pdf (Accessed: 23 April 2022).

26. Koo, T. K. and Li, M. Y. (2016) 'A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research', *Journal of Chiropractic Medicine*. Elsevier B.V., 15(2), pp. 155–163.

27. Juncos, D. G. *et al.* (2014) *Acceptance and Commitment Therapy for the Treatment of Musical Performance Anxiety: A Single Subject Design.* La Salle University, Philadelphia, PA.

28. Juncos, D. G. *et al.* (2017) 'Acceptance and commitment therapy for the treatment of music performance anxiety: A pilot study with student vocalists', *Frontiers in Psychology*, 8(JUN), pp. 1–16.

29. Glassman, L. H. *et al.* (2016) 'The effects of a brief acceptance-based behavioral treatment versus traditional cognitive-behavioral treatment for public speaking anxiety: an exploratory trial examining differential effects on performance and neurophysiology.', *Behav. Modif.*, 40, pp. 748–776.

30. Geringer, J. M., MacLeod, R. B. and Sasanfar, J. K. (2015) 'In tune or out of tune: Are different instruments and voice heard differently?', *Journal of Research in Music Education*, 63(1), pp. 89–101.

31. Warren, R. A. and Curtis, M. E. (2015) 'The Actual vs. Predicted Effects of Intonation Accuracy on Vocal Performance Quality', *Music Perception*, 33(2), pp. 135–146.