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The Neural Impact of a Brief Mindfulness and Improvisational Singing Practice on Music Performance Anxiety:

An fMRI Study

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Abstract

Music Performance Anxiety (MPA) negatively impacts musicians' personal lives, professional functioning, and performance quality, and is most prevalent in young adulthood. This mixed methods study investigated whether two weeks of a novel intervention called Environmental Vocal Exploration (EVE; Oddy, 2022), combining mindfulness and vocal improvisation, could alter neural activity associated with MPA in young musicians. The EVE intervention was compared with 1) a traditional two-week mindfulness program and 2) no intervention. Pre- and post-intervention, 27 musicians aged 18–28 (n = 7: EVE, n = 10: mindfulness, n = 10: no intervention) completed an anxiety-provoking task and a letter N-back working memory task during fMRI. A thematic analysis was also conducted on discussion transcripts from EVE sessions. During the anxiety-provoking task, blood flow in emotional processing and attention-related brain areas (e.g., limbic and salience network areas) increased from pre- to post-EVE, consistent with themes (e.g., present-moment awareness). During the post-intervention N-back, EVE participants showed less activity than the other groups in cognitive processing areas (e.g., middle cingulate gyrus), indicating enhanced neural efficiency. Both interventions may impact neural activation linked to MPA, through increased attentional and emotional regulation. Vocal improvisation in a mindfulness intervention seemed to augment such effects. Results support further study of EVE's use for MPA.

Keywords: mindfulness; music performance anxiety; neuroimaging; environmental vocal exploration; singing

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Music Performance Anxiety (MPA) refers to marked, persistent apprehension toward musical performance (Kenny, 2011) that surfaces through anxious cognitions and behaviours, as well as through autonomic arousal (Kenny, 2005). This type of anxiety is highly debilitating for musicians of various types, ages, and levels of study (Craske & Craig, 1984; Kenny, 2006; 2011), impacting a high proportion of musicians' personal, professional, and performance related functioning (Zhukov, 2019). Young adult and late adolescent musicians exhibit significantly higher MPA than older musicians (Butković et al., 2021). Therefore, it is crucial to implement accessible, cost-effective methods of alleviating MPA among young musicians.

Mindfulness, a family of emotional and attentional regulatory practices, involves purposeful, non-judgmental attention to the present moment (Kabat-Zinn, 2003). Mindfulness can enhance emotional regulation in young musicians experiencing MPA (Chang et al., 2003; Diaz, 2018). These beneficial effects may arise through improved awareness of one's internal processes (Gibson, 2019) and decreased emotional reactivity towards negative stressors (Britton et al., 2012). For example, mindfulness can increase cognitive flexibility and attentional regulation (Lutz et al., 2015), helping people appraise stimuli in a positive, adaptive way, and reduce selective attention towards negative stimuli (Malinowski, 2013). Mindfulness practices typically all share the same goals: Cultivation of wellbeing and emotional balance (Lutz et al., 2006). Focused attention and open monitoring are two commonly studied styles of mindfulness (Lutz et al., 2008). Focused-attention involves concentration on a stimulus while ignoring irrelevant stimuli, and open monitoring involves enhanced attentional focus to all incoming sensations, emotions, and thoughts.

On a neurobiological level, mindfulness may reduce anxiety through increasing activation (i.e., cerebral blood flow) in brain regions associated with emotional regulation, such as the dorsomedial prefrontal cortex (Lutz et al., 2014). Mindfulness can also decrease activation in brain areas that produce arousal and process emotional valence (i.e., intensity), such as the right amygdala, parahippocampal gyrus, and insula (Lutz et al., 2014). Additionally, mindfulness can lead to decreased activation in areas involved in processing stress and anxiety, such as the posterior cingulate cortex (Monti et al., 2012). Networks linked to the cognitive aspects of mindfulness include the default mode network (DMN), central executive network (CEN), and salience network (SN; Lutz et al., 2015). A meta-analysis by Boccia and colleagues (2015) revealed that the positive effect of mindfulness training on emotional regulation may be due to training-related brain changes, notably reduced activity in the dorsolateral prefrontal cortex (DLPFC) areas (associated with self-criticism), reduced amygdala activity (associated with emotional reactivity), and increased activity in areas involved in attentional processes (e.g., middle temporal gyrus). Additionally, Fox and colleagues (2016) found that mindful practices were consistently associated with structural and functional changes in regions integral for emotion regulation, such as the anterior cingulate cortex (ACC).

Mindfulness practices have consistently been established as evidence-based interventions for stress, anxiety, and depression; such practices have implications for various mental health disorders due to their versatility, diversity, client/patient interest, and direct influence on resilience and wellbeing (Wielgosz et al., 2019). Notably, interventions lasting as little as two weeks are enough to have positive and beneficial effects (Berghoff et al., 2017; Vesa & Liedberg, 2016). However, there exist few studies on mindfulness and MPA.

Czajkowski and colleagues' (2021) study of a mindfulness intervention in the context of music performance showed that participants' mindset changes included greater awareness and concentration as well as reduced mind-wandering, distractions, self-criticism, worry, and stress, suggesting positive effects of mindfulness on MPA. Chang and colleagues (2003) also found that an eight-week meditation intervention reduced MPA levels in participants.

To understand the mechanisms through which mindfulness can influence MPA, these variables must be examined on a neurobiological level.

Environmental Vocal Exploration

There is a gap in the literature on the neurobiological influence of mindfulness techniques on MPA. The current project investigated the brain activity and anxiety levels of young adults with MPA who completed a two-week mindfulness intervention that had been adapted to include improvisational, mindful singing practice. The program is entitled Environmental Vocal Exploration (EVE; Oddy, 2022). EVE was conducted in a group setting and was led by a certified music therapist, where participants explored various environments (indoors) while doing a series of breath and vocal exercises. EVE involves directing attention inwardly (to one's own body, breath, and emotional state) and outwardly (to the environment and the people around oneself) during improvisational vocalisation experiences, with the primary goals being to improve performers' relationships with their instruments, the act of performing, and their performance environments as well as to reduce anxiety surrounding performance.

The effect of EVE on MPA has yet to be established. However, sharing all foundational aspects of mindfulness training, its effectiveness and impact are promising. EVE's inclusion of singing necessitates vagus nerve (VN) stimulation, which can reduce anxiety. Natural methods of stimulating the VN to reduce psychological stress include breathing exercises, chanting or humming, therapeutic music, mindfulness practice, and laughter (Yuen & Sander, 2017). In fact, Kalyani and colleagues (2011) demonstrated that 'OM' chanting was associated with significant bilateral deactivation in the orbitofrontal cortex, ACC, parahippocampal gyri, thalami, and hippocampi, as well as significant right amygdala deactivation, indicating reduced stress. While these natural VN stimulation methods are commonly employed in traditional mindfulness, EVE employs such methods further by incorporating singing.

The themes derived from Oddy's (2022) investigation of EVE's effects may map onto the presumed neural influences of EVE on MPA. One theme was that of listening as a practice of awareness, directing attention to the outside world, which can then direct attention away from internal anxiety. An emotional relationship between the vocal self and the environment was also highlighted, with Oddy's participants engaging playfully and creatively with the acoustic environment. Experiencing eigentones is one example (i.e., acoustical resonance or standing soundwaves), allowing participants to think beyond their ears and attend to reverberant acoustics of their environments (e.g., a tunnel).

Spirituality was another component of participants' experience during its inaugural implementation by Oddy (2022), where participants focused on the expansive nature of outer and inner worlds. Ritualistic elements were also incorporated into the practice (e.g., beginning the practice with breathing experiences and debriefing before and after singing). Similarly, community emerged as a theme, which despite some nervousness for fear of being judged, promoted belonging, connection, and gratitude for others during music-making. This was validated during the last session of the EVE mindfulness training when participants reported increased openness and engaged in spontaneous communal singing; participants' discussions of EVE seemed to amplify their connection. Several participants also experienced vulnerability when vocally improvising with others, where relinquishing preconceptions of proper vocal technique allowed a sense of freedom.

Participants' vocal relationships with different environments (e.g., rushing water, reverberant tunnel walls) varied. The effect of intermateriality (Eidsheim, 2015) was revealed, in which the material qualities of the place where people sang changed their experience of awareness to matter, sound, and their bodies. The whole concept of EVE has the effect of enhancing gratitude for the environment and reducing a fixation on singing quality. In addition, when participants paid attention to their vocal relationships with the world around them, they reflected on the environmental history of places as well as the influence of settler culture and industrialization.

The Present Study

Our goals for the present study were to 1) investigate changes in participant brain activity before and after two weeks of EVE sessions and 2) compare the neural activity of the EVE group to that of a similar group of musicians who underwent an active control condition, which was a two week mindfulness intervention (reminiscent of a mindfulness-based stress reduction program, incorporating a mix of focused attention and open monitoring styles of practices) and to another group who completed no intervention. During fMRI, participants completed an anxiety-provoking video task where they watched videos of their own and another person's musical performance, as well as a video of a judge panel critiquing the performances. This task aimed to target neural circuitry involved in MPA, permitting investigation of EVE's and mindfulness' effects on neural activation patterns during MPA. Participants also completed an fMRI letter N-back task to measure working memory (one aspect of executive functioning required by musicians), investigating differential activation of the brain's cognitive control networks before and after interventions. In addition, a thematic analysis was conducted of participants' EVE discussion transcripts to enrich our understanding of participants' feelings and thoughts during EVE. Considering that fMRI research is correlational in nature, adding a thematic component can improve our understanding of how EVE neurally influences participants' experiences of MPA.

This mixed methods study will add to the limited literature on the neurobiological effects of mindfulness and vocal practices on MPA among young musicians. The practices employed in this study are accessible, cost-effective, and may have promising impacts on wellbeing. Understanding the neurological effects of such training can provide empirical evidence to support the use of these techniques as a means to decrease MPA.

Method

Participants

Twenty-seven musicians (ages 18–28, $M = 23.1$, $SD = 2.68$) who self-identified as having MPA were included in the study. Their mean Kenny Music Performance Anxiety Inventory (KMPAI) score at the beginning of the study was 52.95; the revised KMPAI contains 40 items within eight domains of performance anxiety. Scores are expressed as percentages, with higher scores indicating more severe MPA (Kenny, 2009). Eleven participants identified as male, and 16 identified as female. The participants played a range of instruments, including piano ($n = 7$), violin ($n = 4$), percussion ($n = 2$), flute ($n = 1$), viola ($n = 1$), bagpipes ($n = 1$), clarinet ($n = 1$), French horn ($n = 1$), guitar ($n = 1$), trumpet ($n = 1$), cello ($n = 1$), bassoon ($n = 1$), double bass ($n = 1$), saxophone ($n = 1$), and vocals ($n = 2$). Participants' mean starting age for their instruments was 9½ years of age. There were no significant demographic differences between the three groups.

Participants were allocated to the experimental, active control, and passive control groups based on date of enrollment in the study: The first ten participants who registered were allocated to the mindfulness condition (five females and five males), the next 10 were allocated to the control condition (five females and five males), and the next seven were allocated to the EVE condition (six females and one male). Participants were recruited by posters located throughout a Canadian university's music building, through convenience sampling via email, and by contacting private music instructors. This study was approved by the Canadian university's research ethics board.

In order to participate in this study, the young adult musicians were required to have achieved grade seven from the Royal Conservatory of Music, or to have completed or currently be in the process of completing a post-secondary degree program in music. Participants were also included if they had normal or corrected vision and had normal hearing.

Participants were excluded if they had ever engaged in any kind of formal mindfulness training or if they had psychological disorders that they were currently being medicated for. They were also excluded if they had experienced loss of consciousness for more than ten minutes at any point in the past other than during surgery, if they had non-removable metal in their body or implanted devices, were currently pregnant or breastfeeding, if they had back problems, or if they were claustrophobic.

Measures

Demographic and Health Questionnaire

Demographic and health information included participants' age, sex, and previous experience with mindfulness activities (e.g., yoga, meditation, mindfulness-based stress reduction). It also included information about participants' history as musicians, such as their instrument type, number of years of music lessons, the age at which they commenced studying their instrument, and their highest degree of music training attained. Additionally, participants were asked whether they had pre-existing psychological conditions or used any substances.

Spielberger State-Trait Anxiety Inventory

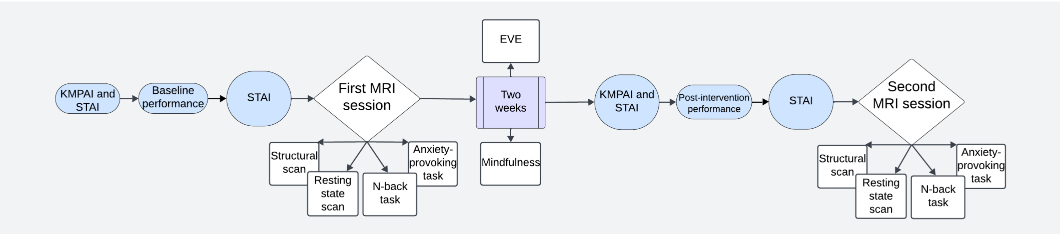
MPA was measured several times during this study using the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983), which contains two subscales: One measuring trait anxiety and the other measuring state anxiety. Only the state subscale was used in the current study. The state subscale contains 20 questions in which participants use a 4-point Likert scale to rate the extent to which a given statement resonates with how they feel in the present moment. Participants answered questions such as "I feel at ease" and "I feel strained" on a scale ranging from one (*not at all*) to four (*very much so*). A total sum score was computed after reverse scoring certain items, with higher scores indicating higher anxiety. The STAI has been employed in MPA studies (Brooker, 2018; Spahn et al., 2010) and studies on mindfulness training (La Torre et al., 2020). Previous studies have shown high content validity of the STAI. For example, it has shown correlations of 0.73 and 0.85 with the Taylor Manifest Anxiety Scale (Taylor, 1953) and Cattell and Scheier's Anxiety Scale Questionnaire respectively (Cattell & Scheier, 1963; Julian, 2011). The STAI has also shown high reliability in previous studies (Julian, 2011). For example, the STAI's test-retest reliability coefficients ranged from 0.31 to 0.86 on initial development (Spielberger et al., 1983), with intervals ranging from one hour to 104 days. Considering that the state anxiety scale detects transitory states, test-retest coefficients were lower for state than trait anxiety. It has also shown high internal consistency, with Cronbach's alpha coefficients ranging from 0.86 for high school students to 0.95 for military recruits (Spielberger et al., 1983).

Procedure

Participants first completed the demographic and health questionnaire and the STAI. They were then instructed to perform 6–10 minutes of solo repertoire (that they had previously performed at least once with their instrument of choice) in front of a mock panel of two judges. Participants were given 5–7 minutes to warm up with their instruments in a different room. Prior to performance, the participants were told that the jury panel would evaluate their performances. Each participant's performance was video-recorded, and this recording was used for the anxiety-provoking task during the fMRI session.

Following performances, participants completed the STAI once again. Within seven days ($M = 6.7$, $SD = 2.3$) of their initial performance session, participants underwent a one-hour MRI scan, which included a high-resolution structural scan, a resting state fMRI scan, a working memory letter N-back task, and the anxiety-provoking task (tasks described below). The data of interest for this study were the two task-based fMRI scans. (See Figure 1 for a timeline of the full study procedure.)

Figure 1. Procedural Timeline.



Note: This flowchart depicts a timeline of testing procedures from the beginning to the end of the study. The flow chart moves from left to right across the page: 1) Administration of the KMPAI and STAI; 2) Baseline performance; 3) Administration of the STAI; 4) Baseline MRI session which encompassed a structural, resting state, N-back task, and anxiety-provoking task scan; 5) EVE and traditional mindfulness interventions. The first four testing procedures are then repeated.

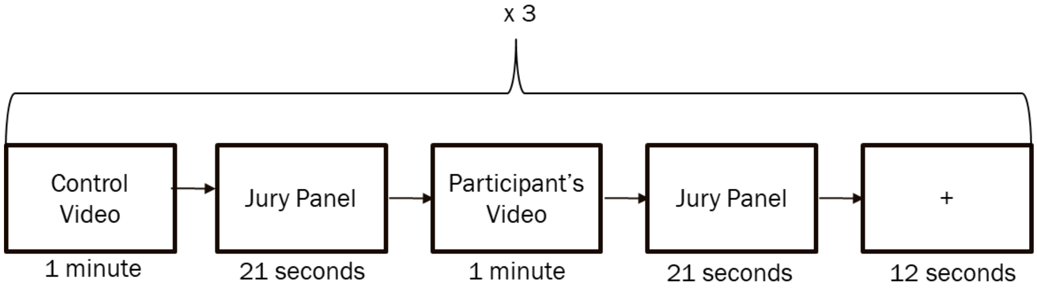
fMRI procedure

All participants underwent MRI scans at a 3.0 Tesla Siemens Biograph MR-PET scanner. Participants were asked to lie on the bed of the scanner with their head immobilized in a 12-chanel head coil. The two fMRI tasks were performed using an echo planar pulse sequence, TR/TE 3000/27 ms, flip angle 90°, FOV 24x24 cm 2, 64x64 matrix, slice thickness 3 mm, 38 axial slices, bandwidth 62.5 kHz. The results from the other pulse sequences will be presented elsewhere.

Anxiety-provoking task

Each participant's video recording of their baseline performance was used to evoke feelings of performance anxiety while in the scanner. Participants were also told that a jury panel of two individuals (a different panel of judges than those who were present at their performances) reviewed and judged the videos of their performances. The jury panel consisted of confederates. During the task, participants were shown a control video (one minute), followed by a video of the mock jury panel writing notes about the participant's performances (21 seconds), followed by the anxiety-provoking condition (their own performance—one minute), followed by another jury video (21 seconds). This sequence repeated three times with 12 second fixations (cross hair on screen) in between. Each video started where the last video left off (e.g., participants were shown one minute of a control video and the next control video they saw was a continuation of the first one-minute video and so on). This was the same for the participant videos and the jury videos as well. The control videos consisted of sections of a recording of a young adult female confederate musician playing the trumpet. All participants were shown the same jury panel and control condition confederate. The only difference between participants' imaging experience was the anxiety-provoking condition (watching themselves play their piece). Overall, this task lasted eight minutes and 42 seconds. (See Figure 2 for a visual of the task procedure.)

Figure 2. Anxiety Provoking fMRI Task Design.

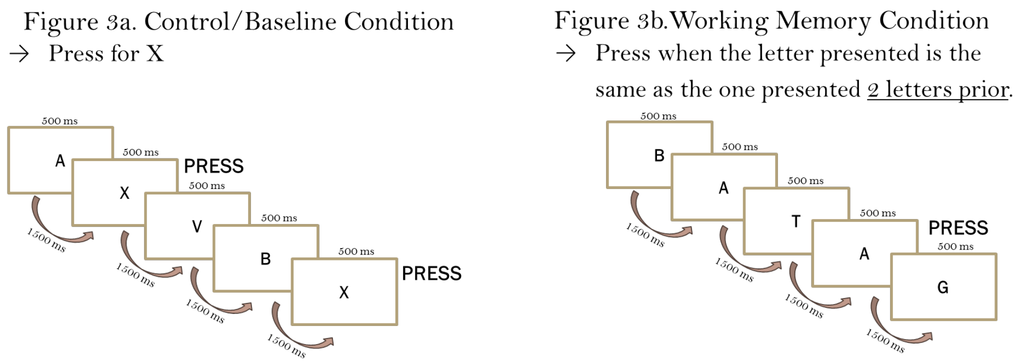


Note: This flowchart depicts the sequence of testing procedures. Box 1 reads "Control Video" (with 1 minute underneath). Box 2: "Jury Panel" (21 seconds underneath). Box 3: "Participant's Video" (1 minute). Box 4: "Jury Panel" (21 seconds). Box 5 contains a fixation cross (12 seconds). There is a bracket above the 5 boxes with x 3 in the center.

Letter N-back task

Black letters were presented, one at a time, in the middle of a white screen. A fiber optic response pad was provided to the participants in the scanner where they were instructed to press the button with their right index finger as quickly and accurately as possible, depending on the instruction. The block design task included two conditions: 1) A control or baseline condition with Press for X presented on the screen followed by 16 stimuli (letters of the alphabet); a button press for every X presented was required, and 2) a working memory condition with Press for 2-back presented on the screen followed by 16 stimuli (letters of the alphabet except for X); the same button response was required when the letter presented was the same as the one presented two letters prior. Letters were presented for 500 milliseconds with an inter-stimulus interval of 1500 milliseconds, and blocks were counterbalanced. Six blocks of each condition were performed with six responses required within each block. Rest periods were interspersed between blocks for 21 seconds with the word 'Rest' on the screen. (See Figure 3 for a visual of the task procedure.)

Figure 3. N-back fMRI Task Design.



Note: These figures depict two conditions of the N-back task design. Figure 3a presents the control or baseline condition. Five boxes are shown overlapping, with each box down and to the right a little. In each box is a letter: A, X, V, B and X. The word "press" is written to the side of the boxes with the letter X. Figure 3b presents the working memory condition. The sequence of letters in these 5 boxes is B, A, T, A (with the word "press" to the right), G. For both Figure 3a and 3b, each box has 500ms written above and an arrow (with 1500ms written) moving from one box to the next.

The EVE and mindfulness groups then underwent two weeks of EVE and mindfulness training, respectively, while the control group was instructed not to practice any mindfulness-like activities throughout the duration of the study. Following these two weeks, all participants completed the same procedures as the pre-training session. Each participant played the same piece of music in front of the mock jury panel at both the baseline and post-training sessions. Within three days ($M = 2.2$, $SD = 2.9$) of the post-training performance session, participants completed another one-hour MRI session, which included the same imaging sequences as the first scanning session.

EVE Intervention Procedure

Ten group EVE sessions took place in three rooms of the University and were led by the certified music therapist that developed EVE. The sessions encompassed breathwork, sitting meditation exercises, exploration of the room around them, communal improvised singing, body and voice awareness exercises, and processing of experiences through discussion before and after sessions as well as through creative expression (e.g., drawing, writing).

During the first three sessions, participants lay on their mats while the music therapist invited them to direct attention to various parts of the body by first breathing toward, and then singing *into* these body parts, sending them nurturance, acceptance, and gratitude as a foundation for self-exploration. During the fourth and fifth sessions, participants engaged in both sitting and walking meditations directing attention towards the body, the room, and the outside world. They were also invited to consider (metaphorically) what they could give to and receive from the earth. During these sessions everyone improvised at the same time in a kind of "parallel play," at the same time but not together.

Sessions six through eight emphasized community. Singing experiences included the following: Participants doing their own singing while listening to others and creating joint melodies; all participants singing in a drone while one person at a time improvised over the drone; exploring sonic properties of gongs, drums, and a piano while singing along with these instruments. The ninth session emphasized reciprocity between participants' bodies and their external surroundings as well as between themselves and the other singers; this session also included a spontaneous droning experience in an improvisation circle at the end. During the last session they explored the guttural parts of their voices, focusing on the power they could foster within their bodies.

The EVE sessions all ended with activities that invited the participants to process their experiences such as mandala drawing, body scans where participants renamed and embraced feelings of anxiety that arose, drawing, writing, song writing, and further improvisational singing. There was always a group discussion afterward, when people could consider feelings that arose, and applications for the mindfulness skills learned throughout this experience.

Mindfulness Intervention Procedure

The mindfulness intervention involved a two-week training program. The program comprised ten one-hour sessions. Sessions were taught by a registered Mindfulness-Based Cognitive Therapy facilitator and were conducted in group format. Each session consisted of a variety of meditation exercises, body scanning, breath awareness, mindful walking, qigong, and discussion groups. Participants also had discussion groups focused on their daily stresses, their experiences with mindfulness training so far, and their experience with MPA in the past. Participants in this condition were asked to refrain from any additional mindfulness activities (e.g., yoga, meditation, mindfulness-based stress reduction) during this training, to reduce external variability in this group's mindfulness practices.

Unfortunately, there were no transcripts obtained during this intervention as in the EVE group.

Data Analysis

Quantitative Analyses of fMRI, STAI, and N-back Performance Data

Using Statistical Parametric Mapping (SPM12), data was pre-processed from both fMRI tasks by realigning images to control for motion, normalizing the images using the Montreal Neurological Institute (MNI) brain template, and smoothing the data using a 6mm Gaussian kernel. Following pre-processing, first-level analyses were performed. For each participant, the contrast of interest for the anxiety-provoking task was the brain activity left when the control video blocks were subtracted from the anxiety-provoking video blocks. This included the first 45 seconds of each video only given the possibility of habituation of the hemodynamic response. The N-back contrast of interest was the Press for 2-back minus Press for X contrast. These contrasts were then entered into respective second-level random effects analyses to compare the pre- and post-training activation both between and within groups. Paired samples *t*-tests were subsequently used to compare each individual group's baseline versus post-training brain activity. A three-way ANOVA was performed to identify if there were any significant differences between the three groups at both time points, for each task. Given the significance found, further independent-samples *t*-tests to compare the baseline and post-training brain activity between the EVE and mindfulness, EVE and control, as well as mindfulness and control groups, were performed. Repeated-measures ANOVAs were also conducted on STAI scores and performance on the N-back task (reaction time and accuracy; i.e., number of errors), to examine within- and between-group effects. For all analyses, p-values < 0.05 were considered significant. The p-values for the fMRI analyses were Bonferroni corrected for multiple comparisons. For the STAI and N-back performance analyses, p-values were corrected using the Benjamini-Hochberg correction, with a False Discovery Rate (FDR) of 0.10, considering the exploratory nature of these analyses.

Thematic Analyses of Interview Data

Participants in the EVE group engaged in discussions before and after various practices. During these discussions, participants' responses to exercises were transcribed. A thematic analysis was conducted based on transcribed responses, using a process similar to that of Braun & Clarke (2006). First, initial notes and observations were made for all 10 sessions. Then, open codes were generated by highlighting portions of text within sessions that reflected trends across multiple participants. Finally, themes were formed based on open codes and a thematic map was generated.

Results

State Anxiety

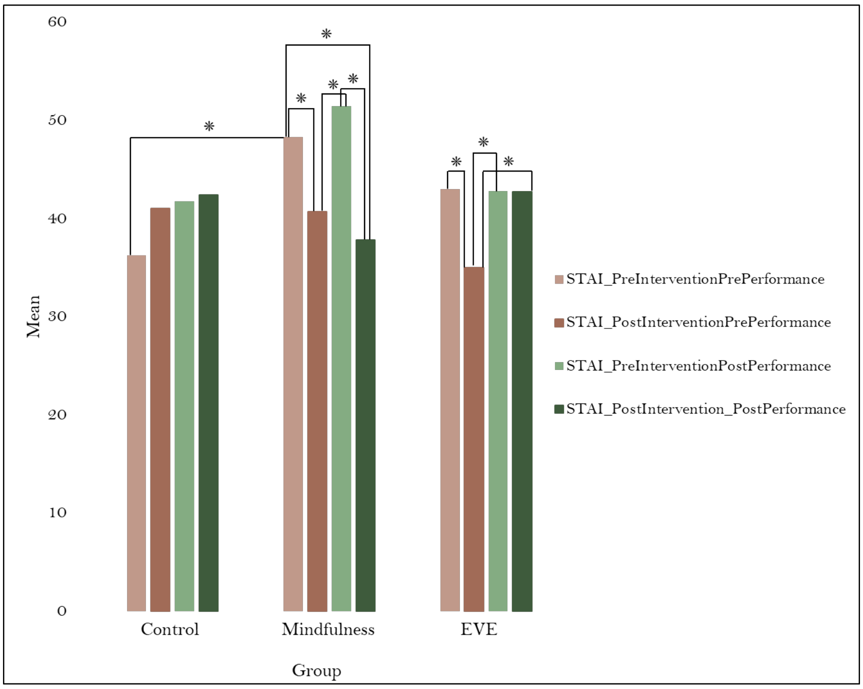
The three (group) x four (time) ANOVA results revealed a significant main effect of time ($F(3, 22) = 6.060$, $p = 0.004$, $\eta_p 2 = 0.452$). Post hoc pairwise comparisons showed that time one (i.e., pre-intervention) post-performance (after participants performed their musical piece) STAI scores were significantly higher than time two (i.e., post-intervention) pre-performance (before participants performed their musical piece) STAI scores ($p < 0.001$).

There was also a time by group interaction (F (6, 46) = 3.464, p = 0.007, η_p2 = 0.622). Post hoc pairwise comparisons showed a significant difference in pre-performance anxiety scores between the no-intervention control and mindfulness groups at time one (p = 0.023), with mindfulness participants showing higher anxiety levels than control participants.

There was a significant difference in anxiety scores from time one to time two in the mindfulness group, where both pre-performance STAI scores (p = 0.027) and post-performance STAI scores ($p < 0.001$) were lower at time two. The mindfulness group also showed lower STAI scores post-performance at time two than pre-performance at time one (p = 0.007), as well as lower STAI scores at time two pre-performance than time one post-performance ($p < 0.001$).

Among the EVE group, time one pre-performance STAI scores were higher than time two pre-performance STAI scores (p = 0.049). Post-performance STAI scores were not significantly different between times one and two. Additionally, the EVE group's time two pre-performance anxiety was significantly lower than time one post-performance anxiety (p = 0.017) and time two post-performance anxiety (p = 0.011). The control group showed no STAI differences between time points. (See Figure 4.)

Figure 4. STAI Results.



Note: This bar graph represents STAI scores. On the x-axis are three groups: control, mindfulness and EVE. Each group has four columns; light brown = pre-Intervention pre-performance; dark brown = post-intervention pre-performance; light green = pre-intervention post-performance; dark green = post-intervention post-performance. The y-axis represents participants' mean STAI scores, ranging from zero to 60. Lines with asterisks represent significant differences in several columns and this is discussed in the text above.

Thematic Analysis

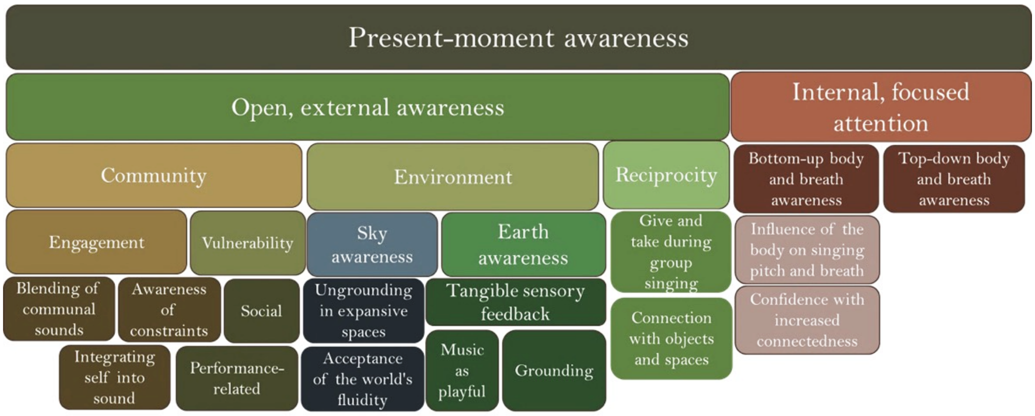
Present Moment Awareness

In both externally focused (i.e., environment and community awareness) and internally focused (i.e., breath and body awareness) aspects of EVE, several participants reported increased attention to the present moment. See Figure 5 for a thematic map. For example, in the first session, two participants' quotes revealed EVE's emphasis on *internally* focused attention on the present moment. One participant said: "[…] when I was breathing out, I tried to breathe out the past and future and focus on the present. It did help me. I was able to focus better." Another said "I found it easier to connect to my body through the breath. Started integrating the voice."

EVE also involved *externally* focused attention, as was indicated by a participant in the final session, discussing the skills they would take with them from EVE:

> Maybe I can have the centre in mind. Singing around the room. I think about the room more than what I'm doing. The people in the room. Casting your mind out rather than into the anxiety. Making music is more joyful.

Figure 5. Thematic Map.



Note: This figure represents a thematic map based on EVE discussion transcripts. All of the themes, which are discussed in-depth below, are represented as boxes in this figure. Lower boxes represent increasingly narrow subthemes, while the top boxes represent dominant ones.

Open, External Awareness

Community

This subtheme within "Open, External Awareness" represents participants' statements about both comfortable and uncomfortable forms of engagement with other participants during singing practices, such as during sessions six and seven.

Engagement

"Engagement" was revealed in three ways: First, it was revealed through "Blending of Communal Sounds." For example, in relation to both drawing and singing exercises in EVE, a participant said: "I was thinking about homogeneity and blending, but also the way I drew it I started all around the edge. We started far away from each other and slowly came together. We blended so that we didn't stand out."

A second subtheme of engagement was "Awareness of Constraints," a potential hindrance to full engagement with EVE that was noted by a few participants. This subtheme was discussed when describing pictures that they drew based on feelings evoked from communal singing exercises:

> I was thinking—we try to make it an organic thing, interacting with each other in a spur of the moment way, but at the same time we're still bound by the hour here. We can't take our time completely. We can't do an expansive thing and that really sucks. We're on this schedule and all have other things to do today, and we can't let things be as they are. Then I was thinking that everything in nature has constraints on it. Plants are limited by how much sunlight they have, how much ground space, but that doesn't mean it's not real. [I describe a

> part of the picture I see: That little plant is surrounded by warmth and somehow contained]. It's representative of memory to me.

Finally, engagement was shown through "Integrating Self into Sound" when singing as a group, as was expressed by one participant: Usually, I'm so in my head and it was hard to focus on what was outside of me. Trying to integrate myself into the sound. I started off caring what I sound like and then do just whatever. It was fun.

Vulnerability

Another aspect of "Community" is "Vulnerability" a subtheme that emerged in contexts of both "Social" and "Performance-Related" vulnerability. Social vulnerability was exemplified by two participants during a walking exercise, involving greeting other participants with one's voice. First, a participant said: "Because I'd done it before I was a little more comfortable. But my social tendencies were coming out. I was thinking that people were running away from me as I was heading toward someone."

Vulnerability evoked by performance-related vulnerability was also shown by participants discussing how their greetings to one another felt like a performance, as was seen in the following participant quote:

> The transition between being a person who's talking to others and then transitioning to performer of music. I find it hard and awkward. If I introduce myself and then start singing, I have to transition between my normal speaking voice and my singing voice, getting ready or getting into character, or getting into the vibe of the piece.

Environment

This is a subtheme within "Open, External Awareness" representing participants' statements about their connections to the spaces they were in and the objects surrounding them. Statements about the environment encompassed awareness of both the sky and earth, thus we added the subthemes of "Sky Awareness" and "Earth Awareness."

Sky Awareness

"Sky Awareness" contained two subthemes: "Ungrounding in Expansive Spaces" and "Acceptance of the World's Fluidity." "Ungrounding in Expansive Spaces" was exemplified during session 8 and 9. In session 8, various participant quotes revealed a sense of awe, or vastness in a large space, that, contrary to grounding experiences, made participants feel more of a sense of oneness with the universe (i.e., blurred lines between where the individual ends and where the rest of the world begins). Such oneness evoked a mixture of feelings for participants, as is exemplified in the following quotes about singing in spaces. An example of such a quote was: "Singing out into the universe ungrounds me. I'm a quiet person and I play quietly."

Another example was: "This was one of the harder ones for me. How big of a space that was to fill." Another participant said: "It feels more connected. I closed my eyes a lot. I felt like beyond the outside world, I could go further in perceiving what's around. You don't feel so isolated."

"Acceptance of the World's Fluidity" was revealed during session 9. Participants discussed several aspects of the fluid nature of the world. A participant had arranged her page so that it was in the shape of a diamond and said the following quote:

> At first, I was wondering about the orientation. The word didn't come to me at first, but I had the feeling from the experience and looking out. I was trying to be open minded and feel based on what I just saw. Yesterday the sky was blue and today it's grey, so I didn't want to

> have preconceptions. I tried to think with a wider spectrum of things. It was a feeling of freeing. Everything is up and down as [name of another participant] said, between the good and the bad. In the end the word that came to me was "fluid." I didn't have any shapes that came to mind—just colours.

Earth Awareness

"Earth Awareness" encompassed three additional subthemes: "Grounding," "Music as Playful," and "Tangible Sensory Feedback." The subthemes within "Earth Awareness" were revealed across sessions, primarily during sessions four and five. In these sessions, participants sang together in a circle, then moved around the room while vocalizing and focusing on outdoors. First, the theme of "Tangible Sensory Feedback" emerged, based on participants' statements about the significance of their sensory experiences in the room while singing, increasing their connections to the outside world. One comment that exemplified this was: "Touching surfaces. This one makes sound—that one doesn't make sound." Similar sentiments were: "The corners were great. And the alcove," Two related participant comments included:

> With touching stuff, I felt the lower notes. Paper, plastic, and wood were higher. I was trying to separate—knowing where the materials came from what I just perceive—the pitch of stuff. Anything wooden inspired higher notes. If I touched metal, my tone was lower. The pitch was different according to different objects. Letting the material flow through and bounce off of me. I also felt exhausted afterward too. I felt more comfortable reconnecting with basic materials that we always see, but then taking time to identify them and connect with them. This room doesn't feel scary.

> It's a good way of thinking. If I saw this room as a performance venue it would make sense to get comfortable with the materials in the room beforehand. Especially for piano where you don't necessarily know the instrument beforehand. Spend time with the instrument. Humanize it.

Second, the subtheme of "Music as Playful" emerged, where participants made statements about the fun in exploring the environment and community with their voices. One participant said: "I definitely felt more comfortable than yesterday. I'm more open to being more playful." Another said "Casting your mind out rather than into the anxiety. Making music is more joyful."

Third, "Grounding" was shown in participants' quotes while singing and moving around the room. One participant said "I ended up singing by that pillar there. It probably has a connection to the ground."

Reciprocity

"Reciprocity between the Self and the Outside World" is a subtheme within "Open, External Awareness" representing participants' statements about feelings of taking in and giving out to the environment and the community (i.e., an exchange of focus, care, nurturance, breath, and sound). Within the "Reciprocity" are the subthemes of "Give and Take during Group Singing" and "Connection with Objects and Spaces."

Give and Take during Group Singing

This was exemplified through several participant quotes about the exchange between themselves and other participants. One said: "It was give and take. I was more harmonizing with people or being an echo. It really enriches a piece and makes it great but it's not the focus." Taking a more analytic standpoint, another participant said: "I didn't realize that people were supposed to make harmony. I started analysing. If she's singing an A then I should sing an F."

Connection with Objects and Spaces

This subtheme was shown through participants' energetic reactions to their surroundings while singing. For example, one participant quote was:

> I was thinking about resonance and cooperation. A certain tone would resonate really well. I feel like even though it was just my sound that was resonating it felt like a lot more than just me. I feel like that's how I want to feel in general as I move through the world. I want to feel like I'm putting something in and getting a lot back. It's not as if I'm taking from anyone else, but just positioning and what I'm doing and where I am at the time. My efforts are able to be multiplied, I guess. That sense of reciprocity. I loved looking out the window. I would stand there all day and just watch the world go by. It was very comforting to know that the world goes on with or without me. It helps me know that I can find my place within it.

Internal, Focused Attention

Bottom-up Breath and Body Focus

This subtheme within "Internal Focused Attention" comprised of statements about how participants would develop thoughts and feelings about their bodies and vocal tones based on bodily feedback. Participants tended to express these feelings in session 3, after achieving more top-down integration of the voice and breath into the body. There were two additional subthemes within this one: "Influence of the Body on Singing Pitch and Breath" and "Confidence with Increased Connectedness."

Influence of the Body on Singing Pitch and Breath

Participants discussed how scanning different parts of the body influenced their vocal output. One of these statements was: "Yesterday, I was singing a high note, and today I noticed that I was going toward my low register. I found that easier to feel in my body." Another was: "It feels like it vibrates more, and it was a good way to connect. The head voice and the chest voice."

Confidence with Increased Connectedness

This was another subtheme exemplified in participants' descriptions of the connections they felt to their bodies during vocal and breathing exercises, emphasizing that body parts of greater strength are where their musical confidence was strongest. One participant said:

> I think that confidence is physical strength. I have that association in my mind. If my core is strong, then I can't be physically overpowered. That's where my brain was. There were times when I was stronger than I am now, and I felt more confident in general. More centred.

Another participant said: "At first, I thought it was in my feet, but then my stomach and then my upper body. I use my upper body more." Finally, another quote was: "From today I can take my sense of confidence. Maybe I can have the centre in mind."

Top-down Breath and Body Awareness

This is a subtheme within "Internal Focused Attention," comprised of statements about how participants' thought patterns as well as their breath and vocal patterns influenced their body sensations. This subtheme was shown through quotes about the connections between the voice, breath, and body, and how it became easier to connect them under specific circumstances. One participant said: "I found it easier to connect to my body through the breath. Started integrating the voice. I find myself more at ease than I expected not knowing what to expect." Another said "I found it I was more connected on the lower notes." Another participant said: "I liked seeing how it was so hard to focus on just breathing. I feel like that can help me focus on other stuff, since breathing is so basic. It might help me focus in general." Finally, another said: "When I'm performing, I'm all in my head and I'm trying to get more in my body and become present and aware, and I'm hoping that this will help me get to that."

Anxiety-Provoking Task

Participants also showed quantitative changes in brain activity, between time points and between groups. Paired samples *t*-tests showed several changes in brain activity within the EVE and mindfulness groups from pre- to post-intervention. First, during the Anxiety Provoking task, participants in the EVE group showed increased activity from baseline to post-intervention when watching themselves compared to another in the right superior temporal gyrus, right anterior cerebellum, middle cingulate, right postcentral gyrus, right middle temporal gyrus, and right fusiform (Table 1). The mindfulness group showed an increase in activity post-intervention compared to pre-intervention in the hippocampus, caudate, right fusiform gyrus, right lingual gyrus, left inferior temporal gyrus, right supplementary motor area (SMA), left paracentral lobule, and left precentral gyrus (Table 1).

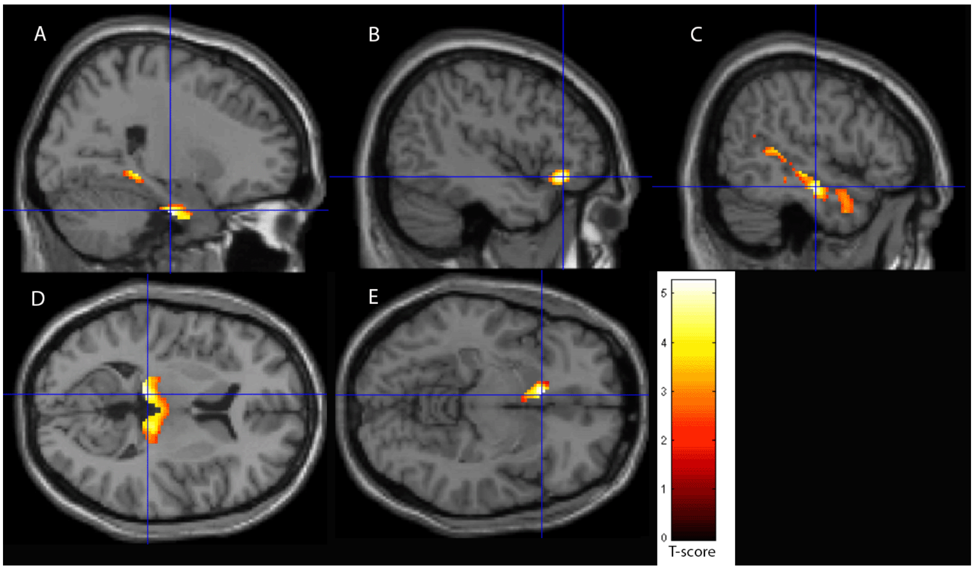
The three-way ANOVA revealed a significant interaction effect between group and time. Comparing the EVE and mindfulness groups post-intervention using follow-up independent samples *t*-tests, the EVE group showed more activity in the caudate, right parahippocampal gyrus, right middle temporal gyrus, left thalamus, inferior orbitofrontal gyrus, and right temporal pole than the mindfulness group (Table 1, Figure 6). The EVE group showed more activity in similar regions compared to the no-intervention control group, including bilateral parahippocampal gyrus, caudate, bilateral thalamus, middle and superior temporal gyri, left temporal pole, and right insula (Table 1).

Table 1. Anxiety Provoking Task Results.

Contrast	Brain Region	MNI Coordinates	T-score	*p*-value
EVE group Post > Pre	R Superior Temporal Gyrus	48 -42 18	11.6	0.000
Cluster Size – 8229	R Anterior Cerebellum	14 -54 -26	9.53	0.000
	Middle Cingulate	8 -8 32	7.32	0.000
	R Postcentral Gyrus	38 -28 54	7.09	0.000
	R Middle Temporal Gyrus	52 -58 2	7.06	0.000
	R Fusiform Gyrus	42 -54 -20	5.7	0.000
Mindfulness group Post > Pre	Hippocampus	26 -14 -14	7.44	0.000
	Caudate	6 8 -8	7.39	0.000
	R Fusiform Gyrus	42 -12 -30	5.49	0.000

Contrast	Brain Region	MNI Coordinates	T-score	*p*-value
Cluster Size – 6274	R Lingual Gyrus	14 -52 -4	5.40	0.000
Cluster Size – 4629	L Inferior Temporal Gyrus	-58 -42 -18	5.07	0.000
	R Supplementary Motor Area	14 -16 62	4.77	0.002
	L Paracentral Lobule	-10 -22 62	4.74	0.002
	L Precentral Gyrus	-34 -18 52	4.50	0.002
Post Intervention EVE > Mindfulness	Caudate	-6 18 -8	5.25	0.000
Cluster Size – 12927	R Parahippocampal Gyrus	24 -14 -30	4.1	0.000
	R Middle Temporal Gyrus	52 -14 -16	3.93	0.000
	L Thalamus	-10 -30 8	3.92	0.000
	Inferior Orbitofrontal Gyrus	-44 30 -10	3.39	0.000
	R Temporal Pole	44 6 -28	3.75	0.000
Post Intervention EVE > Controls	Bilateral Parahippocampal Gyrus	26 -2 -32 -24 -6 -30	4.81 3.96	0.000 0.000
Cluster Size – 18106	Caudate/Medial Prefrontal Cortex	-6 16 -12	4.67	0.000
	Bilateral Thalamus	-10 -30 8	3.92	0.000
	Middle Temporal Gyrus	-62 -24 0	4.45	0.000
	Superior Temporal Gyrus	54 -32 4	4.11	0.000
	L Temporal pole	-50 6 -12	3.62	0.000
	R Insula	44 0 0	3.61	0.000

Figure 6. Anxiety Provoking Task Where EVE Post-intervention > Mindfulness Post-intervention.



Note: Five brain cross-section images (from a template provided by SPM12) with fMRI results from the anxiety-provoking task superimposed. Yellow, orange and/ or red areas, highlighted with blue crosshairs, depict brain regions where the EVE group showed significantly more activity than the mindfulness group post-intervention. Regions of Interest have the letters A, B, C, D, and E next to them, which depict the following brain areas: A) R parahippocampal gyrus, B) L inferior orbitofrontal gyrus, C) R middle temporal gyrus, D) Bilateral thalamus, E) L caudate. At the bottom right of the image, there is a legend that represents T-scores. This legend contains colours ranging from black (corresponding to a T-score of 0) to white (corresponding to a T-score of 5), with red, orange, and yellow in between 0 and 5). Lighter coloured brain regions correspond to higher T-scores and darker coloured regions correspond to lower T-scores.

N-back Task

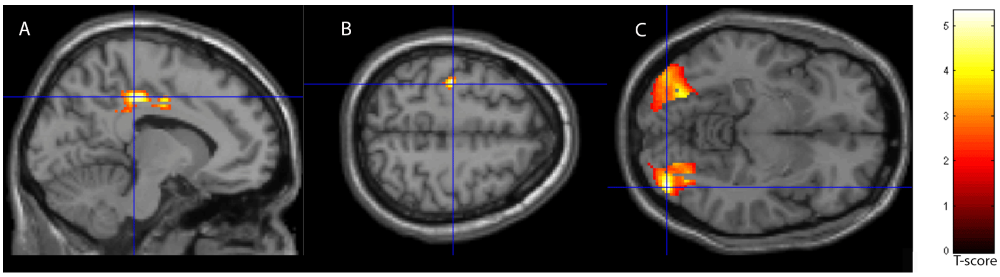
Paired samples *t*-tests revealed that, during the N-back task, the EVE group showed significantly more activity after the intervention compared to baseline in the midbrain, left middle temporal gyrus, cerebellum, putamen, and superior orbitofrontal frontal gyrus (Table 2). A three-way ANOVA revealed a significant group by time interaction. Independent samples *t*-tests showed that, post-intervention, the EVE group showed significantly less activity than the mindfulness group and the control group in various regions (Table 2). The EVE group differed from the mindfulness group in the middle cingulate gyrus and several visual areas, including the right cuneus, bilateral fusiform, bilateral inferior occipital gyrus, and left middle occipital gyrus, as well as the left precentral gyrus (Table 2, Figure 7). EVE participants showed similar patterns compared to controls (Table 2). The mindfulness group showed significantly less activity in visual areas compared to controls (bilateral cuneus, bilateral lingual gyrus, and bilateral superior occipital gyrus; Table 2).

Table 2. N-back Task Results.

Contrast	Brain Region	MNI Coordinates	T-score	*p*-value
EVE group Post > Pre Cluster Size – 9774	Midbrain	8 -14 -16	10.45	0.000
	L Middle Temporal Gyrus	-64 -46 -10	7.11	0.000
	Cerebellum	10 -40 -18	6.96	0.000
	Putamen	3-20 14 8	5.87	0.000
	Superior orbitofrontal gyrus	-16 42 -20	5.85	0.000
Post Intervention EVE < Mindfulness Cluster Size – 7167	Bilateral Inferior Occipital Gyrus	40 -84 -8 -36 -84 -6	5.32 3.8	0.000 0.000
	Bilateral Fusiform Gyrus	28 -72 -12 -28 -74 -12	4.67 4.61	0.000 0.000
	L Middle Occipital Gyrus	-32 -92 10	4.07	0.000
	R Cuneus	12 -96 14	3.89	0.000
	L Middle Cingulate Gyrus	-10 -30 42	3.77	0.000
	L Precentral Gyrus	-34 -20 56	3.71	0.000

Contrast	Brain Region	MNI Coordinates	T-score	*p*-value
Post Intervention EVE < Controls	Cuneus	10 -94 18	6.13	0.000
Cluster Size – 15293	R Inferior Occipital Gyrus	40 -84 -8	5.24	0.000
	Bilateral Middle Cingulum	8 -20 42 -12 -6 42	5.11 4.93	0.000 0.000
	Bilateral Superior Occipital Gyrus	16 -86 28 -16 -86 28	4.92 4.87	0.000 0.000
	Fusiform	-26 -72 -4	4.75	0.000
	Lingual Gyrus	-22 -70 -10	4.71	0.000
Post Intervention Mindfulness < Controls	Bilateral Cuneus	6 -92 16 -10 -94 18	4.3 3.48	0.003 0.003
Cluster Size – 4292	Bilateral Superior Occipital Gyrus	-20 -86 22 16 -88 22	4.12 3.6	0.003 0.003
	Bilateral Lingual Gyrus	20 -70 2 -20 -70 0	4.11 3.49	0.003 0.003

Figure 7. N-back Results where EVE < Mindfulness (and controls) post-intervention.



Note: Three brain cross-section images (from a template provided by SPM12) with N-back task results superimposed. Yellow, orange and red areas, highlighted with blue crosshairs, depict brain regions where the EVE group showed significantly less activity than the mindfulness group post-intervention. Regions of Interest have the letters A, B, and C beside them, which depict the following brain areas: A) middle cingulate, B) L precentral gyrus, C) visual regions. To the right of the three brain images, there is a legend that represents T-scores. This legend contains colours ranging from black (corresponding to a T-score of 0) to white (corresponding to a T-score of 5), with red, orange, and yellow in between 0 and 5). Lighter coloured brain regions correspond to higher T-scores and darker coloured regions correspond to lower T-scores.

N-back Task Performance

A three (group) x two (time) x two (condition) ANOVA also revealed changes in N-back task performance. There was a main effect of condition (F (1, 24) = 49.160, $p < 0.001$, $\eta_p2 = 0.672$). Post hoc pairwise comparisons showed that reaction times (RTs) were faster for Press for X than Press for 2-Back ($p < 0.001$).

There was also a significant interaction between group and time (F (2, 24) = 5.764, $p = 0.009$, $\eta_p2 = 0.324$). Specifically, the mindfulness group showed lower RTs than the control ($p = 0.002$) and EVE ($p = 0.012$) groups at time 2. The control group also showed higher RT at time 2 than time 1 ($p = 0.006$).

There was a time by condition interaction as well (F (1, 24) = 6.308, $p = 0.019$, $\eta_p2 = 0.208$). At time 1, RTs were higher for the 2-back condition than for Press for X condition ($p < 0.001$). This was also the case at time 2 ($p < 0.001$). RTs also increased from time 1 to time 2 ($p = 0.002$) for the Press for X blocks. Accuracy on the N-back task did not differ between groups, conditions, or time points.

General Discussion

The present study provides preliminary neuroimaging evidence that the two-week EVE intervention produced significant effects on musicians with MPA during an anxiety-provoking task and a working memory task. Both qualitative (thematic) and quantitative (fMRI and questionnaire) results reveal EVE to be a promising new intervention that warrants further investigation. We found these results even without including the important outdoor element of EVE. The principles and techniques of this intervention may facilitate neural and behavioural changes indicative of reduced MPA, regardless of EVE taking place indoors or outdoors.

EVE and Mindfulness Effects on State Anxiety

The EVE and mindfulness groups showed significant decreases in STAI scores post-intervention. For the mindfulness group, both pre- and post-performance scores decreased, and for the EVE group, only pre-performance scores decreased. Interestingly, the EVE group's time two pre-performance STAI scores were significantly lower than their time one and time two post-performance scores. The mindfulness group also showed lower STAI scores post-performance at time two than pre-performance at time one; their STAI scores at time two pre-performance were also lower than time one post-performance. Additionally, before the intervention, the mindfulness group had significantly higher baseline STAI scores (pre-performance) than the no-intervention control group.

The EVE and mindfulness groups' decreases in pre-performance anxiety after their respective interventions suggests that both interventions provide techniques that are applicable to dealing with such anxiety. However, decreases in post-performance anxiety were observed only in the mindfulness group. This post-performance STAI score decrease suggests that mindfulness may have, through methods of non-reactivity and acting with awareness (Parkinson et al., 2019), modulated their anxiety after performing (e.g., being aware of the present moment rather than reacting to or ruminating about how they performed). The EVE group, being more focused on engagement before and during a performance (e.g., awareness of the space, sounds, and sensations), may not have experienced this post-performance anxiety reduction to the same degree as mindfulness. However, the STAI, being a subjective measure, depicts only perceived anxiety and can be prone to error. Such flaws in subjective measures emphasize the need for a combination of objective (brain imaging) and subjective (self-report) measures in evaluating the efficacy of EVE compared to that of mindfulness. The EVE group also only had seven participants while the mindfulness group had 10, neither sample size being large enough for sufficient power for this analysis.

Themes Evoked During EVE

Themes of internal and external present-moment focus speak to EVE's primary motivation to inspire a "noticing" through sensory input in the environment and engagement with the body (Oddy, 2022). To experience a full range of emotional involvement with the places they sang in, Oddy (2022) noted that an open mind is required to move beyond typical patterns of tonality, melody, vocal sounds, and rhythms. Participants from the current study showed this openness when allowing uncontrolled vocal output in response to other singers, directing attention toward the community of participants and away from internal feelings of control and anxiety. Such shifts were made possible by the present-moment co-development of musical structures in response to other singers. However, participants noted several constraints (e.g., time, vulnerability level, and vocal patterns) that may have impeded their ability to access a full range of emotional involvement.

Connections were revealed between participants and the environments they sang in, exemplifying "inter-material vibration," a term proposed by Eidsheim (2015) to represent the character music takes from materiality. According to Eidsheim's "vibrational" theory of music (2015), music is thought to be interconnected with the materiality of the place it is performed in; performance is, therefore, affected by performance conditions. Participants' energetic, emotional, and physical responses to different aspects of their surroundings illustrate the importance of connecting with a performance space, as well as paying attention to perceptions of it. Through participants' connections with performance spaces, they seemed to engage more with their senses and less with anxious thoughts.

As noted by Oddy (2022), EVE is a practice of sonic-spatial exploration, where connectivity is central. As participants gained awareness of their relationships to objects and spaces, the idea of sound as a way of knowing (i.e., acoustemology) was exemplified. Acoustemology heavily implies reciprocity, between the self and all other life, human and non-human (Feld, 2015). As participants connected with their surroundings, EVE acted as a place-based sound making, involving heightened awareness of one's own connection to an environment as well as the environment's history (Feld, 2015). Such knowing through sound is thought to arise from participation (i.e., engagement with surroundings during practices) followed by reflection (i.e., group discussions after practices; Oddy, 2022).

Considering the entire body's involvement in singing (Cavarero, 2005; Sataloff, 1992), participants seemed to gain substantial awareness of the sensations of various vocal tones when connecting them to the body. For example, singing allows us to look within ourselves, at what is unfolding within our bodies (Oddy, 2022; Thomaidis & Macpherson, 2015); the personal, rootedness of the voice accounts for this, which is connected to our emotions and our lives in general (Uhlig, 2006). EVE appeared to evoke such inward focus through top-down attention to bodily sensations evoked by the voice. A couple of participants suggested that this top-down attention could be carried over to other forms of focus.

Participants' feelings of confidence near the end suggest that EVE is indeed a form of mindfulness and self-discovery (Oddy, 2022). In top-down awareness quotes, participants appeared to develop several skills for engaging with the body through voice and breath. Such top-down awareness (as was practiced in sessions one and two) led to participants' abilities to find areas of strength within their bodies that correspond to vibrational vocal sensations that indicate confidence (e.g., low, earthy tones felt in the strongest part of the body).

Influence of EVE and Mindfulness on Emotion Regulation During the Anxiety-Provoking Task

Compared to the mindfulness and no-intervention groups, the EVE group showed more activation in the caudate nuclei, the parahippocampal gyrus, and various temporal regions. Both the meditation styles of focused-attention and open monitoring have been associated with activation in a neural network including these regions, which are linked to self-awareness and self-regulation (Boccia et al., 2015; Fox et al., 2016; Wielgosz et al., 2019). Furthermore, themes from EVE participants' transcripts were self-referential (e.g., body, breath, and voice awareness; Boccia et al., 2015). EVE may overlap with and even surpass mindfulness techniques in the brain regions it targets, promoting regulation of negative emotions during music performance. EVE's activation of the vagus nerve (Yuen & Sander, 2017) may have amplified such emotional regulation.

In decreasing negative emotions about musical performances, EVE may target brain regions responsible for emotional valence processing as well. Compared to the no-intervention group, the EVE group showed increased parahippocampal gyrus activation. Compared to the mindfulness group, the EVE group showed increased activation of both the parahippocampal gyrus and inferior orbitofrontal gyrus. This contradicts findings that mindfulness practices can decrease activation in these areas, due to their respective associations with arousal and default mode network activity (Kalyani et al., 2011; Lutz et al., 2014; Tomasino & Fabbro, 2016). However, previous findings of parahippocampal gyrus activation and orbitofrontal activation were observed during meditation (Boccia et al., 2015), and during mindfulness meditation-induced pain relief, respectively (Zeidan et al., 2015), arising from emotion regulation strategies targeting these regions. EVE participants may, therefore, have engaged in learned strategies while watching the videos of themselves performing that influenced emotion regulation (e.g., viewing music as playful and fluid).

Post-intervention, the mindfulness group may also have improved emotional regulation during the video task, but perhaps through different emotion regulation strategies: For example, non-reactivity (linked to precentral gyrus activation) and acting with awareness (linked to the activation of the fusiform, lingual, and inferior temporal gyri). Similar to the present study, Parkinson and colleagues (2019) found correlations between activation of these brain regions and the “non-reactivity” and “acting with awareness” dimensions of the Five-Facet Mindfulness Questionnaire.

EVE and Mindfulness Target Attentional Focus During the Anxiety Provoking Task

The EVE intervention may also impact attentional focus, as was revealed through the core theme of present moment awareness, and on a neurobiological level, corresponding to the EVE group’s increased caudate activity post-intervention compared to the mindfulness group. The caudate nucleus is associated with motor activity, threat, and reward, and is a supporting part of the salience network (Peters et al., 2016). The salience network is responsible for refocusing one’s mind when it wanders. It allows for the allocation of attention to task relevant stimuli and provides a homeostatic system that can maintain the most relevant task set and orchestrate switching between task sets (Menon & Uddin, 2010; Seeley, 2019). Refocusing attention is a key aspect of mindfulness techniques (Malinowski, 2013). The thalamus, another supporting part of the salience network, was also more strongly activated in the EVE group post-intervention than the Mindfulness group and the no-intervention control group. The thalamus is responsible for monitoring bottom-up sensory feedback; notably, it is involved in pain processing and awareness (including emotional arousal and discomfort; Nakata et al., 2014). Although a seemingly paradoxical finding, post-EVE thalamus activation could be explained by participants’ enhanced modulation of bottom-up emotional arousal signals while watching their performances. EVE’s focus on *engagement* with the environment and community (rather than simply *noticing* these things, as is done in mindfulness) may have strengthened its effects on the salience network.

EVE’s emphasis on community and vulnerability during singing practices may account for this group’s increased insula activation compared to the no-intervention group. The shared circuits hypothesis suggests that heightened activity in the insula is associated with both the acts of experiencing something firsthand and sharing others’ experience (Eisenberger et al., 2003; Laneri et al., 2017). Such activation can represent interoceptive awareness of physiological arousal or affective experience (typically negative) and is strongly influenced by inter-individual differences in empathy. Our findings are consistent with Laneri et al. (2017) who found that anterior insula activity increased among participants who completed a mindfulness intervention involving empathetic sharing for people's embarrassing moments. Similarly, in Young et al.'s (2018) meta-analysis, participants who completed eight-week mindfulness-based interventions showed increased insular cortex activity, potentially because mindfulness promoted present-moment internal awareness. Sharing with others through both vocal experiences and reflections may facilitate present-moment focus and reduce past- or future-focus during performance.

Focus on the body and breath may be especially targeted by EVE, which was revealed through the themes of bottom-up body and breath awareness (i.e., in response to environmental input) and top-down body and breath awareness (i.e., self-regulated). The EVE group exhibited increased activity in the cerebellum following the intervention, which is involved in body awareness. The cerebellum's neuronal circuitry encodes mental representations of body movement (Ito, 2008). EVE participants' increased activation in this region may have arisen from heightened bodily and proprioceptive awareness post-intervention. Similarly, the mindfulness group showed increased SMA activation post-intervention, which may have been driven by body focus as well (Lhomond et al., 2019). The EVE group also revealed increased left temporal pole activity compared to the no-intervention control group, an area that receives input from the auditory pathway and contributes to auditory memory processing (Córcoles-Parada et al., 2019). The EVE group's increased cerebellum and temporal pole activity may have been due to increased sensory engagement with their performances from baseline to post-intervention.

Overall, the EVE intervention appeared to produce the most substantial increases in neural activation associated with present moment awareness and emotional regulation. The mindfulness program seemed to hover between EVE and no intervention, with higher contrasts in neural activation revealed in the EVE versus no-intervention than EVE versus mindfulness.

EVE's and Mindfulness' Effects on Cognitive Processing During Working Memory

In the N-back task, when engaging cognitive processing involved in working memory, the EVE group showed increased activity in areas devoted to motor and sensory function (cerebellum, putamen, midbrain), action-feedback monitoring (middle temporal gyrus), and working memory (superior orbitofrontal gyrus) from pre- to post-intervention. These activation patterns suggest enhanced coordination in responding to stimuli as well as heightened attention to the perceptual nature of stimuli. In Emch et al.'s (2019) fMRI meta-analysis of studies on healthy participants aged 18 to 75, activation of frontal gyri was linked to improved response inhibition and attentional control. The EVE group's higher superior orbitofrontal gyrus activation during working memory post-intervention may reflect superior ability to respond quickly and appropriately to executive demands during the task. The cerebellum and putamen have shown involvement in enhancing motor behaviours and suppressing undesired ones (Alexander et al., 1986; Emch et al., 2019; Mink, 1996). Midbrain nuclei have also shown involvement in initiation of motor sequences (Boecker et al., 2008), as are required in the N-back task. Additionally, the middle temporal gyrus may play a role in action-feedback monitoring, where these gyri detect conflict (e.g., non-matching or incongruent stimuli in the 2-back condition; van Kemenade et al., 2019). Through enhanced executive control, attentional focus, and monitoring post-EVE, the EVE group may have better controlled and suppressed their actions during the N-back task than the other groups.

Interestingly, the EVE group showed less activity than the other groups in cognitive processing (middle cingulate gyrus) and visual areas (cuneus, fusiform, inferior occipital gyrus, and middle occipital gyrus). The mindfulness group also showed less activity in visual areas (bilateral cuneus, lingual gyrus, and superior occipital gyrus) than controls. The EVE group's reduced activity in cognitive processing regions indicates less cognitive strain during working memory performance than the mindfulness and control groups. Similarly, the mindfulness group's reduced activity compared to the control group suggests that the mindfulness intervention also reduced cognitive strain during the N-back. This is consistent with the mindfulness group's reduced reaction time compared to the other groups for both Press for X and Press for 2-back conditions at time 2. Mindfulness novices have been found to require more cognitive effort to sustain attention on stimuli. Repeated mindfulness practice, however, reduces the effort required to sustain attention from improved attentional control (e.g., shifting attention from the breath to monitoring internal and external sensations; Brefczynski-Lewis et al., 2007; Falcone & Jerram, 2018). For example, a three-day intensive mindfulness meditation course improved resting state functional connectivity between executive and attentional brain areas (e.g., dorsolateral prefrontal cortex and inferior frontal gyrus; Taren et al., 2017). Alterations in the functional connectivity of these regions were also observed during the 2-back condition of the N-back task (Koshino et al., 2005). Through several facets of present-moment awareness strengthening attentional resources and inhibitory control, the EVE and mindfulness groups required less cognitive effort during working memory performance, with the EVE group displaying the most substantial benefits. These cognitive benefits could translate well to the context of music performance, considering the importance of directing attention towards the performance and responding appropriately to the executive demands of playing the piece.

Strengths, Limitations, and Future Directions

The present study sheds light on the neurobiological impact of traditional mindfulness and EVE on MPA. This study has several strengths, the first being its use of an active control mindfulness intervention to compare with the EVE intervention, along with the no-intervention control group. Furthermore, the present study added to the limited literature on longitudinal influences of mindfulness interventions on MPA. The mindfulness and EVE intervention's two-week timeframe has also been shown to be a sufficiently long enough intervention period to produce beneficial effects on anxiety (Berghoff et al., 2017), as was exemplified in the present study's STAI and neuroimaging results. Additionally, the brief, cost-effective nature of these interventions makes them accessible to a wide range of people who experience MPA.

It is also important to note some key limitations. One limitation is the study's sample size. Considering that most studies of the neurophysiological effects of mindfulness interventions have had small sample sizes, it is important for future studies to employ such methods among larger samples. In this preliminary study (with the goal to investigate whether EVE acts similarly to a mindfulness type intervention), we found significant effects of group and time on brain activity, suggesting that EVE is rooted in mindfulness and may even surpass traditional mindfulness techniques. Therefore, EVE warrants further investigation in larger scale studies. Furthermore, the distribution of males and females in the EVE group was uneven with only one male and six females. While this study targeted the population that may benefit most strongly from EVE and mindfulness (females, who often show higher MPA; Iusca & Dafinoiu, 2012), future studies with an even sex distribution should investigate the general impacts of EVE interventions on MPA.

Another important limitation is that some EVE participants were not able to attend all 10 sessions. All attended at least six but in future studies, researchers should ensure that participants can attend all sessions. Additionally, some participants spoke more than others during the discussions, pre- and post-EVE sessions. The thematic analysis was focused on themes that emerged across multiple participants; however, insights from participants who spoke more may have skewed the themes. Participants in the mindfulness group did not have transcripts recorded, which presents a further limitation to the thematic findings. Relatedly, only the mindfulness group was instructed to refrain from other mindfulness activities throughout the duration of the intervention. To ensure greater comparability between the groups' mindfulness activities outside of the interventions (or lack thereof in the case of the passive control condition), future studies should instruct all groups to refrain from mindfulness activities external to the study (or refrain completely for the duration of the study, in the case of passive control participants). Future studies should follow the same protocol for EVE and mindfulness interventions, where discussions held at the beginnings and ends of sessions are transcribed. This procedure will provide a basis for further thematic comparisons of EVE and mindfulness groups.

There were some aspects of the Anxiety-Provoking Task that may be adjusted in future research. For example, the same piece of music was performed and filmed for the Anxiety-Provoking Task pre- and post-intervention. However, all participants had the same procedure, thus controlling for variability in most aspects of their music-making process and task completion. Similarly, viewing their own recordings of the same piece during each scan, despite them being continuous from their performance, may have yielded attenuated self-critical thoughts by the third presentation. It could also be argued that as participants watched more of the video, they may have picked up on various aspects of their performance, with more opportunities to feel self-critical. Future studies might choose to have participants play different pieces pre- and post-intervention, to potentially enhance the anxiety provocation. They may also provide different clips for each of the blocks being presented.

Furthermore, the present study only included musicians with MPA as participants. To understand more precisely how musicians benefit from EVE and mindfulness interventions compared to the general public (as well as people in other performance-intensive professions), future studies should examine these effects among musicians (with and without MPA), people in other performing disciplines (with and without performance anxiety), as well as participants from the general public (e.g., healthy adults matched to the other groups for age and sex). Lastly, we only examined young adults in the present study. Despite MPA being most prevalent among young adults and adolescents, future studies should examine the effects of EVE and mindfulness on MPA in participants of various age groups, furthering our understanding of how such effects manifest across the lifespan. Finally, in our preliminary investigation of EVE, it is important to note that these sessions were carried out by the music therapist who developed the intervention. Future studies should investigate the replicability of the EVE protocol to see if EVE sessions conducted by other music therapists (trained on this protocol) have the same effects as those shown in the present study.

Conclusion

Both neuroimaging and qualitative evidence reveal that EVE may be a valuable intervention to implement into the lives of musicians experiencing MPA. Our findings exhibit that the EVE intervention may, through both internal and external aspects of present-moment awareness, be as effective or even more effective than mindfulness in influencing brain activity. When participants with MPA watched videos of themselves performing with their instruments (compared to watching videos of another person performing with their own instrument), the EVE group showed increased activation in brain regions associated with emotional processing, attention, self-awareness, empathy, and executive control. EVE also may surpass mindfulness in reducing the cognitive effort needed to complete a working memory task. Based on both thematic analysis and neuroimaging results, EVE may exert its cognitive and emotional effects through focused attention and open monitoring that were drawn upon in the EVE intervention. While traditional mindfulness training also revealed several similar neural effects to those of EVE, mindfulness appears to hover between EVE and the no-intervention control condition in exerting such effects on emotional and cognitive processing during tasks. Through improved present-moment engagement with internal processes, the environment, and the community, EVE is an accessible, cost-effective method that could be applied as a mindfulness-type intervention for alleviating MPA. We all enjoy music, so why not try to ensure the musicians enjoy creating it.

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The authors have no known conflicts of interest to disclose.

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Kayla Boileau: Kayla Boileau, a researcher with over 10 years of experience, has a PhD in Experimental Psychology from the University of Ottawa. Her PhD research focused on how brief mindfulness training influenced the neural activity of musicians with music performance anxiety using functional magnetic resonance imaging (fMRI) technology. Her current research role focuses on the wellbeing—including the social, physical, emotional, spiritual, and mental wellbeing—of First Nations people and communities. In her current research position, she engages with First Nations across Turtle Island, providing her expertise in statistics, psychological research, and neurophysiological research across various projects.

Nicola Oddy: Nicola Oddy, PhD, MTA has had a long career as a certified music therapist in Canada, providing front line services to people in long-term care, schools, and day programs. She has taught at both Concordia and Carleton universities and for two decades, provided supervision for both students and professionals. She is currently a member of the University of Ottawa Music and Health Research Institute, engaged in committee work and research. She has used the voice as her primary tool during all her years of practice, and her research interest explores how singing in different places effects people's perceptions of self and place.

Laurie-Ann Welch: Laurie-Ann Welch graduated with a Bachelor of Arts in psychology (with honours) from the University of Ottawa. Her research interests and experience span from neurocognitive disorders, notably Alzheimer's Disease, to trauma and anxiety disorders. She particularly appreciates working with a variety of neuroimaging techniques, notably functional Magnetic Resonance Imaging (fMRI). She aspires to pursue a career in medical imaging to complement her future research endeavors.

Nicole Stanson: Nicole Stanson is a researcher with a passion for the cross-sectional domain of music and health. Having received degrees in both music performance and interdisciplinary music research, Nicole strives to bring insights from both her fields of expertise to her work. After completing her undergraduate degree in music performance from Acadia University, her studies brought her to the University of Ottawa where she completed a master's in trumpet performance and a second master's researching the impacts of mindfulness on music performance anxiety. In 2019, Nicole joined the Music and Health Research Institute where she continues to contribute to the field of musicians' mental health research, and investigates the health outcomes of music interventions on a variety of populations.

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