Article

MUSICÆ SCIENTIÆ

Musicae Scientiae
2025, Vol. 29(2) 279–313

DOI: 10.1177/10298649241290448
journals.sagepub.com/home/msx
Sage

Psychological interventions for the self-regulated enhancement of music performance: A systematic review

Veronika J. Lubert
University of Vienna, Austria

Peter Gröpel
University of Vienna, Austria

Abstract

Psychological interventions to enhance musicians' self-regulation are increasingly being recognized as essential for supporting them in their development and optimization of performance skills. The aim of this review was to provide a synthesis of such interventions and examine their effects on expert-rated music performance quality. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol, we initially identified 3,182 articles, of which we selected 89 studies. Using the theoretical framework of self-regulated learning, we present a comprehensive overview of experimental, quasi-experimental, and single-case studies published until April 2022 that tested how musicians can improve their performance through self-regulation strategies such as goal setting, imagery, attention focusing, relaxation, and self-evaluation. The results show mixed evidence with mostly positive or non-significant effects, indicating that expressive writing, external focus, feedback, combined electromyographic (EMG) and electroencephalographic (EEG) biofeedback, and imagery combined with physical practice can increase expert-rated music performance quality. The reported methodological quality, the applied performance task and evaluation, and potential mechanisms underlying the interventions should be considered when interpreting the results. We critically discuss possible improvements for future studies, as well as practical implications.

Keywords

musician, psychological skills, performance enhancement, self-regulation, self-regulated learning

Corresponding author:
Veronika J. Lubert, Division of Sport Psychology, Centre for Sport Science and University Sports, University of Vienna, Auf der Schmelz 6a, Vienna 1150, Austria.
Email: veronika.lubert@univie.ac.at

Musicians face high expectations and undertake great efforts in striving for expertise and excellence (Ericsson et al., 1993). Knowledge of the repertoire and the development of technical and musical skills are usually emphasized when students aspiring to be professional musicians are taught how to prepare for performance (Gaunt & Westerlund, 2016; Simones, 2017), rather than psychological considerations and an understanding of what leads to excellence (Pecen et al., 2016). However, psychological skills and the capacity to self-regulate, for example, in order to improve the quality of individual practice, to cope with performance anxiety, or to experience flow, are being increasingly recognized in their importance for optimal performance and have thus received more attention in recent years (Mornell et al., 2020; Nordin-Bates, 2012). Psychological interventions to support musicians in self-regulating and reaching their optimal performance are needed at different levels of expertise but may also require encouragement for take-up (Pecen et al., 2018). The aim of this review was thus to explore the effects of such psychological interventions and provide a synthesis of what has been done so far to enhance music performance through self-regulation skills.

This review is embedded in the theoretical framework of self-regulated learning (SRL). SRL is a multifaceted, social psychological construct that was originally defined in an academic context as the management of one's own learning in a metacognitive, motivational, and behavioral way (Zimmerman, 1986). Whereas research on peak performance has described the successful application of self-regulatory processes by several expert musicians, athletes, and writers as exemplars, research on SRL has predominantly focused on academic learning (Zimmerman, 1998). Where SRL has been investigated in music education, participants tend to be school-aged rather than (aspiring) professional musicians (McPherson & Zimmerman, 2002, 2011), so SRL has therefore been considered to be in contrast with expertise-oriented models such as deliberate practice (e.g., Ericsson et al., 1993). SRL is grounded in social cognitive theory, based on the idea that musicians need self-observation, self-judgment, and self-reaction to manage the interactions between their person, behavior, and environment; it has informed a substantial number of studies in music education research (McPherson et al., 2019). The theoretical lens of SRL has also been used to investigate how musicians improve their performance by regulating their thoughts, attentional resources, emotions, arousal, and behavior (Hatfield, 2016; McPherson & Zimmerman, 2011). In the model of SRL proposed by Zimmerman (2000), the development of the ability to perform well is conceptualized as a cyclical process in which the performer plans to carry out a task, monitors their performance, and then reflects on the outcome. Accordingly, the model distinguishes three reciprocal phases: forethought, performance, and self-reflection (Figure 1).

In the *forethought* phase of preparation for performance, musicians carry out a task analysis, which includes the processes of goal setting and strategic planning. Their beliefs about self-motivation, particularly self-efficacy, underlie these processes and also play an important role. In the *performance* phase, musicians need to exert volitional control through self-control and self-observation. Self-control includes self-instruction, imagery, attention focusing, and task strategies for optimal task focus and effort; self-observation refers to monitoring specific aspects, surrounding conditions, and effects of one's own performance. Finally, in the *self-reflection* phase, musicians evaluate the outcomes of their performance, make causal attributions, and compare information gained through self-monitoring with previously set goals or standards. These self-evaluative processes then lead to self-reactions, such as self-satisfaction and adaptive inferences (Hatfield et al., 2017; Zimmerman, 2000).

A large body of previous research on SRL consists of descriptive studies of developing approaches to music practice and focuses on beginning and intermediate music students' self-reports of SRL tendencies (Miksza et al., 2018). A systematic review of studies published until

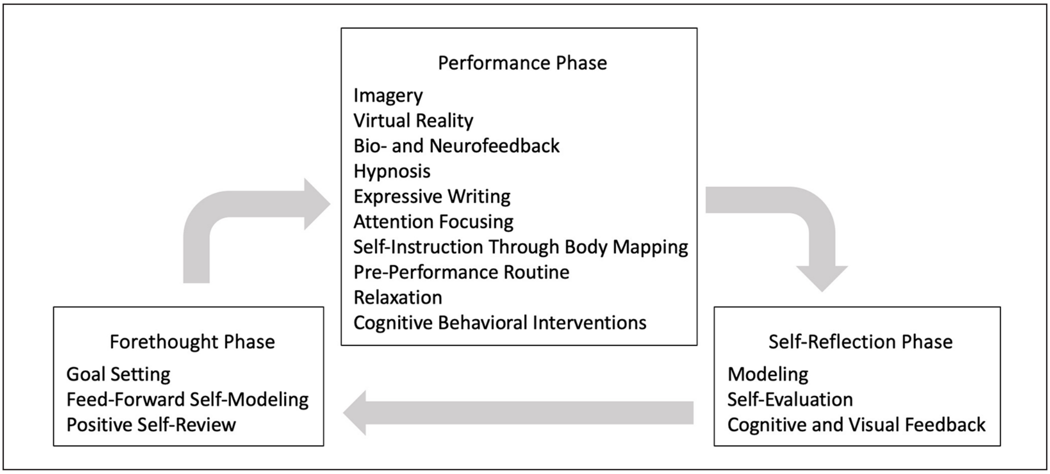

Figure 1. Classification of psychological interventions based on Zimmerman's (2000) model of self-regulated learning and its adaptation by Hatfield et al. (2017).

2011, which investigated music students' self-regulation during music practice based on Zimmerman's SRL model, revealed positive but weak relationships between self-regulatory processes and musical attainment, persistence, amount, content, and efficiency of practice (Varela et al., 2016). Notably, interventions using self-regulation instructions were most strongly correlated with SRL. Such interventions may be aimed at maintaining concentration and persistence, adapting suitable strategies, planning and managing one's time, enhancing one's behavior and environment, and connecting socially in the interests of learning to play a musical instrument (McPherson et al., 2013).

Psychological interventions can generally be defined as "any actions or processes that alter functioning and/or performance through changes in an individual's thought and behavior" (Brown & Fletcher, 2017, p. 78). In this review, we look at psychological interventions including, but also going beyond the typical components of psychological skills training (PST), goal setting, arousal regulation, attentional control, self-talk, and imagery (Hatfield, 2016). Psychological interventions can thus be aimed at optimizing task analysis and self-motivation beliefs during preparation, reaching an optimal physical and mental state immediately before and during performance, and enhancing the musician's self-assessment, self-reaction, and perception of progress. To identify and categorize the interventions, we also took an adaptation of Zimmerman's (2000) model of SRL for higher music education into account, which explicitly refers to psychological skills in the context of SRL (Hatfield et al., 2017; see also Figure S1 in the Supplemental Material). Notably, according to this adaptation, the psychological skills of imagery, concentration, arousal regulation, self-observation, and self-control all belong to the performance phase of the model.

Existing systematic reviews of psychological interventions in music have been focused on the (clinical) treatment or reduction of music performance anxiety (MPA; Brugués, 2011; Burin & Osório, 2016, 2017; Fernholz et al., 2019; Finch & Moscovitch, 2016; Kenny, 2005); on Alexander Technique (AT), a combination of psychophysical methods (Klein et al., 2014); or on PST transferred from sports to music (Ford & Arvinen-Barrow, 2019). While some of the studies included in these reviews also measured performance quality, the impact of psychological interventions on the quality of music performance has not yet been systematically reviewed.

In the present review, we, therefore, aimed to include studies of psychological interventions using SRL for the purposes of improving quality of music performance rather than skill acquisition by beginner musicians. Ultimately, SRL comprises self-directed processes that enable a musician to transform their mental abilities (e.g., to recall music) into performance skills (e.g., performing a piece from memory; Osborne et al., 2021; Zimmerman, 2008). Therefore, while previous research on SRL often focused on the quality of these self-directed processes (Osborne et al., 2021), we focused on performance quality as the result of successfully transforming these processes into performance skills. Importantly, we thus investigated the enhancement of skilled individuals' performance rather than skill acquisition by novices without prior musical training. Furthermore, while SRL is often measured using self-report questionnaires, we selected studies in which performance quality was evaluated by experts or audience members rather than by the musicians themselves.

The objective of the present review was to provide a comprehensive overview of studies published until April 2022 explicitly testing musicians' use of self-regulation strategies to improve their performance. These strategies are not just aimed at reducing performance anxiety but also for training attentional focus, arousal control, mental practice and imagery, and the use of visual, cognitive, or peer feedback. We asked the following research question: What is the impact of interventions designed to enhance self-regulation on the quality of musicians' performance? To answer this question, we did not only consider the findings of the studies we included in the review but also their methodological approaches and the methods that were used. In this way, we hoped to gain an understanding of how the effectiveness of psychological interventions has been investigated in the field of music performance to date, and how they can be classified according to the SRL framework.

Method

We followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA; Moher et al., 2009) and specified inclusion criteria and methods of analysis in an advance protocol (PRISMA-P; Shamseer et al., 2015).

Inclusion criteria

To be included, studies had to meet all the following inclusion criteria: (a) employ a psychological (non-pharmacologic) intervention for self-regulation skills to enhance music performance; (b) implement an artistic music performance task; (c) assess performance quality through either expert or audience evaluations, or objective measures such as statistical analysis of MIDI recordings; (d) include skilled individuals or trained novices; (e) compare participants' individual performances before and after the intervention (i.e., pre-test–post-test or multiple baseline design); and (f) include quantitative measurements of the performance outcome. We therefore excluded intervention studies focused on improving the process of learning or practice rather than performance, or using non-artistic performance tasks (e.g., selecting intervals via a computer keyboard). In the interests of comparability between studies, we excluded those evaluating ensemble but not individual performance, and studies in which the samples consisted of untrained novices, musicians with clinical conditions, or a combination of musicians and non-musicians. Finally, we only included reports of empirical studies written in the languages in which we are fluent: English or German.

Search strategy

We conducted a comprehensive literature search on the databases PsycINFO (1880 to present), Scopus (1788 to present), ProQuest Music Periodicals Database (1874 to present), ProQuest Performing Arts Periodicals Database (1864 to present), ProQuest Dissertations & Theses Global (1861 to present), SPORTDiscus (1970 to present), and Web of Science (1898 to present). We used the following keyword combinations: *"music* performance"* AND *intervention* OR *training* OR *enhance** OR *improve**. In addition, we hand-searched (a) the reference lists of previous meta-analytic, systematic, and narrative reviews; (b) volumes of relevant journals (e.g., *Psychology of Music*); and (c) pertinent articles for any unidentified studies. We explicitly included unpublished studies as reported in master's and doctoral dissertations to counteract publication bias (Thornton & Lee, 2000).

Study selection and data extraction

Study selection was performed in two steps. First, after having removed duplicates, the first author screened titles and abstracts and excluded irrelevant records that clearly did not meet the criteria. Second, we independently assessed the full-text versions of the remaining 154 records for eligibility, then discussed divergent results and agreed whether to include or exclude the respective studies. We developed and pilot-tested a data extraction form and extracted the following characteristics from each study: (a) authors; (b) publication date; (c) mean age of sample; (d) size of sample; (e) participant characteristics (gender, instrument, level of expertise); (f) study design; (g) performance measure(s); (h) performance task; (i) intervention used; and (j) key findings. After the first author had extracted these characteristics for each included study, the second author reviewed the extraction form. Amendments were made to keep the resulting tables as concise as possible. Throughout the review process, we were aware of author(s), institution(s), and journal title.

Quality assessment

We assessed methodological quality and risk of bias of each selected study with Version 2018 of the Mixed Methods Appraisal Tool (MMAT; Hong et al., 2018). The MMAT has previously been used effectively in other systematic reviews of literature on the psychology of performing artists (Willis et al., 2019). In the present review, eligible studies included randomized controlled trials (experiments), non-randomized controlled trials (quasi-experiments), or case reports (single-case studies). To follow the recommendation by Hong et al. (2018) of a detailed presentation of the ratings of each criterion, while also providing a concise overview, we conceived a coding scheme according to the number and kinds of criteria that were met (see Table 1). For randomized controlled trials, we assessed randomization, comparability of groups at baseline, allocation concealment, and drop-out rate, using a total score from 25% (one criterion met) to 100% (all four criteria met). For non-randomized controlled trials, we assessed participant selection, measurements, and drop-out rate, as well as design and analysis, again using a total score from 25% (one criterion met) to 100% (all four criteria met). For case reports, we assessed sampling, selection, and appropriate measurements; risk of bias; and analysis, resulting in a total score from 20% (one criterion met) to 100% (all five criteria met). Criteria relevant only to clinical studies were not considered in the assessment.

Table 1. Summary of included studies.

Reference	Design	Participants	Sample size (female)	Age (years)	Level of expertise	Quality assessment
Allingham and Wöllner (2022)	Experimental	Violinists/violists and instrumentalists	32 (18)	25.0	Mixed	3a
Allingham et al. (2021)	Experimental	Violinists/violists and instrumentalists	32 (18)	25.0	Mixed	3a
Appel (1976)	Experimental	Pianists (mixed majors)	29 (22)	20–61	University	1b
Atkins (2017)	Experimental	Trained singers (mixed majors)	20 (12)	21.0	University	2a
Atkins (2018)	Experimental	Vocal students	11 (6)	20.0	University	2a
Bazanova and Shtark (2007)	Quasi-experimental	Music performance majors	29 (16)	22.3	University	2d
Bernardi et al. (2013)	Experimental	Pianists	16 (10)	30.5	Professional	2b
Bissonnette et al. (2015)	Experimental	Piano and guitar majors	17 (10)	21.7	University	3a
Braden et al. (2015)	Quasi-experimental	Instrumental students	62 (62)	13.8	Secondary school	3c
Brandmeyer et al. (2011)	Experimental	Percussion majors	18 (NR)	22.4	University	1b
Brooker (2018)	Experimental	Pianists	46 (29)	NR	Mixed	1b
Broomhead (2010)	Experimental	Choir singers (mixed majors)	86 (NR)	NR	University	3a
Broomhead et al. (2012)	Experimental	Choir singers	155 (NR)	NR	Secondary school	3a
Broomhead et al. (2018)	Experimental	Choir singers	132 (NR)	NR	Secondary school	1c
Christakou et al. (2019)	Single-case	Pianist	1 (1)	17.0	Amateur	4
Coffman (1990)	Experimental	Music education/therapy majors	80 (40)	23.1	University	3a
Cohen and Bodner (2019)	Quasi-experimental	Music therapy majors	24 (19)	30.5	University	3c
Crawford (2011)	Experimental	Music majors	16 (10)	NR	University	3a
Currie (2001)	Experimental	Music majors	35 (18)	NR	University	1b
Davies (2020)	Quasi-experimental	Music performance majors	14 (11)	20.2	University	3c
Dennis (1987)	Experimental	Wind instrumentalists	13 (8)	20–33	NR	1b
Duke et al. (2011)	Experimental	Music majors	16 (8)	NR	University	2b
Egner and Gruzelier (2003, Study 1)	Experimental	Music majors	36 (22)	20.9	University	2c
Egner and Gruzelier (2003, Study 2)	Experimental	Music majors	61 (43)	23.1	University	2c

(Continued)

Table 1. (Continued)

Reference	Design	Participants	Sample size (female)	Age (years)	Level of expertise	Quality assessment
Engelhart (1989)	Quasi-experimental	Voice students (other majors)	24 (18)	20.1	University	4
Gill (2020, Study 2)	Quasi-experimental	Music students	1. 9 (7) 2. 26 (18)	1. 15.1 2. 16.8/15.3	Secondary school	2e
Gill (2020, Study 3)	Quasi-experimental	Music students	31 (22)	14.9	Secondary school	2e
Gill (2020, Study 4)	Experimental	Music students	72 (37)	16.2	Secondary school	4
Gruzelier et al. (2014b)	Experimental	Instrumentalists	24 (10)	26.0	Mixed	2c
Gruzelier et al. (2014a)	Experimental	Instrumentalists	19 (7)	24.0	Mixed	2c
Hewitt (2001)	Experimental	Wind and percussion students	82 (NR)	NR	Secondary school	1b
Hewitt (2011)	Quasi-experimental	Wind and percussion students	211 (112)	NR	Secondary school	3c
Highben and Palmer (2004)	Experimental	Pianists	16 (NR)	NR	University to professional	1b
Higuchi et al. (2011)	Quasi-experimental	Pianists	9 (NR)	25.1	University	3c
Hoffman and Hanrahan (2012)	Experimental	Musicians	33 (29)	42.1	Mixed	3a
Iorio et al. (2022)	Quasi-experimental	Guitar performance majors	26 (4)	24.0	University	4
Juncos and Markman (2016)	Single-case	Violin education major	1 woman	NR	University	4
Juncos et al. (2017)	Quasi-experimental	Vocal students	7 (6)	23.3	University	3c
Juslin and Laukka (2000)	Experimental	Guitarists	8 (0)	22.1	Amateur	2b
Juslin et al. (2006, Study 1)	Experimental	Guitarists	36 (1)	28.0	Semi-professional	1b
Kageyama (2007)	Experimental	Music performance majors	21 (13)	19.6	University	3b
Kendrick et al. (1982)	Experimental	Pianists	53 (48)	18.8	Mixed	3a
Kenny and Halls (2018)	Quasi-experimental	Community musicians	68 (45)	44.5	Mixed	4
Kjelland (1985, Case 1)	Single-case	Cellist	NR	NR	University	4
Kjelland (1985, Case 2)	Single-case	Cellist	NR	NR	University	4
Kjelland (1985, Case 3)	Single-case	Cellist	NR	NR	University	4
Kjelland (1985, Case 4)	Single-case	Cellist	NR	NR	University	4
Kjelland (1985, Case 5)	Single-case	Cellist	NR	NR	University	4
Kjelland (1985, Case 6)	Single-case	Cellist	NR	NR	University	4

(Continued)

Table 1. (Continued)

Reference	Design	Participants	Sample size (female)	Age (years)	Level of expertise	Quality assessment
Kjelland (1985, Case 7)	Single-case	Cellist	NR	NR	University	4
Lim and Lippman (1991	Experimental	Piano majors	7 (NR)	NR	University	2b
Lubert and Gröpel (2022)	Experimental	Violinists and violists	46 (37)	26.3	University	4
Lund (1972)	Experimental	Band students	12 (9)	16.5	Secondary school	3b
Markovska-Simoska et al. (2008)	Experimental	Violin and viola majors	12 (9)	20.0	University	2c
MacAfee and Comeau (2020, Case 1)	Single-case	Piano student	1 female	15	Conservatory	4
MacAfee and Comeau (2020, Case 2)	Single-case	Piano student	1 female	12	Conservatory	4
MacAfee and Comeau (2020, Case 3)	Single-case	Piano student	1 male	14	Conservatory	4
MacAfee and Comeau (2020, Case 4)	Single-case	Piano student	1 female	16	Conservatory	4
MacAfee and Comeau (2020, Case 5)	Single-case	Piano student	1 male	14	Conservatory	4
Miksza (2015)	Experimental	Wind-instrument majors	28 (13)	20.0	University	2b
Montello et al. (1990, Study 2)	Quasi-experimental	Musicians	24 (NR)	28.0	Professional	3d
Moody (2014)	Experimental	Violin and cello students	12 (9)	16.0	Amateur	2b
Moorcroft (2011, Study 1)	Experimental	Singers	6 (6)	28.8	University to professional	2b
Morasky et al. (1983)	Quasi-experimental	Clarinetists	8 (NR)	23.6	University to professional	3c
Mornell and Wulf (2019, Study 1)	Experimental	Music performance/education majors	23 (17)	25.8	University	2c
Mornell and Wulf (2019, Study 2)	Experimental	Music performance/education majors	18 (8)	23.9	University	2c
Ornoy and Cohen (2021	Experimental	Music education majors	55 (35)	29.2	University	1a

(Continued)

Table 1. (Continued)

Reference	Design	Participants	Sample size (female)	Age (years)	Level of expertise	Quality assessment
Osborne et al. (2007)	Experimental	Music students	23 (14)	13.9	Conservatory	1a
Plott (1986)	Quasi-experimental	Piano majors	7 (4)	NR	University	3c
Richard (1992)	Experimental	Music majors	21 (12)	20.4	University	1b
Roland (1993, Study 1)	Experimental	Piano majors	25 (22)	18.4	University	2b
Roland (1993, Study 3)	Experimental	Musicians	33 (29)	24.7	University to professional	2b
Ross (1985)	Experimental	Trombone majors	30 (1)	NR	University	1a
Slade et al. (2020)	Quasi-experimental	Piano majors	38 (29)	26.4	University	3c
Spahn et al. (2016)	Quasi-experimental	String-instrument majors	21 (14)	22.1	University	3c
Stambaugh (2017)	Experimental	Music majors (woodwind players/ instrumentalists)	30 (13)	20.0	University	3a
Stambaugh (2019)	Experimental	Band students	57 (NR)	12.4	Secondary school	3a
Steenstrup et al. (2021)	Experimental	Trumpet players	50 (11)	23.0	University	4
Sweeney-Burton (1997)	Quasi-experimental	Violin minors	30 (NR)	NR	University	3c
Sweeney and Horan (1982)	Experimental	Piano majors	49 (24)	NR	University	3a
Tang and Ryan (2020)	Experimental	Piano majors/minors	35 (NR)	20.9	University	2b
Theiler and Lippman (1995)	Experimental	Voice and guitar majors	14 (NR)	19–29	University	3a
Tief and Gröpel (2021)	Experimental	Violin majors	30 (26)	23.6	University	4
Timmers et al. (2012)	Experimental	Conservatory students	24 (NR)	24.3	University	2b
Valentine et al. (1995)	Experimental	Music performance majors	25 (21)	20.9	University	3a
Van McKinney (1984)	Quasi-experimental	Wind-instrument majors	32 (0)	NR	University	3c
Van Zijl and Luck (2013)	Quasi-experimental	Violinists	8 (8)	24.3	Mixed	3c
Wardle (1974)	Experimental	Brass instrumentalists	30 (0)	NR	University	2b
Williams (2019, Study 1)	Quasi-experimental	Natural trumpet minors	7 (2)	30.6	University	3c

Note: NR = not reported; quality assessment of experimental studies: one criterion fulfilled (25%)—1a = only met comparable baseline, 1b = only met complete outcome data, 1c = only met blinded evaluation; two criteria fulfilled (50%)—2a = met randomization and complete outcome data, 2b = met comparable baseline and complete outcome data, 2c = met complete outcome data and blinded evaluation; three criteria fulfilled (75%)—3a = met all criteria except randomization, 3b = met all criteria except blinded evaluation; four criteria fulfilled (100%)—4; quality assessment of quasi-experimental studies: two criteria fulfilled (50%)—2d = met representativeness and complete outcome data, 2e = met representativeness and appropriate measurement; three criteria fulfilled (75%)—3c = met all criteria except accounting for confounders, 3d = met all criteria except complete outcome data; four criteria fulfilled (100%)—4; quality assessment of single-case studies: five criteria fulfilled (100%)—4.

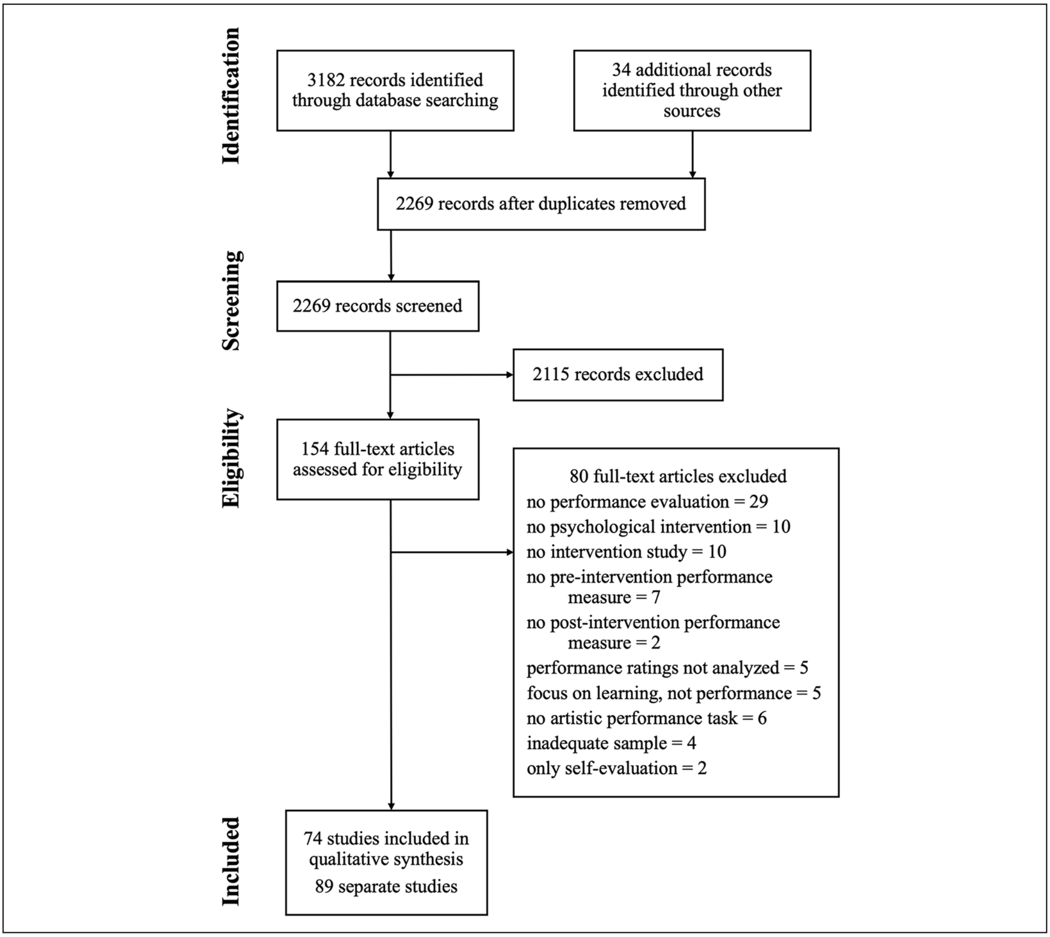

Figure 2. PRISMA chart for study inclusion adapted from the work of Moher et al. (2009).

Results

We found 3,182 records in the initial database search and identified an additional 34 records through the additional sources listed above. After removing duplicates and dissertations also published as journal articles, we reduced the initial results to 154 records by screening titles and abstracts. Seventy-four articles (61 journal articles and 13 dissertations) with $K = 89$ separate intervention studies met all inclusion criteria and were included in the final qualitative synthesis (Figure 2). We considered the studies (K) as the unit of analysis as all studies, also those in the multi-study articles, were based on independent samples. Sample characteristics, research design, and methodological quality are summarized in Table 1, and performance task, type of intervention, and key findings are summarized in Table 2.

Characteristics of samples

Regarding sample size, 14 studies (16%) were single-participant studies, 63 studies (71%) included between six and 50 participants, nine studies (10%) included between 51 and 90

Table 2. Summary of study results.

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Allingham and Wöllner (2022)	Bowing task	Attentional focus (internal, external, somatic)	P	Experts made significantly more errors when focusing on arm movement compared to focusing on string resistance. There was no significant effect for novices.
Allingham et al. (2021)	Bowing task	Attentional focus (internal, external, somatic)	P	Performance was most improved with a somatic focus, compared to an external or internal focus.
Appel (1976)	Piece	Systematic desensitization	P	Systematic desensitization and music analysis interventions led to significantly reduced performance errors when compared to a no-intervention control group.
Atkins (2017)	Vowels, song, piece	Attentional focus (internal, external)	P	Tone quality was better in external than internal focus conditions.
Atkins (2018)	Sequence, piece	Attentional focus (internal, external)	P	Tone quality was better in external than internal focus conditions.
Bazanova and Shtark (2007	Piece	EEG/EMG-Biofeedback	P	Performance was better with biofeedback than with standard practice.
Bernardi et al. (2013)	Arpeggio sequence	Mental/physical practice	P	Both mental and physical practice led to greater accuracy than no practice, with a stronger and sooner effect of physical practice.
Bissonnette et al. (2015)	Memorized piece	Virtual reality (VR) training	P	VR exposure resulted in a significant increase in performance quality when compared to a no-intervention control group.
Braden et al. (2015)	Piece	CBI	F, P, S	CBI had no effect on performance quality when compared to a no-intervention control group.
Brandmeyer et al. (2011)	Imitation of 2 standard beat patterns	Visual feedback	P	Neither form of feedback led to significantly smaller timing and dynamics errors. Compared to low-level feedback on timing and dynamics and no feedback, high-level feedback on expressive style resulted in better imitation of expressive performances.
Brooker (2018)	Piece	Cognitive hypnotherapy; EMDR	P	Both cognitive hypnotherapy and EMDR equally led to significantly improved performance when compared to a no-intervention control group.
Broomhead (2010)	Song	PPR	P	Both PPR intervention groups improved expressive performance at post-test when compared to a no-intervention control group. At follow-up, participants who received a reminder intervention performed worse than those who had only received the primary intervention.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Broomhead et al. (2012)	Song	PPR	P	Compared to the no-intervention control period, the PPR intervention had a significant positive effect on expressive performance at post-test but not at follow-up.
Broomhead et al. (2018)	Song	PPR	P	Compared to the no-intervention control period, the PPR intervention had a significant positive effect on expressive performance at post-test and follow-up.
Christakou et al. (2019)	Memorized piece	Motor imagery	P	There was a significant reduction in performance after no practice, but the motor imagery intervention appeared to help maintain the performance level.
Coffman (1990)	Sight-read/perform piece	Mental practice	P	Compared to no-practice control, all three practice modes (physical only, mental only, alternating both) improved performance. Physical only and alternating practice were equally superior to mental only.
Cohen and Bodner (2019)	Piece	PST	F, P, S	After PST, participants showed significant improvements in performance quality compared to waitlist control participants.
Crawford (2011)	Piece	Virtual reality training	P	There were no significant effects on performance quality.
Currie (2001)	NR	Coping skills seminar	F, P	There were no significant differences between the coping skills group and the behavioral exposure group.
Davies (2020)	3 excerpts	Alexander Technique	P	There were positive changes in tonal resonance, instrumental technique, and movement quality.
Dennis (1987)	Excerpt	Alexander Technique	P	There were no significant differences in performance between the Alexander Technique group and the no-intervention control group.
Duke et al. (2011)	Sequence on keyboard	Attentional focus (internal, external)	P	Performance was most accurate and generalizable with external than internal focus; the more distal the focus was, the more accurate was the motor control.
Egner and Gruzelier (2003, Study 1)	2 pieces	Neurofeedback (SMR, beta1, alpha/theta); physical exercise, PST	P	Participants on neurofeedback protocols significantly improved performance quality compared to participants doing PST and physical exercise and to control participants receiving no intervention. Whereas neither SMR nor beta1 learning co-varied significantly with performance change, alpha/theta learning success correlated significantly with improvements on 10 out of 12 performance criteria.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Egner and Gruzelier (2003, Study 2)	2 pieces	Neurofeedback (SMR; beta1; alpha/theta); physical exercise; PST; Alexander Technique	P	Only the alpha/theta group improved performance significantly, whereas neither SMR, beta1, physical exercise, PST, nor Alexander Technique groups exhibited any post-training performance changes.
Engelhart (1989)	Excerpt	Alexander Technique; body awareness; vocalization	P	Groups did not differ significantly regarding pre- to post-change scores, but vocalization resulted in a negative change in performance.
Gill (2020, Study 2)	Piece	PST	F, P, S	Self-evaluation and teacher evaluations increased from pre- to post-intervention.
Gill (2020, Study 3)	Piece	PST	F, P, S	Self- and teacher evaluations increased from pre- to post-intervention compared to a no-intervention control group.
Gill (2020, Study 4)	NR	PST	F, P, S	Both intervention and control groups increased their performance quality; between-group differences were non-significant.
Gruzelier et al. (2014b)	Excerpts; improvisation	Neurofeedback (alpha/theta; SMR)	P	There were no significant effects.
Gruzelier et al. (2014a)	Excerpts, piece, improvisation	Neurofeedback (alpha/theta; SMR)	P	There were no significant effects.
Hewitt (2001)	Etude	Combinations of modeling, self-listening, and self-evaluation	S	Modeling resulted in improvements in 6 out of 8 criteria of performance quality; modeling during self-evaluation led to more improvement in 5 out of 8 criteria.
Hewitt (2011)	3 pieces	Self-evaluation	S	Instruction in self-evaluation had little impact on music performance; all intervention groups improved similarly.
Highben and Palmer (2004)	4 sequences	Mental practice	P	There were significant effects of both motor and auditory feedback during practice; pianists with strong aural skills were least affected in memory tests by removal of auditory feedback during practice.
Higuchi et al. (2011)	Excerpt	Attentional focus (cognitive/affective)	P	More left hand note errors occurred in cognitive than affective performances, but more wrong notes occurred in affective than in cognitive performances.
Hoffman and Hanrahan (2012)	Piece	CR + imagery	P, S	Participants performed significantly better after the intervention, while waitlist-control participants performed significantly worse.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Iorio et al. (2022)	Memorized piece	Mental practice	P	The combination of MP and PP improved performance at post-test and follow-up when compared with PP alone.
Juncos and Markman (2016)	Piece	ACT	P	Performance improvement from 3 to 5 (on a scale from 1 to 5).
Juncos et al. (2017)	4 pieces	ACT	P	There was a significant performance improvement after the intervention but insufficient agreement between jurors.
Juslin and Laukka (2000)	Emotional expression in 3 songs	Cognitive feedback	S	Compared to a waitlist control group, cognitive feedback increased communication accuracy.
Juslin et al. (2006, Study 1)	Emotional expression in song	Feedback from computer program and/or music teachers	S	The computer program resulted in the greatest improvement in communication accuracy.
Kageyama (2007)	Excerpt	Attention control training; arousal control training	P	There were no significant differences between intervention groups and the no-intervention control group.
Kendrick et al. (1982)	Piece	Attentional training; behavior rehearsal	P	The three groups did not differ between pre- and post-test, but at follow-up, both attentional training and behavior rehearsal groups equally showed better performance quality than the wait-list control group.
Kenny and Halls (2018)	Piece	CBI; anxiety sensitivity reduction	P	All participants showed improved performance quality across 4 performances; CBT participants performed at similar levels at performance 3 and 4, while ASR further improved at performance 4 (follow-up).
Kjelland (1985, Case 1)	4 memorized excerpts	EMG biofeedback	P	On a scale from 1 to 5, where 3 meant no change in performance quality, 1 meant much worse, and 5 meant much better, performance improved by 0.7 points after the intervention.
Kjelland (1985, Case 2)	4 memorized excerpts	Focus on relaxed shoulders	P	Performance decreased by 1.1 points after the intervention.
Kjelland (1985, Case 3)	4 memorized excerpts	EMG biofeedback	P	Performance increased by 0.8 points after the intervention.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Kjelland (1985, Case 4)	4 memorized excerpts	EMG biofeedback	P	Performance increased by 0.4 points after the intervention.
Kjelland (1985, Case 5)	4 memorized excerpts	EMG biofeedback	P	Performance increased by 1.2 points after the intervention.
Kjelland (1985, Case 6)	4 memorized excerpts	Focus on relaxed shoulders	P	Performance decreased by 0.7 points after the intervention.
Kjelland (1985, Case 7)	4 memorized excerpts	EMG biofeedback	P	Performance increased by 0.1 points after the intervention.
Lim and Lippman (1991)	6 memorized excerpts	Mental practice	P	Physical practice led to the best performance compared to mental practice conditions.
Lubert and Gröpel (2022)	Excerpts	PPR; goal-setting	F; P	There were no significant differences in performance quality.
Lund (1972)	Sight-reading exercise	Insight therapy; systematic desensitization; relaxation	P	At follow-up, there were significant improvements in performance quality for groups doing insight and desensitization, and an improvement in performance errors for the insight group.
Markovska-Simoska et al. (2008)	Piece	Alpha-EEG/EMG biofeedback	P	Participants who received alpha-EEG/EMG-biofeedback in addition to their musical practice performed significantly better than participants who only practiced.
MacAfee and Comeau (2020, Case 1)	3 pieces	Self-modeling video	F	Performance increased from 71 to 77 during both intervention and return and baseline.
MacAfee and Comeau (2020, Case 2)	3 pieces	Self-modeling video	F	Performance decreased from 77 to 71 during intervention and increased again to 77 for return to baseline.
MacAfee and Comeau (2020, Case 3)	3 pieces	Self-modeling video	F	Performance remained stable throughout the phase: 85, 85, and 84.
MacAfee and Comeau (2020, Case 4)	3 pieces	Self-modeling video	F	Performance increased slightly from 76 to 78 during intervention and then further to 87 during return to baseline.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
MacAfee and Comeau (2020, Case 5)	3 pieces	Self-modeling video	F	Performance remained stable during baseline and intervention (both 75) and decreased to 71 during return to baseline.
Miksza (2015)	2 etudes	Self-regulation instruction	F, P, S	Both groups made significant gains in performance quality, but participants in the experimental condition made significantly greater gains than those in the comparison condition.
Montello et al. (1990, Study 2)	Piece	Music therapy	P	The music therapy group's performance was significantly more musical than that of the two control groups (attentional control; waitlist control).
Moody (2014)	Piece	Feedforward self-modeling video	F	Performance of all participants improved, but was not superior for using the feedforward self-modeling video.
Moorcroft (2011, Study 1)	Excerpt	Breathing imagery	P	Breathing imagery improved singers' vibrato quality more than Braille music code imagery and a non-imagery control condition.
Morasky et al. (1983)	7 × 15-s trills/ scales	EMG biofeedback	P	There was no significant effect on performance quality.
Mornell and Wulf (2019, Study 1)	Memorized piece	Attentional focus (internal/ external)	P	External focus instructions enhanced musical expression relative to both internal focus and control conditions. There was no effect on technical precision.
Mornell and Wulf (2019, Study 1)	Memorized piece	Attentional focus (internal/ external)	P	External focus led to superior musical expression and higher technical precision compared with internal focus and control conditions.
Ornoy and Cohen (2021)	Excerpt	Mindfulness meditation, relaxation, gratitude journals	P	There was no significant effect on performance quality.
Osborne et al. (2007)	Piece	CBI	F, P	There was no significant effect of CBI on performance when compared to behavioral exposure.
Plott (1986)	Memorized piece	Hypnotic relaxation, hypnotic treatment, self-hypnosis	P	There was no significant effect on performance quality.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Richard (1992)	NR	Ericksonian Resource Retrieval, CCR	P	Both conditions showed significant performance improvement.
Roland (1993, Study 1)	Piece	CR; relaxation; combined training	F, P	There were no significant differences in performance between the three groups. According to within-group analyses, the relaxation group improved significantly and consistently, but the cognitive restructuring and combined groups did not.
Roland (1993, Study 3)	Piece	CBI (self-talk, relaxation); CBI + goal-setting, PPR, imagery	F, P	There were no significant differences in performance between the three groups, nor between pre- and post-test.
Ross (1985)	Sight-reading etude	Mental practice	P	Combined mental and physical practice (CP) resulted in most substantial performance improvement, but not significantly better than either the all physical (PP) or mental practice with simulated movements; only the CP and PP groups were significantly better than the no-practice control group.
Slade et al. (2020)	Scales and arpeggios	Body mapping	P	Subtle changes in MIDI data were neither statistically significant, nor audible.
Spahn et al. (2016)	Audition excerpts	PST	F, P, S	Participants receiving PST had a significantly higher performance quality than those without an intervention.
Stambaugh (2017)	Sequences on wind controller	Attentional focus (internal/ external)	P	There were no significant effects of focus condition on performance outcomes.
Stambaugh (2019)	Sequences	Attentional focus (internal/ external)	P	There were no significant effects of focus condition on performance outcomes.
Steenstrup et al. (2021)	5 unfamiliar etudes	Physical practice; mental practice; singing; all three combined	P	There were higher gains in overall performance and pitch accuracy for physical practice and combined practice strategies, compared to no practice. Only the combined strategy yielded a significant improvement in musical expression.
Sweeney-Burton (1997)	Composition	Relaxation techniques	P	There were no significant differences in performance between intervention and control groups.
Sweeney and Horan (1982)	Unfamiliar composition	CCR; CCR + CR	P	CCR and CCR + CR improved musical performing competence, compared to musical analysis training and no intervention control groups.

(Continued)

Table 2. (Continued)

Reference	Performance task	Intervention	Phase(s) of SRL	Key findings
Tang and Ryan (2020)	Composition; sight-reading	Expressive writing; writing about recent event	P	Expressive writing group had a higher reduction of errors in the post-test.
Theiler and Lippman (1995)	4 excerpts	Mental practice	P	Mental practice with a model recording resulted in superior performance. For guitar players, mental practice without a model and physical practice only led to higher pitch accuracy than the control condition.
Tief and Gröpel (2021)	Excerpts	PPR; goal setting	F; P	There were no significant differences in performance quality between groups, but performance decreased overall from pre- to post-test.
Timmers et al. (2012)		Visual feedback	S	The ability to imitate target performances improved after exploration training.
Valentine et al. (1995)	Piece	Alexander Technique	P	There was a significant increase in performance quality in the intervention group when compared to control group.
Van McKinney (1984)	Sight-reading exercise	Thermal biofeedback	P	Biofeedback training had no effect on skin temperature, and also no effect on performance ratings by two judges, but a significant effect on performance ratings by one judge.
Van Zijl and Luck (2013)	Phrase	Attentional focus (technical, expressive, emotions felt)	P	Performances in the expressive condition were rated as played by the most skilled performers and as being most expressive of sadness, and they were also preferred to the technical and emotional performances.
Wardle (1974)	Sight-reading exercise	Systematic desensitization; insight-relaxation	P	There were no significant differences between groups in performance quality or error reduction.
Williams (2019, Study 1)	Excerpts	Attentional focus (external)	P	Accuracy improved for the external focus intervention compared to the control phase.

Note: ACT = acceptance and commitment therapy; CBI = cognitive behavioral intervention; CR = cognitive restructuring; CCR = cue-controlled relaxation; EMDR = eye movement desensitization and reprocessing; NR = not reported; PPR = pre-performance routine; PST = psychological skills training; SMR = sensorimotor rhythm. Column 4 displays which phase(s) of the self-regulated learning (SRL) model were addressed in each study when considering all intervention components and included study groups; F = Forethought; P = Performance; S = Self-evaluation.

participants, two studies (2%) included more than 130 participants, and only one study (1%) included more than 200 participants. The mean age of participants ranged from 11 to 18 years in 15 studies (17%), and from 19 to 29 years in 43 studies (48%), while six studies (7%) included samples with a mean age above 30 years. Twenty-five studies (28%) did not report the participants' age. Regarding expertise, 59 studies (66%) had been conducted with music students at universities or conservatories, four studies (5%) comprised both university and professional levels, and only two studies (2%) had been conducted exclusively with professional musicians. Eleven studies (12%) included musically trained students at secondary school level, and four studies (5%) included amateurs. The samples of eight studies (9%) comprised mixed levels of expertise from beginner to professional. One study (1%) did not report the participants' level of expertise.

Characteristics of studies

The selected studies included 60 studies with single instruments or instrument groups, namely piano ($K=20$), (bowed) strings ($K=17$), guitar ($K=3$), wind and percussion instruments ($K=12$), and voice ($K=8$), and 29 studies with mixed performance instruments. Regarding psychological interventions, the analysis process and categorization based on Zimmerman's (2000) model of SRL, and its adaptation for higher music education by Hatfield and colleagues (2017) involved careful consideration of what exactly the intervention entailed and which phase of SRL it was designed to improve. According to this categorization, eight studies tested interventions for the forethought phase, 66 studies addressed the performance phase, and six studies focused on the self-reflection phase. In nine studies, several phases were addressed simultaneously with comprehensive training programs.

In terms of research design, 54 studies (61%) employed an experimental design, 21 studies (23%) were quasi-experimental, and 14 studies (16%) used single-case designs. The results of our quality assessment are displayed in Table 1. All 14 single-case studies met all quality criteria according to the MMAT. Of the 21 quasi-experimental studies, three met 100%, 15 met 75%, and three met 50% of the MMAT criteria. Four experimental studies met 100%, 16 met 75%, 21 met 50%, and 13 met 25% of the criteria. It should be noted that in most of the assessed studies, it was not possible to tell with certainty whether criteria had been fulfilled or not, which resulted in a lower score. Forty-eight of the experimental studies did not include a description of their randomization procedure but merely mentioned that "participants were randomly assigned" or provided a similarly insufficient statement (Hong et al., 2018). For 18 studies, there was no information on the baseline comparability of the experimental groups, and for 22, there was none on whether outcome assessors had been unaware of the experimental conditions.

Interventions for the forethought phase

Studies addressing the forethought phase ($K=8$) either implemented a goal-setting intervention ($K=2$) or a self-modeling intervention ($K=6$), with mixed results. Goal setting, which refers to specifying performance objectives to direct attention and enhance effort (Locke & Latham, 2002), resulted in lower expert-rated performance (Tief & Gröpel, 2021), or did not affect performance at all (Lubert & Gröpel, 2022), without differences between groups in both studies. Practice with feed-forward self-modeling videos, which were edited versions of participants' original baseline performance showing a level of mastery not yet acquired, did not result in better performance (Moody, 2014). In a single-case study with five musicians, positive self-review videos had some individual positive effects, but no clear effects across participants (MacAfee & Comeau, 2020).

Interventions for the performance phase

Overall, 66 studies addressed the performance phase. The identified interventions were imagery ($K=10$), virtual reality (VR) training ($K=2$), bio-feedback and neurofeedback ($K=14$), hypnosis ($K=2$), expressive writing ($K=1$), attention focusing ($K=11$), body mapping ($K=6$), pre-performance routines (PPRs; $K=5$), relaxation ($K=4$), and extensive cognitive behavioral interventions ($K=16$).

Imagery. Studies in this category included mental practice with auditory or motor imagery, in which participants visualized playing an instrument (motor imagery) or hearing the sound internally (auditory imagery) without actually playing the instrument. In a case study with a pianist, mental practice with motor imagery helped to maintain and stabilize performance quality after periods without physical practice (Christakou et al., 2019). Breathing imagery was more effective than Braille music code imagery and a non-imagery control condition for improving the quality of singers' vibrato (Moorcroft, 2011, Study 1). Mental practice with both motor and auditory imagery improved performance, but less than physical practice (Bernardi et al., 2013). In two other studies (Highben & Palmer, 2004; Lim & Lippman, 1991), motor and auditory imagery was superior to a non-practice control condition (e.g., visual inspection of a pitch), yet inferior to physical practice.

Researchers also tested whether the combination of physical and mental practice is more beneficial than physical practice on its own (Coffman, 1990; Iorio et al., 2022; Ross, 1985) but found mixed evidence. Whereas the combination of physical and mental practice was superior to physical practice on its own for memorizing music (Iorio et al., 2022), it was also shown to be equally effective for performance quality (Coffman, 1990; Ross, 1985). In a study with trumpet players, Steenstrup et al. (2021) included not only physical and mental practice conditions but also a singing condition and a combination of all three strategies. The authors found that physical practice and the combination of the three strategies led to higher gains in overall performance and pitch accuracy than a non-practice control condition, but only the combined practice significantly improved musical expression. Theiler and Lippmann (1995) also included a modeled recording of the music as a third condition and found that the combination of physical and mental practice with the modeled recording resulted in better performance than physical practice alone, mental practice alternating with physical practice, and a control condition. In sum, imagery seems to be a beneficial addition to, but not a substitution for, physical practice.

Virtual reality. Musicians trained in VR exposure with different performance scenarios performed significantly better than a non-intervention control group (Bissonnette et al., 2015), whereas VR exposure to only one performance scenario did not have a significant effect on performance quality (Crawford, 2011).

Biofeedback and neurofeedback. This category includes electromyographic (EMG) biofeedback, thermal biofeedback, electroencephalographic (EEG) neurofeedback, and a combination of EMG and EEG feedback. Participants received real-time instrumental feedback on activity in their peripheral nervous system (i.e., biofeedback) or central nervous system (i.e., neurofeedback) and learned to regulate this activity through reinforcement in order to be able to "transfer the learned state to the real world" (Gruzelier, 2012, p. 332). A study of thermal biofeedback revealed no effect on skin temperature, and no effect on performance ratings by two judges, but a significant effect on performance ratings by a third judge (Van McKinney, 1984). Eight studies investigated EMG biofeedback, with mixed results: in a case study with seven cellists, this technique improved performance (Kjelland, 1985), but there was no significant performance improvement in a study with clarinetists (Morasky et al., 1983).

Four studies on EEG neurofeedback also found mixed evidence. One study reported performance enhancement for some tasks (Egner & Gruzelier, 2003, Study 2), whereas three other studies found no effects (Egner & Gruzelier, 2003, Study 1; Gruzelier et al., 2014a, 2014b). Egner and Gruzelier (2003) found in their first study that neither training with sensorymotor rhythm (SMR), beta1, and alpha/theta (A/T) EEG neurofeedback protocols nor combining these protocols with PST and physical exercise significantly improved performance quality compared to participants receiving no intervention. In their second study, they investigated six separate groups. Only the A/T neurofeedback group improved their performance significantly, whereas neither SMR nor beta1, physical exercise, PST, and AT groups exhibited any post-training performance changes. Gruzelier et al. (2014a, 2014b) found no effect of either SMR or A/T neurofeedback on instrumental improvisation, nor on instrumental or vocal performance. Finally, in two studies of combined alpha EEG neurofeedback and EMG biofeedback, it was reported that combined training improved music students' performance more than practicing without feedback (Bazanova & Shtark, 2007; Markovska-Simoska et al., 2008).

Hypnosis. Two studies applied interventions based on hypnosis, with mixed results. Brooker (2018) investigated a cognitive hypnotherapy and an eye movement desensitization and reprocessing (EMDR) intervention and found that both interventions resulted in significant performance improvements compared to a non-intervention control group, with no difference between groups. In contrast, Plott (1986) reported that hypnotic relaxation training, individualized hypnotic treatment, or self-hypnosis training showed no significant effects on music performance quality.

Expressive writing. Writing down feelings and thoughts about upcoming performances improved performance quality compared to writing about a topic unrelated to performing (Tang & Ryan, 2020).

Attention focusing. Studies in this category tested the effect of internal versus external focus of attention on performance. An internal focus is directed toward components of body movement, such as on finger movements, whereas an external focus is directed toward the effect of the movement, such as an expressive sound (Wulf, 2013). The majority of studies (83%) found that the induction of an external focus improved music performance quality relative to an internal focus (Allingham et al., 2021; Allingham & Wöllner, 2022; Atkins, 2017, 2018; Duke et al., 2011; Higuchi et al., 2011; Mornell & Wulf, 2019; Van Zijl & Luck, 2013; Williams, 2019), whereas two studies yielded non-significant effects (Stambaugh, 2017, 2019). This implies that instructing participants to focus on external aspects is beneficial for music performance quality. However, these aspects vary greatly across studies, including a focus on objects with different degrees of distance from the performer, somatic aspects or tactile sensory feedback, and one's (expressive) sound and/or on communication with the audience.

Self-instruction through body mapping and Alexander Technique. Body mapping is a way of identifying differences between the mental representation of one's body and its actual anatomical structures. A study implementing a body-mapping workshop showed no effects on performance quality (Slade et al., 2020). The related psychophysical AT involves the conscious re-education of thinking and moving by using kinesthetic awareness and self-instructions and is aimed at increasing ease of movement, coordination, and breathing through releasing unnecessary muscle tension (Klein et al., 2014). Five studies provide mixed evidence for the effectiveness of AT: two studies (Davies, 2020; Valentine et al., 1995) demonstrated a significant increase in performance quality, whereas the other three studies found no performance improvements following AT interventions (Dennis, 1987; Egner & Gruzelier, 2003, Study 2; Engelhart, 1989).

Pre-performance routines. To reach an optimal, task-related attentional focus for performance, performers can systematically engage in a PPR, a set of cognitive (e.g., imagery) and behavioral elements (e.g., deep breathing) immediately prior to performance (Cotterill, 2010). Five studies tested PPR interventions in the field of music, with mixed effects. Broomhead (2010) and Broomhead et al. (2012, 2018) found that a PPR intervention with breathing and cue words enhanced musical expressiveness in choir singers. In contrast, individualized PPRs for music students did not lead to better performance (Lubert & Gröpel, 2022), or even produced worse performance quality under pressure (Tief & Gröpel, 2021).

Relaxation. Four studies of different relaxation interventions revealed mixed effects. An intervention combining four relaxation techniques did not lead to a significant increase in music performance quality compared to no intervention (Sweeney-Burton, 1997). Two studies compared a relaxation intervention to interventions based on cognitive restructuring and reported that both interventions led to increased performance quality (Kenny & Halls, 2018; Richard, 1992). Of three groups doing cognitive restructuring, relaxation, or a combination of both, only the relaxation group improved significantly and consistently between pre- and post-test and follow-up (Roland, 1993, Study 1).

Cognitive-behavioral interventions. All studies in this category included psychoeducation as one element of the intervention combined with various other cognitive-behavioral elements. Eight studies (50%) yielded positive effects on performance (Appel, 1976; Hoffman & Hanrahan, 2012; Juncos et al., 2017; Juncos & Markman, 2016; Kenny & Halls, 2018; Montello et al., 1990, Study 2; Richard, 1992; Sweeney & Horan, 1982), six studies (38%) showed non-significant effects (Currie, 2001; Egner & Gruzelier, 2003, Study 2; Kageyama, 2007; Ornoy & Cohen, 2021; Roland, 1993, Study 1; Wardle, 1974), and two studies showed significant effects only at follow-up (Kendrick et al., 1982; Lund, 1972).

Three studies of systematic desensitization, that is, imagery of situations invoking performance anxiety combined with relaxation, yielded mixed effects. Appel (1976) reported reduced performance errors for both systematic desensitization and music analysis interventions, compared to no intervention. Lund (1972) found no mid-term differences in performance quality or errors between groups who received systematic desensitization, relaxation, insight therapy, or no intervention. However, the desensitization and insight groups exhibited fewer errors in the long term than the control group. Wardle (1974) reported no significant differences in performance quality or error reduction between three groups receiving systematic desensitization, insight discussion, or no intervention.

Other interventions were centered on cognitive restructuring, which involves identifying and changing ineffective patterns of thinking. Cognitive restructuring and cognitive restructuring combined with relaxation both improved performance, compared to musical-analysis training and no intervention (Sweeney & Horan, 1982). Similarly, Ericksonian Resource

Retrieval, with cognitive restructuring as its key element, produced significant improvements in performance (Richard, 1992). Combinations of either cognitive restructuring and behavioral exposure or relaxation and behavioral exposure increased performance quality (Kenny & Halls, 2018). Training in cognitive restructuring, self-talk, and imagery led to better performance compared to a waitlist-control group (Hoffman & Hanrahan, 2012). In another study that investigated cognitive restructuring, relaxation, and a combination of both, no significant differences in performance between the three groups were found, but within-group analyses revealed that only the relaxation group improved significantly and consistently between pre- and post-test and follow-up, whereas the other groups did not (Roland, 1993, Study 1). Furthermore, a music therapy intervention resulted in significantly better performance than two control groups (Montello et al., 1990, Study 2).

In yet another cognitive-behavioral approach, two studies added attentional training. Neither the combination of relaxation and behavioral exposure nor this combination with additional attentional training led to statistically significant differences compared to no intervention (Kageyama, 2007). Similarly, neither behavioral exposure nor combined attentional training and behavioral exposure showed significant effects at post-test but at follow-up, the intervention groups showed similar better performance quality than the wait-list control group (Kendrick et al., 1982).

Finally, acceptance and commitment therapy (ACT) is intended to increase the ability to stay present with emotional distress by promoting mindfulness and acceptance of one's symptoms during performance (Juncos et al., 2017). A case study and a pilot study both showed improvements in performance after ACT interventions (Juncos et al., 2017; Juncos & Markman, 2016). In a related study, the combination of mindfulness meditation—aimed at cultivating nonjudgmental and accepting attention—with relaxation, positive event logs, and gratitude journals, did not affect performance quality (Ornoy & Cohen, 2021).

Interventions for the self-reflection phase

For this phase, studies ($K = 6$) were focused on combinations of modeling and self-evaluation ($K = 2$) and on different kinds of feedback ($K = 4$).

Modeling and self-evaluation. In a study exploring different combinations of modeling, self-listening, and self-evaluation, using a model during self-evaluation led to more performance improvement than not using a model (Hewitt, 2001). Groups not doing self-evaluation but using modeling either exclusively or combined with self-listening did not differ. Generally, groups that listened to a model showed more performance improvement than groups not using a model. There were no differences between groups for self-listening. In another study, instruction in self-evaluation had little impact on performance, as all groups improved in the post-test: there was no difference between groups only practicing music and intervention groups in which participants either did self-evaluation by themselves or received self-evaluation instruction during their practice time, thereby spending less time practicing the music (Hewitt, 2011). Modeling thus appears to be more beneficial for music performance than self-evaluation.

Feedback. These interventions included visual and cognitive feedback. Cognitive feedback refers to the enhancement of communicating emotions based on the relationships among performers, expressive cues, and listeners (Juslin & Laukka, 2000). Visual feedback uses real-time depictions related to task execution (Timmers et al., 2012). Cognitive feedback increased communication accuracy compared to a waitlist control group (Juslin & Laukka, 2000). When testing cognitive and visual feedback via a computer program compared to cognitive feedback from music teachers, a combination of both, or repetition without feedback, it was shown that the computer program led to the greatest improvement in communication accuracy (Juslin et al., 2006, Study 1).

In a study using two different forms of visual feedback, neither high-level feedback on expressive style nor low-level feedback on timing and dynamics improved participants' timing or reduced their errors (Brandmeyer et al., 2011). However, high-level feedback resulted in better imitation of expressive performances than low-level and no feedback. In another study, visual feedback on participants' timing while they were exploring different ways of performing grace-notes increased their ability to imitate target performances (Timmers et al., 2012). To conclude, cognitive and visual feedback were both shown to have rather specific benefits for music performance.

Interventions addressing several phases

Lastly, comprehensive training programs ($K = 9$) were used to address several phases of SRL simultaneously. The interventions typically consisted of a combination of goal setting, relaxation, self-talk, attentional control, PPR, imagery, body awareness, and self-evaluation. Six studies yielded a positive effect (Cohen & Bodner, 2019; Gill, 2020; Miksza, 2015; Spahn et al., 2016), and three studies reported null results (Braden et al., 2015; Osborne et al., 2007; Roland, 1993, Study 3). In three studies, performance quality increased after a comprehensive online training program (Gill, 2020). Two interventions including either goal setting and PPR (Cohen & Bodner, 2019) or body awareness and video feedback (Spahn et al., 2016), along with relaxation, behavioral exposure, self-talk, attentional control, imagery, and practice strategies, led to performance improvements for experimental compared to control participants. By contrast, combined cognitive restructuring, relaxation, and goal setting (Osborne et al., 2007) and a similar combination with additional imagery (Braden et al., 2015) had no effect on performance quality, compared to no intervention. In sum, the evidence for the effectiveness of comprehensive training programs is still equivocal.

Discussion

In this systematic review, we summarized 89 studies of various psychological interventions designed to enhance musicians' self-regulation (see Table 2). The results show that few interventions had consistent, positive effects on expert-rated music performance quality; only expressive writing, cognitive and visual feedback, and the combination of EMG and EEG biofeedback appeared to improve performance in all respective studies. However, the quality of the biofeedback studies, in particular, was rather poor, and to date, there is only one study of expressive writing. Evidence points to the effectiveness of imagery if it is combined with physical practice, with further benefits if singing or modeling are added to the combination. Regarding attentional focus instructions, most studies support the notion that focusing externally on (expressive) sound, somatic aspects, or tactile sensory feedback is more beneficial for music performance quality than focusing internally on specific bodily movements. Two studies point toward the effectiveness of ACT, but generalizability is limited by the study designs, and further experimental research is required.

Negative effects were only found in one study, showing that both PPR and goal-setting interventions yielded lower performance ratings in the post-test (Tief & Gröpel, 2021); yet this study was also one of the few that met all the quality criteria. Furthermore, the other studies on PPRs showed positive or non-significant effects on performance. Indeed, the majority of the reviewed studies produce a complex overall picture with a mix of positive and non-significant effects on performance. Remarkably, studies employing a follow-up test often reported positive effects only at this later point in time, rather than at the post-test immediately after the intervention.

Our results are thus not straightforward and are somewhat inconclusive, which we attribute to two major challenges: first, the tested interventions were very heterogenous, which limits the comparability of the respective studies. Second, the reported methodological quality varied but was often low. Consequently, caution should be taken when making practical decisions about which intervention to apply.

Study characteristics

In terms of study characteristics, our analysis revealed three problematic aspects: the studies' methodological quality, the heterogeneity of interventions within the categories, and the uneven number of studies per intervention and level of expertise (see Tables 1 and 2). Most of the included studies employed (or were intended to employ) experimental designs, which are considered the gold standard for the investigation of causal effects (Hariton & Locascio, 2018). As pointed out earlier, a large body of these experimental studies did not report how randomization was carried out, whether assessors were aware of the experimental conditions, or whether groups were comparable at baseline. During the quality assessment, many studies were thus marked "can't tell" for these criteria and received a lower score. Conversely, several studies reported complete outcome data without dropouts after intervention periods lasting several weeks, which seems unlikely to reflect reality as other studies with longer interventions do report dropouts. This could be due to imprecision in reporting sample sizes; authors may either not have reported dropouts or only reported the final but not the initial numbers of participants. It is important to emphasize that such lack of accuracy cannot be automatically equated with low methodological quality. Notably, this issue was present across studies irrespective of the year in which they were conducted and is thus not limited to older studies. Furthermore, methodological quality was no higher in published studies than unpublished studies.

There were also additional methodological issues that were not covered by the MMAT, such as incomplete reporting of statistical analyses and lack of (reported) interrater reliability among assessors. We encountered the dilemma of excluding studies that had no statistical outcome analysis due to insufficient interrater reliability (e.g., Clark & Williamon, 2011), while including studies that simply did not report this reliability (e.g., Bazanova & Shtark, 2007) or prioritized the assessment of only one rater out of several (e.g., Juncos et al., 2017). Similarly, some studies did not report their full statistical analysis (e.g., Egner & Gruzelier, 2003). These aspects may potentially lead to an overestimation of the effect of the intervention. Generally, we determined that the amount of detail in reporting methods was insufficient for many studies, making their assessment rather difficult. Future researchers are thus encouraged to present their work in accordance with established reporting guidelines (e.g., the CONSORT statement; Moher et al., 2012).

Another issue is the disproportionate number of studies per intervention and level of expertise (see Tables 1 and 2). Whereas there is a substantial body of evidence for the effectiveness of external attentional focus, or the supportive effect of imagery in addition to physical practice, there are very few studies on VR, expressive writing, or hypnosis. More research is needed to determine the effectiveness of these interventions. Regarding expertise, most studies were conducted with students at music universities. They are an important target group, but interventions are also relevant to professional musicians and may be especially beneficial when implemented in the early stages of musical training (Pecen et al., 2018). Future studies might therefore be focused on proficient young musicians, as well as professionals who express an interest in enhancing their performance through psychological interventions.

Perhaps most importantly, the interventions within the different categories were quite heterogenous and thus difficult to compare. For example, attentional control training was implemented using three different approaches. Kageyama (2007) included both attention focusing and relaxation techniques. Kendrick et al. (1982) included cognitive restructuring, and Montello et al. (1990) included psychological testing and the discussion of musical topics. This heterogeneity was particularly evident in interventions combining several elements; cognitive-behavioral and combined relaxation interventions, and the comprehensive programs, typically had the same components in common but never in the same combination. Results therefore appear restricted to each specific combination of psychological strategies. Furthermore, the evidence so far does not point toward a superior effectiveness of combined over stand-alone interventions.

Performance task and evaluation

Performance tasks (see Table 2) and settings were also heterogenous, as were the methods by which performance quality was evaluated. Performers apply interventions for different reasons, to improve their performance on a range of tasks from playing on open strings to giving a concert to an audience. It may be easier to measure performance on narrower, more specific tasks by analyzing MIDI data or using acoustic parameters than relying on expert ratings, but these methods are very different from the ecologically valid evaluations that reflect the perceptions of an expert or lay audience. We only included studies using objective evaluations and excluded studies using only self-evaluations, as self-evaluation and expert evaluations can sometimes diverge substantially (Tief & Gröpel, 2021). When designing an intervention study, it is therefore important to consider the perspective on performance quality that is being taken and whether the intervention is intended to improve the experience primarily of the performer or the audience.

Intended aims of the interventions

Some of the interventions reported in the included studies were designed to improve performance quality by reducing the performer's MPA. This is an endeavor that has received a lot of attention in the literature on music performance research, as reflected by numerous studies and systematic reviews of treatment or reduction of MPA. Generally, however, interventions aimed to improve performers' self-regulation of either musical skills, arousal, and emotions immediately connected to performing or planning and evaluating one's practice and performance in the interests of long-term performance enhancement. Thus, while this review was intended to reveal the interventions that improve performance, measured objectively, some of them enhanced other outcomes such as the musicians' own perceived performance quality, accuracy of self-evaluation, self-efficacy, or psychological skills, sometimes without immediate effects on expert-rated performance.

Many studies also lack measures of the skills underlying the implemented interventions. Some include measures of compliance, such as diaries recording whether an intervention technique had been applied but did not investigate how well it had been applied (e.g., Bernardi et al., 2013; Lubert & Gröpel, 2022). For example, participants in the study by Bernardi et al. (2013) recorded their daily time devoted to mental practice but were not tested on the quality of their imagery skills. The three studies of PST by Gill (2020) are a notable exception, as they included measures of psychological performance skills in addition to evaluations of performance quality. Future studies would enhance our understanding of SRL by including measures for the specific skill that an intervention is designed to improve. Improvements on this more personal level can have important implications for musicians' wellbeing and could also be the focus for a different review in the future.

Strengths and limitations of the present review

Our aim was to provide a comprehensive overview of psychological interventions for performance enhancement. To do so, we included unpublished master's and doctoral dissertations in this review. Another strength is the integration of the identified interventions into the framework of SRL, as it has been increasingly applied in music performance research (e.g., Hatfield et al., 2017; McPherson et al., 2019; Osborne et al., 2021). Indeed, the majority of reviewed interventions were not embedded in a theoretical background, making an understanding of their conceptualization or justification difficult.

Our definition of psychological intervention remains arguably broad and perhaps too vague. It resulted in our reviewing a diverse collection of mental strategies and psychophysical methods that may render comparisons problematic. Nevertheless, we were able to show many different possibilities for self-regulated enhancement of music performance. As the interventions were very heterogenous, categorization was sometimes challenging (see Table 2). For example, writing down thoughts and emotions about an upcoming performance (expressive writing) could be seen as part of the forethought phase, but because it was intended to reduce MPA, we categorized it as an intervention for arousal regulation in the performance phase (see also Supplemental Figure S1). Similarly, PPRs should be executed immediately before performing and thereby aid arousal regulation and concentration (Rupprecht et al., 2021). We therefore included PPRs in the performance rather than the forethought phase. Another example is modeling, which features both in the forethought and in the self-evaluation phases but has different functions. During forethought, self-modeling may enhance self-efficacy, whereas listening to an external model may enhance the self-evaluation phase by making one's own assessment more accurate. Modeling could thus also be seen as a linking element in the SRL model, leading from the self-evaluation phase back into the forethought phase. It is precisely the cyclical nature of SRL that should be emphasized; whereas many comprehensive programs already address several phases, interventions such as imagery, expressive writing, or relaxation could be applied before as well as after performance. Previous studies with musicians and athletes clearly show this cyclical relationship and interrelatedness of the three phases and the predictive value of processes during the self-reflection phase for those in the forethought phase (Cleary & Zimmerman, 2001; Hatfield et al., 2017).

Future research

Based on our analyses and results, we propose some possibilities for improving the methodological quality of future intervention studies and enriching their scientific and practical contribution. First, steps should be taken in future research to improve and report elements of the methods used in more detail; these include randomization, procedures to conceal conditions for participants and/or evaluators, drop-out rates, and the provision of sufficient information to determine whether groups were comparable at baseline level. Second, studies would be stronger if they included a pre-test of performance quality and an appropriate control group. The lack of the former constituted an exclusion criterion in this review; promising interventions using self-affirmation (Churchill et al., 2018) and meditation (Lin et al., 2008) could not be included. Third, more studies should include follow-up tests, as several studies in this review revealed positive effects at follow-up although not at post-test. Relatedly, researchers should consider the duration of interventions, as those we reviewed varied from a few hours to several weeks. It could be determined in future research whether certain interventions need to be implemented over a longer period in order to show effects on performance quality, while ensuring appropriate control conditions and limiting the influence of other factors.

Perhaps not surprisingly, most studies could be categorized for the performance phase, whereas there are few studies of interventions for forethought or self-evaluation (see Table 2). Given the importance of both planning and preparing for performance, and of self-regulating one's post-performance processing (Haccoun et al., 2020), it might be beneficial to focus on these two SRL phases in future research.

It may be that the lack of conclusive evidence is due to the personal nature of SRL in relation to music performance such that each individual would benefit from a unique combination of strategies. Future studies could begin with tailored interventions and incorporate musicians' individual characteristics and needs into subsequent psychological interventions.

Finally, we should like to emphasize that more research is needed to determine which interventions may be most advantageous for the quality of music performance. Those interventions that have been corroborated by positive evidence so far may require further support from more, higher-quality studies, while the inconclusive evidence demands further exploration and replication. For effective replication, the repeatability of interventions, especially of comprehensive programs, could be made a priority, for example, by following the Template for Intervention Description and Replication (TIDieR) checklist for interventions (Hoffmann et al., 2014).

Conclusion

Many different psychological interventions to enhance music performance quality through the use of self-regulation strategies have been tested in the past decades. The reviewed studies provide mixed, that is, mostly positive or non-significant, results for their effectiveness, which should be considered in light of the methodological quality of the studies and the context of the intervention. While it was not possible to determine overall which interventions are most useful, we identified several methodological concerns that should be addressed in future research. This review had a strict focus on objective performance quality and did not take into account other beneficial outcomes that were occasionally reported for the musicians, such as more positive self-evaluation, increased self-efficacy, or reduced MPA. Practitioners should therefore consider what it is that they specifically wish to enhance through a psychological intervention and keep in mind that even if an intervention does not readily translate into increased objective performance quality, it may still provide support for the musician in a more holistic context.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was in part funded by a Marietta Blau Grant from the OeAD-GmbH, which is financed by the Austrian Federal Ministry of Education, Science and Research (BMBWF).

ORCID iD

Veronika J. Lubert https://orcid.org/0000-0001-8334-4965

Supplemental material

Supplemental material for this article is available online.

References

References preceded by an asterisk (*) were included in the systematic review.

*Allingham, E., Burger, B., & Wöllner, C. (2021). Motor performance in violin bowing: Effects of attentional focus on acoustical, physiological and physical parameters of a sound-producing action. *Journal of New Music Research*, *50*(5), 428–446. https://doi.org/10.1080/09298215.2021.1978506

*Allingham, E., & Wöllner, C. (2022). Effects of attentional focus on motor performance and physiology in a slow-motion violin bow-control task: Evidence for the constrained action hypothesis in bowed string technique. *Journal of Research in Music Education*, *70*(2), 168–189. https://doi.org/10.1177/00224294211034735

*Appel, S. S. (1976). Modifying solo performance anxiety in adult pianists. *Journal of Music Therapy*, *13*(1), 2–16. https://doi.org/10.1093/jmt/13.1.2

*Atkins, R. L. (2017). Effects of focus of attention on tone production in trained singers. *Journal of Research in Music Education*, *64*(4), 421–434. https://doi.org/10.1177/0022429416673842

*Atkins, R. L. (2018). Focus of attention in singing: Expert listeners' descriptions of change in trained singers' tone quality. *International Journal of Research in Choral Singing*, *6*, 3–24.

*Bazanova, O. M., & Shtark, M. B. (2007). Biofeedback in optimizing psychomotor reactivity: I. Comparison of biofeedback and common performance practice. *Human Physiology*, *33*(4), 400–408. https://doi.org/10.1134/S0362119707040044

*Bernardi, N. F., De Buglio, M., Trimarchi, P. D., Chielli, A., & Bricolo, E. (2013). Mental practice promotes motor anticipation: Evidence from skilled music performance. *Frontiers in Human Neuroscience*, *7*, Article 451. https://doi.org/10.3389/fnhum.2013.00451

*Bissonnette, J., Dubé, F., Provencher, M. D., & Moreno Sala, M. T. (2015). Virtual reality exposure training for musicians: Its effect on performance anxiety and quality. *Medical Problems of Performing Artists*, *30*(3), 169–177. https://doi.org/10.21091/mppa.2015.3032

*Braden, A. M., Osborne, M. S., & Wilson, S. J. (2015). Psychological intervention reduces self-reported performance anxiety in high school music students. *Frontiers in Psychology*, *6*, Article 195. https://doi.org/10.3389/fpsyg.2015.00195

*Brandmeyer, A., Timmers, R., Sadakata, M., & Desain, P. (2011). Learning expressive percussion performance under different visual feedback conditions. *Psychological Research*, *75*(2), 107–121. https://doi.org/10.1007/s00426-010-0291-6

*Brooker, E. (2018). Music performance anxiety: A clinical outcome study into the effects of cognitive hypnotherapy and eye movement desensitisation and reprocessing in advanced pianists. *Psychology of Music*, *46*(1), 107–124. https://doi.org/10.1177/0305735617703473

*Broomhead, P. (2010). The effect of positive mindset trigger words on the performance expression of non-expert adult singers. *Contributions to Music Education*, *37*(2), 65–86.

*Broomhead, P., Skidmore, J. B., Eggett, D. L., & Mills, M. M. (2012). The effects of a positive mindset trigger word pre-performance routine on the expressive performance of junior high age singers. *Journal of Research in Music Education*, *60*(1), 62–80. https://doi.org/10.1177/0022429411435363

*Broomhead, P., Skidmore, J. B., Eggett, D. L., & Mills, M. M. (2018). The effects of a teacher-directed preperformance routine on expressive performance mindset. *Bulletin of the Council for Research in Music Education*, *215*, 57–74. https://doi.org/10.5406/bulcouresmusedu.215.0057

Brown, D. J., & Fletcher, D. (2017). Effects of psychological and psychosocial interventions on sport performance: A meta-analysis. *Sports Medicine*, *47*, 77–99. https://doi.org/10.1007/s40279-016-0552-7

Brugués, A. O. (2011). Music performance anxiety—Part 2: A review of treatment options. *Medical Problems of Performing Artists*, *26*, 164–171.

Burin, A. B., & Osório, F. D. L. (2016). Interventions for music performance anxiety: Results from a systematic literature review. *Archives of Clinical Psychiatry (São Paulo)*, *43*, 116–131.

Burin, A. B., & Osório, F. D. L. (2017). Music performance anxiety: A critical review of etiological aspects, perceived causes, coping strategies and treatment. *Archives of Clinical Psychiatry (São Paulo)*, *44*, 127–133.

*Christakou, A., Vasileiadis, G., & Kapreli, E. (2019). Motor imagery as a method of maintaining performance in pianists during forced nonpractice: A single case study. *Physiotherapy Theory and Practice*, *37*(4), 540–548. https://doi.org/10.1080/09593985.2019.1636917

Churchill, S., Jessop, D. C., Goodwin, S., Ritchie, L., & Harris, P. R. (2018). Self-affirmation improves music performance among performers high on the impulsivity dimension of sensation seeking. *Psychology of Music*, *46*(2), 292–302. https://doi.org/10.1177/0305735617705007

Clark, T., & Williamon, A. (2011). Evaluation of a mental skills training program for musicians. *Journal of Applied Sport Psychology*, *23*(3), 342–359. https://doi.org/10.1080/10413200.2011.574676

Cleary, T. J., & Zimmerman, B. J. (2001). Self-regulation differences during athletic practice by experts, non-experts, and novices. *Journal of Applied Sport Psychology*, *13*, 185–206. https://doi.org/10.1080/104132001753149883

*Coffman, D. D. (1990). Effects of mental practice, physical practice, and knowledge of results on piano performance. *Journal of Research in Music Education*, *38*(3), 187–196. https://doi.org/10.2307/3345182

*Cohen, S., & Bodner, E. (2019). Music performance skills: A two—pronged approach—facilitating optimal music performance and reducing music performance anxiety. *Psychology of Music*, *47*(4), 521–538. https://doi.org/10.1177/0305735618765349

Cotterill, S. (2010). Pre-performance routines in sport: Current understanding and future directions. *International Review of Sport and Exercise Psychology*, *3*(2), 132–153. https://doi.org/10.1080/1750984X.2010.488269

*Crawford, C. R. (2011). *Effects of exposure to virtual audience environments on performing musicians* (Publication No. MR75937) [Doctoral dissertation, McGill University]. ProQuest Dissertations and Theses Global.

*Currie, K. A. (2001). *Performance anxiety coping skills seminar: Is it effective in reducing musical performance anxiety and enhancing musical performance quality?* [Doctoral dissertation, Virginia Polytechnic Institute and State University]. Virginia Tech Electronic Theses and Dissertations. https://vtechworks.lib.vt.edu/handle/10919/28032?show=full

*Davies, J. (2020). Alexander technique classes for tertiary music students: Student and teacher evaluations of pre- and post-test audiovisual recordings. *International Journal of Music Education*, *38*(2), 194–207. https://doi.org/10.1177/0255761419880007

*Dennis, R. J. (1987). *Musical performance and respiratory function in wind instrumentalists: Effects of the Alexander technique of musculoskeletal education* (Publication No. 8721097) [Doctoral dissertation, Columbia University]. ProQuest Dissertations and Theses Global.

*Duke, R. A., Cash, C. D., & Allen, S. E. (2011). Focus of attention affects performance of motor skills in music. *Journal of Research in Music Education*, *59*(1), 44–55. https://doi.org/10.11770022429410396093

*Egner, T., & Gruzelier, J. H. (2003). Ecological validity of neurofeedback: Modulation of slow wave EEG enhances musical performance. *Neuroreport*, *14*(9), 1221–1224.

*Engelhart, R. J. (1989). *An electromyographic study of preparatory set in singing as influenced by the Alexander technique* (Publication No. 9001945) [Doctoral dissertation, The Ohio State University]. ProQuest Dissertations and Theses Global.

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*(3), 363–406.

Fernholz, I., Mumm, J. L. M., Plag, J., Noeres, K., Rotter, G., Willich, S. N., . . .Schmidt, A. (2019). Performance anxiety in professional musicians: A systematic review on prevalence, risk factors and clinical treatment effects. *Psychological Medicine*, *49*, 2287–2306.

Finch, K., & Moscovitch, D. A. (2016). Imagery-based interventions for music performance anxiety. *Medical Problems of Performing Artists*, *31*, 222–231.

Ford, J., & Arvinen-Barrow, M. (2019). Exploring the use of psychological skills training interventions in a music domain: A systematic review. *Medical Problems of Performing Artists*, *34*, 222–229.

Gaunt, H., & Westerlund, H. (2016). Prelude: The case for collaborative learning in higher music education. In H. Gaunt & H. Westerlund (Eds.), *Collaborative learning in higher music education* (pp. 21–30). Routledge.
*Gill, A. (2020). *Enhancing music performance self-efficacy through psychological skills training* [Doctoral dissertation, University of Melbourne]. Melbourne Conservatorium of Music—Theses. http://hdl.handle.net/11343/235510
Gruzelier, J. H. (2012). Enhancing imaginative expression in the performing arts with EEG-neurofeedback. In D. Miell, R. MacDonald, & D. Hargreaves (Eds.), *Musical imaginations: Multidisciplinary perspectives on creativity, performance and perception* (pp. 332–350). Oxford University Press.
*Gruzelier, J. H., Hirst, L., Holmes, P., & Leach, J. (2014a). Immediate effects of alpha/theta and sensory-motor rhythm feedback on music performance. *International Journal of Psychophysiology*, *93*(1), 96–104. https://doi.org/10.1016/j.ijpsycho.2014.03.009
*Gruzelier, J. H., Holmes, P., Hirst, L., Bulpin, K., Rahman, S., van Run, C., & Leach, J. (2014b). Replication of elite music performance enhancement following alpha/theta neurofeedback and application to novice performance and improvisation with SMR benefits. *Biological Psychology*, *95*, 96–107. https://doi.org/10.1016/j.biopsycho.2013.11.001
Haccoun, Y. E., Hildebrandt, H., Klumb, P. L., Nater, U. M., & Gomez, P. (2020). Positive and negative post performance-related thoughts predict daily cortisol output in university music students. *Frontiers in Psychology*, *11*, Article 585875. https://doi.org/10.3389/fpsyg.2020.585875
Hariton, E., & Locascio, J. J. (2018). Randomised controlled trials—The gold standard for effectiveness research. *BJOG*, *125*(13), 1716–1716. https://doi.org/10.1111/1471-0528.15199
Hatfield, J. L. (2016). Performing at the top of one's musical game. *Frontiers in Psychology*, *7*, Article 1356. https://doi.org/10.3389/fpsyg.2016.01356
Hatfield, J. L., Halvari, H., & Lemyre, P. N. (2017). Instrumental practice in the contemporary music academy: A three-phase cycle of self-regulated learning in music students. *Musicae Scientiae*, *21*(3), 316–337. https://doi.org/10.1177/1029864916658342
*Hewitt, M. P. (2001). The effects of modeling, self-evaluation, and self-listening on junior high instrumentalists' music performance and practice attitude. *Journal of Research in Music Education*, *49*(4), 307–322. https://doi.org/10.2307/3345614
*Hewitt, M. P. (2011). The impact of self-evaluation instruction on student self-evaluation, music performance, and self-evaluation accuracy. *Journal of Research in Music Education*, *59*(1), 6–20. https://doi.org/10.1177/0022429410391541
*Highben, Z., & Palmer, C. (2004). Effects of auditory and motor mental practice in memorized piano performance. *Bulletin of the Council for Research in Music Education*, *159*, 58–65.
*Higuchi, M. K. K., Fornari, J., Del Ben, C. M., Graeff, F. G., & Leite, J. P. (2011). Reciprocal modulation of cognitive and emotional aspects in pianistic performances. *PLOS ONE*, *6*(9), Article e24437. https://doi.org/10.1371/journal.pone.0024437
*Hoffman, S. L., & Hanrahan, S. J. (2012). Mental skills for musicians: Managing music performance anxiety and enhancing performance. *Sport, Exercise, and Performance Psychology*, *1*(1), 17–28. https://doi.org/10.1037/a0025409
Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., & Michie, S. (2014). Better reporting of interventions: Template for intervention description and replication (TIDieR) checklist and guide. *BMJ*, Article g1687. https://doi.org/10.1136/bmj.g1687
Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The mixed methods appraisal tool (MMAT) version 2018 for information professionals and researchers [Special Issue]. *Education for Information*, *34*, 285–291. https://doi.org/10.3233/EFI-180221
*Iorio, C., Brattico, E., Munk Larsen, F., Vuust, P., & Bonetti, L. (2022). The effect of mental practice on music memorization. *Psychology of Music*, *50*(1), 230–244. https://doi.org/10.1177/0305735621995234
*Juncos, D. G., Heinrichs, G. A., Towle, P., Duffy, K., Grand, S. M., Morgan, M. C., Smith, J. D., & Kalkus, E. (2017). Acceptance and commitment therapy for the treatment of music performance anxiety: A

pilot study with student vocalists. *Frontiers in Psychology*, *8*, Article 986. https://doi.org/10.3389/fpsyg.2017.00986

*Juncos, D. G., & Markman, E. J. (2016). Acceptance and commitment therapy for the treatment of music performance anxiety: A single subject design with a university student. *Psychology of Music*, *44*(5), 935–952. https://doi.org/10.1177/0305735615596236

*Juslin, P. N., Karlsson, J., Lindström, E., Friberg, A., & Schoonderwaldt, E. (2006). Play it again with feeling: Computer feedback in musical communication of emotions. *Journal of Experimental Psychology: Applied*, *12*(2), 79–95. https://doi.org/10.1037/1076-898X.12.2.79

*Juslin, P. N., & Laukka, P. (2000). Improving emotional communication in music performance through cognitive feedback. *Musicae Scientiae*, *4*(2), 151–183. https://doi.org/10.1177/102986490000400202

*Kageyama, N. J. (2007). *Attentional focus as a mediator in the anxiety-performance relationship: The enhancement of music performance quality under stress* (Publication No. 3297078) [Doctoral dissertation, Indiana University]. ProQuest Dissertations and Theses Global.

*Kendrick, M. J., Craig, K. D., Lawson, D. M., & Davidson, P. O. (1982). Cognitive and behavioral therapy for musical-performance anxiety. *Journal of Consulting and Clinical Psychology*, *50*(3), 353–362. https://doi.org/10.1037/0022-006X.50.3.353

Kenny, D. T. (2005). A systematic review of treatments for music performance anxiety. *Anxiety, Stress, and Coping*, *18*(3), 183–208. https://doi.org/10.1080/10615800500167258

*Kenny, D. T., & Halls, N. (2018). Development and evaluation of two brief group interventions for music performance anxiety in community musicians. *Psychology of Music*, *46*(1), 66–83. https://doi.org/10.1177/0305735617702536

*Kjelland, J. M. (1985). *The effects of electromyographic biofeedback training on violoncello performance: Tone quality and muscle tension* (Publication No. 8609527) [Doctoral dissertation, University of Texas at Austin]. ProQuest Dissertations and Theses Global.

Klein, S. D., Bayard, C., & Wolf, U. (2014). The Alexander technique and musicians: A systematic review of controlled trials. *BMC Complementary and Alternative Medicine*, *14*, 414. https://doi.org/10.1186/1472-6882-14-414

*Lim, S., & Lippman, L. G. (1991). Mental practice and memorization of piano music. *The Journal of General Psychology*, *118*(1), 21–30. https://doi.org/10.1080/00221309.1991.9711130

Lin, P., Chang, J., Zemon, V., & Midlarsky, E. (2008). Silent illumination: A study on Chan (Zen) meditation, anxiety, and musical performance quality. *Psychology of Music*, *36*(2), 139–155. https://doi.org/10.1177/0305735607080840

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

*Lubert, V. J., & Gröpel, P. (2022). Testing interventions for music performance under pressure: A randomized controlled study. *Sport, Exercise, and Performance Psychology*, *11*(1), 93–105. https://doi.org/10.1037/spy0000285

*Lund, D. R. (1972). *A comparative study of three therapeutic techniques in the modification of anxiety behavior in instrumental music performance* (Publication No. 7223026) [Doctoral dissertation, University of Utah]. ProQuest Dissertations and Theses Global.

*MacAfee, E., & Comeau, G. (2020). Exploring music performance anxiety, self-efficacy, performance quality, and behavioural anxiety within a self-modelling intervention for young musicians. *Music Education Research*, *22*(4), 457–477. https://doi.org/10.1080/14613808.2020.1781074

*Markovska-Simoska, S., Pop-Jordanova, N., & Georgiev, D. (2008). Simultaneous EEG and EMG biofeedback for peak performance in musicians. *Prilozi*, *29*(1), 239–252.

McPherson, G. E., Nielsen, S., & Renwick, J. (2013). Self-regulation interventions and the development of music expertise. In H. Bembenutty, T. Cleary, & A. Kitsantas (Eds.), *Applications of self-regulated learning across diverse disciplines: A tribute to Barry J. Zimmerman* (pp. 355–382). Information Age.

McPherson, G. E., Osborne, M. S., Evans, P., & Miksza, P. (2019). Applying self-regulated learning microanalysis to study musicians' practice. *Psychology of Music*, *47*(1), 18–32. https://doi.org/10.1177/0305735617731614

McPherson, G. E., & Zimmerman, B. J. (2002). Self-regulation of musical learning: A social cognitive perspective. In R. Colwell & C. Richardson (Eds.), *The new handbook of research on music teaching and learning* (pp. 327–347). Oxford University Press.

McPherson, G. E., & Zimmerman, B. J. (2011). Self-regulation of musical learning: A social cognitive perspective on developing performance skills. In R. Colwell & P. Webster (Eds.), *MENC handbook of research on music learning* (pp. 130–175). Oxford University Press.

*Miksza, P. (2015). The effect of self-regulation instruction on the performance achievement, musical self-efficacy, and practicing of advanced wind players. *Psychology of Music*, *43*(2), 219–243. https://doi.org/10.1177/0305735613500832

Miksza, P., Blackwell, J., & Roseth, N. E. (2018). Self-regulated music practice: Microanalysis as a data collection technique and inspiration for pedagogical intervention. *Journal of Research in Music Education*, *66*, 295–319. https://doi.org/10.1177/0022429418788557

Moher, D., Hopewell, S., Schulz, K. F., Montori, V., Gøtzsche, P. C., Devereaux, P. J., Elbourne, D., Egger, M., & Altman, D. G. (2012). CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. *International Journal of Surgery*, *10*(1), 28–55. https://doi.org/10.1016/j.ijsu.2011.10.001

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLOS Medicine*, *6*(7), Article e1000097. https://doi.org/10.1371/journal.pmed.1000097

*Montello, L., Coons, E. E., & Kantor, J. (1990). The use of group music therapy as a treatment for musical performance stress. *Medical Problems of Performing Artists*, *5*(1), 49–57.

*Moody, L. D. (2014). *The effects of feedforward self-modeling on self-efficacy, music performance anxiety, and music performance in anxious adolescent musicians* (Publication No. 10005458) [Doctoral dissertation, University of Ottawa]. ProQuest Dissertations and Theses Global.

*Moorcroft, L. (2011). *Pre-performance practices: Breathing imagery and warm-up for singers* [Doctoral dissertation, University of Sydney]. Sydney Digital Theses. http://hdl.handle.net/2123/7870

*Morasky, R. L., Reynolds, C., & Sowell, L. E. (1983). Generalization of lowered EMG levels during musical performance following biofeedback training. *Biofeedback and Self-Regulation*, *8*(2), 207–216. https://doi.org/10.1007/BF00998851

Mornell, A., Osborne, M. S., & McPherson, G. E. (2020). Evaluating practice strategies, behavior and learning progress in elite performers: An exploratory study. *Musicae Scientiae*, *24*(1), 130–135. https://doi.org/10.1177/1029864918771731

*Mornell, A., & Wulf, G. (2019). Adopting an external focus of attention enhances musical performance. *Journal of Research in Music Education*, *66*(4), 375–391. https://doi.org/10.1177/0022429418801573

Nordin-Bates, S. M. (2012). Performance psychology in the performing arts. In S. M. Murphy (Ed.), *The Oxford Handbook of Sport and Performance Psychology* (pp. 81–114). Oxford University Press.

*Ornoy, E., & Cohen, S. (2021). The effect of mindfulness meditation on the vocal proficiencies of music education students. *Psychology of Music*. Advance online publication. https://doi.org/10.1177/03057356211062262

*Osborne, M. S., Kenny, D. T., & 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*(2), 53–84. https://doi.org/10.1177/10298649070110S204

Osborne, M. S., McPherson, G. E., Miksza, P., & Evans, P. (2021). Using a microanalysis intervention to examine shifts in musicians' self-regulated learning. *Psychology of Music*, *49*(4), 972–988. https://doi.org/10.1177/0305735620915265

Pecen, E., Collins, D., & MacNamara, Á. (2016). Music of the night: Performance practitioner considerations for enhancement work in music. *Sport, Exercise, and Performance Psychology*, *5*, 377–395. https://doi.org/10.1037/spy0000067

Pecen, E., Collins, D. J., & MacNamara, Á. (2018). "It's your problem. Deal with it." Performers' experiences of psychological challenges in music. *Frontiers in Psychology*, *8*, Article 2374. https://doi.org/10.3389/fpsyg.2017.02374

*Plott, T. M. (1986). *An Investigation of the hypnotic treatment of music performance anxiety* (Publication No. 8701817) [Doctoral dissertation, University of Tennessee]. ProQuest Dissertations and Theses Global.

*Richard, J. J. (1992). *The effects of Ericksonian resource retrieval on musical performance anxiety* (Publication No. 9409887) [Doctoral dissertation, West Virginia University]. ProQuest Dissertations and Theses Global.

*Roland, D. J. (1993). *The development and evaluation of a modified cognitive-behavioural treatment for musical performance anxiety* (Publication No. 9424349) [Doctoral dissertation, University of Wollongong]. ProQuest Dissertations and Theses Global.

*Ross, S. L. (1985). The effectiveness of mental practice in improving the performance of college trombonists. *Journal of Research in Music Education*, *33*(4), 221–230. https://doi.org/10.2307/3345249

Rupprecht, A., Tran, U., & Gröpel, P. (2021). The effectiveness of pre-performance routines in sports: A meta-analysis. *International Review of Sport and Exercise Psychology*. Advance online publication. https://doi.org/10.1080/1750984X.2021.1944271

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., . . .Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *BMJ*, Article g7647. https://doi.org/10.1136/bmj.g7647

Simones, L. L. (2017). Beyond expectations in music performance modules in higher education: Rethinking instrumental and vocal music pedagogy for the twenty-first century. *Music Education Research*, *19*(3), 252–262. https://doi.org/10.1080/14613808.2015.1122750

*Slade, T., Comeau, G., & Russell, D. (2020). Measurable changes in piano performance of scales and arpeggios following a body mapping workshop. *Journal of New Music Research*, *49*(4), 362–372. https://doi.org/10.1080/09298215.2020.1784958

*Spahn, C., Walther, J.-C., & Nusseck, M. (2016). The effectiveness of a multimodal concept of audition training for music students in coping with music performance anxiety. *Psychology of Music*, *44*(4), 893–909. https://doi.org/10.1177/0305735615597484

*Stambaugh, L. A. (2017). Effects of internal and external focus of attention on woodwind performance. *Psychomusicology*, *27*(1), 45–53. https://doi.org/10.1037/pmu0000170

*Stambaugh, L. A. (2019). Effects of focus of attention on performance by second-year band students. *Journal of Research in Music Education*, *67*(2), 233–246. https://doi.org/10.1177/0022429419835841

*Steenstrup, K., Haumann, N. T., Kleber, B., Camarasa, C., Vuust, P., & Petersen, B. (2021). Imagine, sing, play- combined mental, vocal and physical practice improves musical performance. *Frontiers Psychology*, *12*, Article 757052. https://doi.org/10.3389/fpsyg.2021.757052

*Sweeney, G. A., & Horan, J. J. (1982). Separate and combined effects of cue-controlled relaxation and cognitive restructuring in the treatment of musical performance anxiety. *Journal of Counseling Psychology*, *29*(5), 486–497. https://doi.org/10.1037/0022-0167.29.5.486

*Sweeney-Burton, C. (1997). *Effects of self-relaxation techniques training on performance anxiety and on performance quality in a music performance condition* (Publication No. 9802807) [Doctoral dissertation, University of North Carolina at Greensboro]. ProQuest Dissertations and Theses Global.

*Tang, Y., & Ryan, L. (2020). Music performance anxiety: Can expressive writing intervention help? *Frontiers in Psychology*, *11*, Article 1334. https://doi.org/10.3389/fpsyg.2020.01334

*Theiler, A. M., & Lippman, L. G. (1995). Effects of mental practice and modeling on guitar and vocal performance. *The Journal of General Psychology*, *122*(4), 329–343. https://doi.org/10.1080/00221309.1995.9921245

Thornton, A., & Lee, P. (2000). Publication bias in meta-analysis: Its causes and consequences. *Journal of Clinical Epidemiology*, *53*, 207–216. https://doi.org/10.1016/S0895-4356(99)00161-4

*Tief, V. J., & Gröpel, P. (2021). Pre-performance routines for music students: An experimental pilot study. *Psychology of Music*, *49*(5), 1261–1272/. https://doi.org/10.1177/0305735620953621

*Timmers, R., Sadakata, M., & Desain, P. W. (2012). The role of visual feedback and creative exploration for the improvement of timing accuracy in performing musical ornaments. *Music Perception*, *30*(2), 187–204. https://doi.org/10.1525/mp.2012.30.2.187

*Valentine, E. R., Fitzgerald, D. F. P., Gorton, T. L., Hudson, J. A., & Symonds, E. R. C. (1995). The effect of lessons in the Alexander technique on music performance in high and low stress situations. *Psychology of Music*, *23*, 129–141. https://doi.org/10.1177/0305735695232002

*Van McKinney, H. (1984). *The effects of thermal biofeedback training on musical performance and performance anxiety* (Publication No. 8418130) [Doctoral dissertation, University of Northern Colorado]. ProQuest Dissertations and Theses Global.

*Van Zijl, A. G. W., & Luck, G. (2013). Thoughts in concert: A multi-method approach to investigate the effect of performers' focus of attention. In A. Williamon & W. Goebl (Eds.), Proceedings of the International Symposium on Performance Science (pp. 665–670). European Association of Conservatoires.

Varela, W., Abrami, P. C., & Upitis, R. (2016). Self-regulation and music learning: A systematic review. *Psychology of Music*, *44*(1), 55–74. https://doi.org/10.1177/0305735614554639

*Wardle, A. (1974). Behavioral modification by reciprocal inhibition of instrumental music performance anxiety. *Journal of Band Research*, *11*(1), 18–26.

*Williams, S. G. (2019). *Finding focus: Using external focus of attention for practicing and performing music* [Doctoral dissertation, Universiteit Leiden]. Leiden University Scholarly Publications. https://hdl.handle.net/1887/73832

Willis, S. E., Neil, R., Mellick, M. C., & Wasley, D. (2019). The relationship between occupational demands and well-being of performing artists: A systematic review. *Frontiers in Psychology*, *10*, Article 393. https://doi.org/10.3389/fpsyg.2019.00393

Wulf, G. (2013). Attentional focus and motor learning: A review of 15 years. *International Review of Sport and Exercise Psychology*, *6*(1), 77–104. https://doi.org/10.1080/1750984X.2012.723728

Zimmerman, B. J. (1986). Becoming a self-regulated learner: Which are the key subprocesses? *Contemporary Educational Psychology*, *11*(4), 307–313.

Zimmerman, B. J. (1998). Academic studying and the development of personal skill: A self-regulatory perspective. *Educational Psychologist*, *33*, 73–86. https://doi.org/10.1080/00461520.1998.9653292

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*, 166–183. https://doi.org/10.3102/0002831207312909