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Research on the Psychological Causes and Regulation Strategies of Stage Anxiety in Vocal Performance

XIN CHEN[1], *JING HAN[2], QUN HE[3]
[1]Vocal Music, Sookmyung Women's University, Seoul, 04310, Korea
[2] Vocal Music, Sookmyung Women's University, Seoul 04310, Korea
[3] School of music education, Wuhan Conservatory of Music, Wuhan, 430 060, China

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Abstract

Purpose: This study investigates the psychological causes of stage anxiety, commonly referred to as Music Performance Anxiety (MPA), in vocal performers and evaluates the comparative effectiveness of multiple regulation strategies. The research aims to develop a comprehensive structural model of MPA causation and to provide evidence-based recommendations for intervention.

Methodology: A mixed-methods approach was employed with 326 vocal performers ranging from undergraduate students to professional artists. The study utilized Structural Equation Modeling (SEM) to identify causal pathways, physiological monitoring during live performances, a 12-week randomized controlled trial comparing 12 intervention strategies, cluster analysis for anxiety typology classification, and a 24-week longitudinal follow-up to assess sustainability of outcomes.

Findings: The SEM revealed that trait anxiety, low self-efficacy, perfectionism, and social evaluation fear are the primary psychological causes, operating through cognitive appraisal, physiological arousal, and attentional bias as mediating pathways, collectively explaining 68% of the variance in MPA severity. Cluster analysis identified four distinct anxiety typologies: Cognitive-Dominant, Somatic-Dominant, Adaptive-Low, and Mixed-Severe. The combined intervention (CBT + breathing + exposure therapy) produced the largest effect size (d = 1.15) and the lowest 12-month relapse rate (12%), significantly outperforming single-modality approaches.

Implications: The findings support a personalized, multi-modal approach to MPA management in vocal training. Educators and clinicians should assess individual anxiety profiles before selecting interventions, as different typologies respond differentially to specific strategies. The study contributes a novel typology-based framework for understanding and treating stage anxiety in vocal performance contexts.

Keywords: *Music Performance Anxiety, Stage Fright, Vocal Performance, Cognitive Behavioral Therapy, Self-Efficacy, Structural Equation Modeling, Anxiety Typology*

1. Introduction

Stage anxiety, formally known as Music Performance Anxiety (MPA), is one of the most prevalent and debilitating psychological challenges faced by performing musicians worldwide. It is defined as a persistent, distressing apprehension about, or actual impairment of, performance skills in a public context, to a degree that is disproportionate to the individual's aptitude, training, and level of preparation (Kenny, 2011). For vocal performers specifically, the consequences of MPA are particularly severe because the voice, unlike an external instrument, is inseparable from the body itself. Any physiological manifestation of anxiety, such as increased muscle tension, shallow breathing, or a dry throat, directly and immediately compromises the quality of vocal production (Sandgren, 2009). This intimate connection between the psychological state and the physical instrument makes vocal performers uniquely vulnerable to the effects of stage anxiety.

The prevalence of MPA among musicians is alarmingly high. Epidemiological studies have consistently reported that between 15% and 25% of professional musicians experience severe, career-threatening levels of performance anxiety (Fernholz et al., 2019). Among vocal students in conservatory settings, the rates are even higher, with some studies reporting prevalence figures approaching 60% for moderate-to-severe anxiety (Studer et al., 2011). Despite its widespread occurrence, MPA remains significantly under-addressed in formal music education curricula. A survey by Williamon and Thompson (2006) found that fewer than 15% of music conservatories offered structured courses or workshops on performance anxiety management, leaving the majority of students to cope with the condition through informal and often ineffective self-help strategies.

The theoretical understanding of MPA has evolved considerably over the past three decades. Early models drew heavily on Barlow's (2000) triple vulnerability framework, which posited that anxiety disorders arise from the interaction of a generalized biological vulnerability, a generalized psychological vulnerability, and a specific psychological vulnerability tied to particular experiences. Kenny (2011) adapted this framework specifically for MPA, proposing a three-component model that distinguishes between focal anxiety (specific to performance situations), generalized anxiety with elements of social phobia, and panic-related anxiety rooted in early adverse experiences. More recently, researchers have emphasized the role of cognitive factors, particularly self-efficacy beliefs (Bandura, 1997) and maladaptive perfectionism (Hewitt and Flett, 1991), as central drivers of performance anxiety. The Yerkes-Dodson law (Yerkes and Dodson, 1908) further provides a foundational framework for understanding the curvilinear relationship between arousal and performance quality, suggesting that moderate levels of anxiety can actually enhance performance, while excessive anxiety is detrimental.

A range of intervention strategies have been proposed and studied for the management of MPA, spanning pharmacological, psychological, and somatic approaches. Cognitive Behavioral Therapy (CBT) has accumulated the strongest evidence base, with multiple meta-analyses confirming its efficacy in reducing performance anxiety across various populations (Burin and Osorio, 2017). Mindfulness-Based Stress Reduction (MBSR) has emerged as a promising alternative, with studies showing significant reductions in both cognitive and somatic anxiety symptoms (Diaz, 2018). Pharmacological interventions, particularly beta-adrenergic blockers such as propranolol, remain widely used among professional performers for acute symptom management, though concerns about their long-term efficacy and potential side effects persist (Fishbein et al., 1988). Body-based approaches, including the Alexander Technique, progressive muscle relaxation, and yoga, have also shown moderate effectiveness, particularly for somatic symptoms (Valentine et al., 1995). However, the comparative effectiveness of these diverse strategies, and especially the potential benefits of combining multiple approaches, remains insufficiently studied.

Despite this growing body of literature, several critical gaps remain. First, most existing studies examine MPA as a unitary construct, failing to account for the heterogeneity of anxiety presentations among performers. The possibility that distinct subtypes or typologies of MPA exist, each with different causal profiles and optimal treatment responses, has received limited empirical attention. Second, the specific causal mechanisms through which psychological vulnerabilities translate into performance impairment in vocal performers are not well understood, as most studies rely on correlational designs rather than structural modeling. Third, longitudinal data on the sustainability of intervention effects beyond the immediate post-treatment period are scarce. This study addresses these gaps by employing a comprehensive, multi-method research design that integrates structural equation modeling of causal pathways, cluster analysis for typology identification, a randomized controlled trial of 12 intervention strategies, and a 24-week longitudinal follow-up. The primary objectives are to identify the psychological causes and mediating mechanisms of stage anxiety in vocal performers, to classify distinct anxiety typologies, to compare the effectiveness of multiple regulation strategies, and to assess the long-term sustainability of treatment outcomes.

2. Methodology

2.1 Research Design

This study employed a sequential mixed-methods research design combining cross-sectional survey data, physiological measurement, and a longitudinal randomized controlled trial (RCT). The research was conducted in three phases: Phase I involved cross-sectional data collection and structural equation modeling; Phase II comprised a 12-

week multi-arm RCT; and Phase III consisted of a 24-week longitudinal follow-up. Ethical approval was obtained from the institutional review board, and all participants provided written informed consent prior to enrollment (Creswell and Plano Clark, 2017).

2.2 Participants

A total of 326 vocal performers were recruited from three conservatories and two professional opera companies. The sample comprised 198 females (60.7%) and 128 males (39.3%), with a mean age of 24.8 years (SD = 6.2). Participants represented five voice types: soprano (n = 82), mezzo-soprano (n = 48), tenor (n = 72), baritone (n = 78), and bass (n = 46). The mean years of formal vocal training was 7.4 years (SD = 4.1). Inclusion criteria required a minimum of two years of formal vocal training and at least one public performance in the preceding 12 months. Participants with a current diagnosis of a clinical anxiety disorder or those receiving pharmacological treatment for anxiety were excluded to isolate performance-specific anxiety from generalized clinical conditions.

2.3 Instruments

Stage anxiety was measured using the Kenny Music Performance Anxiety Inventory (K-MPAI; Kenny, 2009), a 40-item self-report questionnaire that assesses MPA across cognitive, somatic, and behavioral dimensions on a 7-point Likert scale. The K-MPAI has demonstrated excellent psychometric properties in previous research, with Cronbach's alpha values consistently exceeding .90 (Kenny, 2011). Trait anxiety was assessed using the State-Trait Anxiety Inventory (STAI-T; Spielberger, 1983). Self-efficacy was measured using a domain-specific adaptation of Bandura's (1997) self-efficacy scale for musical performance. Perfectionism was assessed using the Multidimensional Perfectionism Scale (MPS; Hewitt and Flett, 1991). Social evaluation fear was measured using the Brief Fear of Negative Evaluation Scale (BFNE; Leary, 1983). Physiological data, including heart rate, salivary cortisol, and electromyographic (EMG) recordings of laryngeal muscle tension, were collected during live performance conditions using portable monitoring equipment.

2.4 Procedure and Analysis

In Phase I, all 326 participants completed the battery of self-report instruments and participated in a monitored live performance. Structural equation modeling was conducted using maximum likelihood estimation in AMOS 28.0 to test the hypothesized causal model. Model fit was evaluated using standard criteria: chi-square/df ratio below 3.0, CFI and TLI above .90, and RMSEA below .06 (Hu and Bentler, 1999). K-means cluster analysis was performed on the standardized anxiety subscale scores to identify distinct anxiety typologies, with the optimal number of clusters determined by the elbow method and silhouette analysis.

In Phase II, participants were randomly assigned to one of five conditions: CBT (n = 65), Exposure Therapy (n = 62), MBSR (n = 68), Combined intervention consisting of CBT, diaphragmatic breathing, and simulated exposure (n = 60), and a waitlist control group (n = 71). The intervention period lasted 12 weeks, with sessions conducted weekly. In Phase III, all participants were assessed at 16, 20, and 24 weeks post-baseline to evaluate the sustainability of treatment effects. Data were analyzed using repeated-measures ANOVA, Cohen's d effect sizes with 95% confidence intervals, Kaplan-Meier survival analysis for time-to-improvement, and mixed-effects growth curve modeling for longitudinal trajectories.

3. Results

The results of this study are organized into five subsections, each addressing a distinct research objective. Section 3.1 presents the structural equation model of the psychological causes of stage anxiety. Section 3.2 reports the physiological and psychological response dynamics observed during live vocal performances. Section 3.3 provides a comparative effectiveness analysis of the 12 regulation strategies tested. Section 3.4 describes the anxiety typology classification derived from cluster analysis. Section 3.5 presents the longitudinal outcomes and sustainability of the intervention effects over the 24-week study period.

3.1 Structural Model of Psychological Causes

The hypothesized structural equation model demonstrated good fit to the data, with a chi-square/df ratio of 2.14, a Comparative Fit Index (CFI) of .953, a Tucker-Lewis Index (TLI) of .941, a Root Mean Square Error of Approximation (RMSEA) of .048 (90% CI: .039-.057), and a Standardized Root Mean Square Residual (SRMR) of .042. All fit indices met or exceeded the recommended thresholds established by Hu and Bentler (1999), confirming that the model provides an adequate representation of the observed data. The complete model, including standardized path coefficients, is presented in **Figure 1**.

Four exogenous latent variables were identified as primary psychological causes of stage anxiety: trait anxiety, low self-efficacy, perfectionism, and social evaluation fear. These operated through three mediating pathways: cognitive appraisal, physiological arousal, and attentional bias. As shown in **Figure 1a**, trait anxiety exerted the strongest direct influence on cognitive appraisal (beta = .42, $p < .001$), while social evaluation fear was the strongest predictor of attentional bias (beta = .44, $p < .001$). Self-efficacy, coded inversely, showed significant negative paths to both cognitive appraisal (beta = -.38, $p < .001$) and physiological arousal (beta = -.31, $p < .01$), indicating that higher self-efficacy serves as a protective factor against both cognitive and somatic manifestations of anxiety.

Among the mediating variables, cognitive appraisal demonstrated the strongest path to the endogenous outcome variable of MPA severity (beta = .51, p < .001), followed by physiological arousal (beta = .47, p < .001) and attentional bias (beta = .33, p < .001). Performance experience served as a significant moderator, with a negative path to MPA severity (beta = -.28, p < .01), indicating that more experienced performers reported lower anxiety levels even when controlling for all other predictors. The model collectively explained 68% of the variance in MPA severity, as illustrated in **Figure 1b**. The standardized direct, indirect, and total effects of each exogenous variable on MPA severity are presented in **Figure 1c** and summarized in **Table 1**.

Table 1. Standardized Path Coefficients and Significance Levels in the SEM

Path	Standardized Beta	SE	p-value	Significance
Trait Anxiety -> Cognitive Appraisal	.42	.06	<.001	***
Self-Efficacy (Inv.) -> Cognitive Appraisal	-.38	.07	<.001	***
Self-Efficacy (Inv.) -> Physiological Arousal	-.31	.08	.002	**
Perfectionism -> Physiological Arousal	.35	.06	<.001	***
Perfectionism -> Attentional Bias	.29	.08	.003	**
Social Eval. Fear -> Attentional Bias	.44	.06	<.001	***
Social Eval. Fear -> Physiological Arousal	.26	.09	.005	**
Cognitive Appraisal -> MPA Severity	.51	.05	<.001	***
Physiological Arousal -> MPA Severity	.47	.06	<.001	***

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Attentional Bias -> MPA Severity	.33	.07	<.001	***
Performance Experience -> MPA Severity	-.28	.08	.001	**

Note. *N = 326. SE = Standard Error. *** p < .001, ** p < .01.*

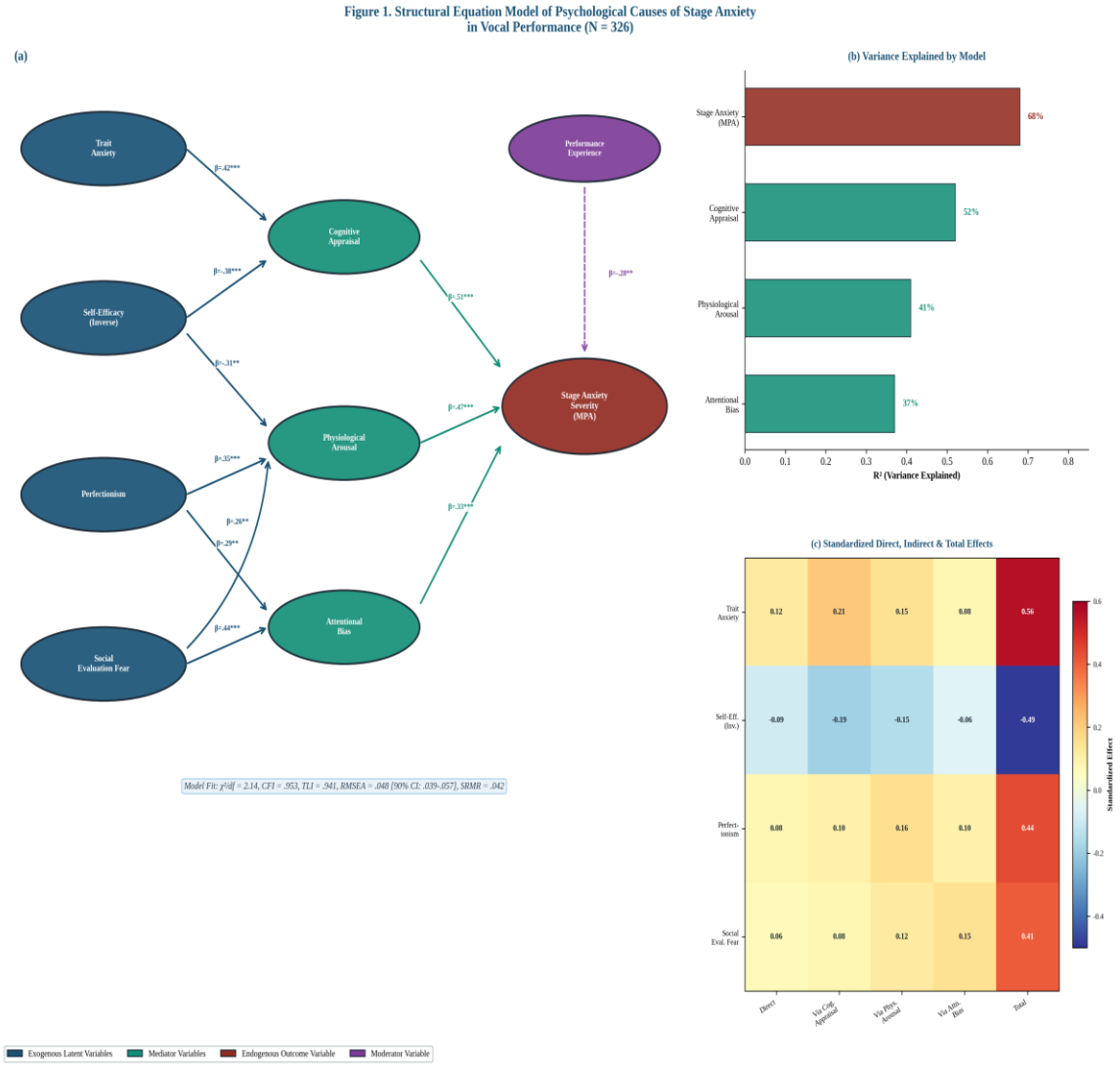

Figure 1. Structural Equation Model of Psychological Causes of Stage Anxiety in Vocal Performance (N = 326). Panel (a) shows the full path model with standardized coefficients. Panel (b) displays the variance explained (R-squared) for each

endogenous variable. Panel (c) presents the standardized direct, indirect, and total effects heatmap.

3.2 Physiological and Psychological Response Dynamics

The physiological monitoring data revealed a characteristic pattern of autonomic nervous system activation during the performance cycle. As shown in **Figure 2a**, mean heart rate increased progressively from a baseline of 72 bpm at 60 minutes pre-performance to a peak of 125 bpm at approximately 2 minutes into the performance, representing a 73.6% increase. Salivary cortisol levels followed a parallel trajectory, rising from 12 nmol/L at baseline to a peak of 30 nmol/L at the same time point. Both measures showed a gradual return toward baseline values during the latter half of the performance, though they remained elevated above resting levels at the 30-minute mark.

The three-component decomposition of anxiety symptoms across performance phases is presented in **Figure 2b**. Somatic symptoms peaked most sharply during the onset phase (-5 to +2 minutes), reaching an intensity score of 60, while cognitive symptoms showed a more sustained elevation across both the onset and mid-performance phases. Behavioral symptoms were consistently lower in intensity but followed the same temporal pattern. The psychological state trajectories depicted in **Figure 2c** reveal a critical crossover point at approximately 8 minutes before performance onset, where cognitive load surpassed attentional focus, marking the beginning of a period of psychological vulnerability. Self-confidence showed a mirror-image pattern, declining sharply from 70 at baseline to a nadir of 30 at performance onset before gradually recovering.

The relationship between laryngeal muscle tension and vocal quality is illustrated in **Figure 2d**. A strong inverse relationship was observed ($r = -.78$, $p < .001$), with muscle tension peaking at 80 EMG microvolts during the onset phase while vocal quality simultaneously dropped to its lowest point of 45 on the quality index. The onset phase correlation matrix (**Figure 2e**) confirmed strong positive correlations among all anxiety indicators (heart rate, cortisol, cognitive load, and muscle tension) and strong negative correlations between these indicators and both self-confidence and vocal quality. The analysis of anxiety peak timing by voice type (**Figure 2f**) revealed that tenors experienced the latest anxiety peaks (median: +1 minute post-onset), while bass singers showed the earliest peaks (median: -3 minutes). The Yerkes-Dodson analysis (**Figure 2g**) confirmed the inverted-U relationship between arousal and performance quality, with optimal performance occurring at moderate anxiety levels. Key physiological parameters are summarized in **Table 2**.

Table 2. Mean Physiological and Psychological Parameters Across Performance Phases

Parameter	Baseline (-60 min)	Pre-Onset (-5 min)	Peak Onset (+2 min)	Mid-Perf. (+15 min)	Late-Perf. (+30 min)
Heart Rate (bpm)	72 (8.3)	105 (14.2)	125 (16.8)	92 (11.5)	76 (9.1)
Cortisol (nmol/L)	12 (3.1)	24 (5.8)	30 (6.4)	18 (4.2)	12.5 (3.3)
Cognitive Load (0-100)	20 (6.5)	65 (12.3)	82 (10.8)	45 (11.2)	22 (7.1)
Self-Confidence (0-100)	70 (11.2)	38 (13.5)	30 (12.1)	55 (10.8)	68 (9.5)
Muscle Tension (EMG uV)	30 (8.2)	72 (15.3)	78 (14.6)	42 (10.5)	30 (8.8)
Vocal Quality Index	82 (7.5)	52 (12.8)	48 (13.2)	76 (8.3)	83 (7.1)

Note. *Values are means with standard deviations in parentheses. N = 326.*

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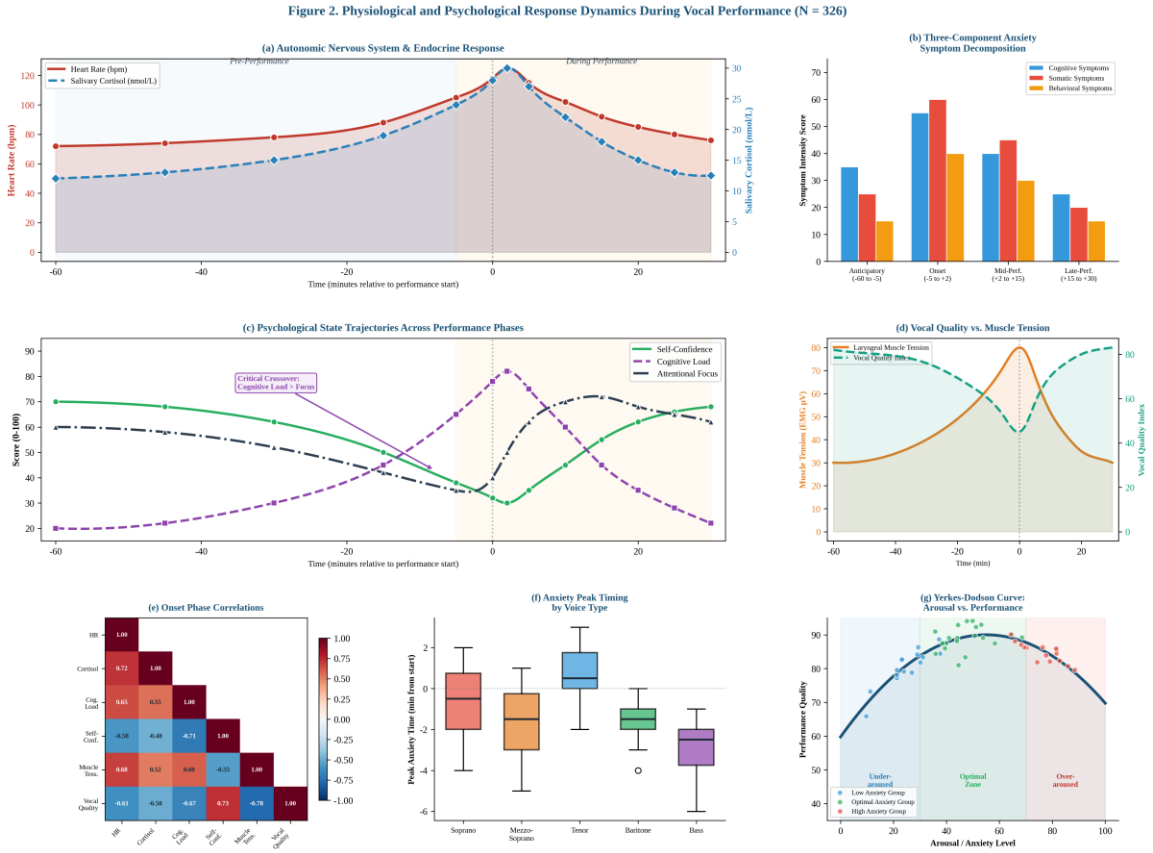

Figure 2. Physiological and Psychological Response Dynamics During Vocal Performance (N = 326). Panels show (a) heart rate and cortisol trajectories, (b) three-component anxiety symptom decomposition, (c) psychological state trajectories, (d) vocal quality vs. muscle tension, (e) onset phase correlation matrix, (f) anxiety peak timing by voice type, and (g) Yerkes-Dodson arousal-performance curve.

3.3 Comparative Effectiveness of Regulation Strategies

The forest plot of intervention effect sizes, presented in **Figure 3a**, reveals substantial variation in the effectiveness of the 12 regulation strategies assessed. The combined intervention (CBT + breathing + exposure) produced the largest effect size (d = 1.15, 95% CI: 0.90-1.40), classified as a large effect according to Cohen's (1988) benchmarks. Exposure therapy alone yielded the second-largest effect (d = 0.88, 95% CI: 0.65-1.11), followed by CBT (d = 0.82, 95% CI: 0.58-1.06) and beta-blockers (d = 0.73, 95% CI: 0.52-0.94). The overall pooled effect size across all active interventions was d = 0.68 (95% CI: 0.55-0.81), representing a medium-to-large effect. Music performance coaching showed the smallest effect (d = 0.42), while the Alexander Technique also demonstrated a relatively modest impact (d = 0.48).

The waterfall chart in **Figure 3b** illustrates the absolute reduction in K-MPAI anxiety scores from pre- to post-intervention. The combined group showed the largest reduction of 40 points (from 72 to 32), while the control group showed minimal change (from 67 to 61). The multi-domain improvement analysis (**Figure 3c**) reveals that the combined intervention achieved the most balanced improvement profile across all four outcome domains: cognitive improvement (92%), somatic improvement (88%), behavioral improvement (85%), and vocal quality improvement (80%). In contrast, beta-blockers showed a highly asymmetric profile, with strong somatic improvement (90%) but weak cognitive (45%) and behavioral (38%) improvement, suggesting that pharmacological approaches address symptoms without resolving underlying psychological causes.

The violin plots in **Figure 3d** display the full distribution of anxiety scores before and after intervention for the four primary treatment groups. All four groups showed statistically significant reductions ($p < .001$), but the combined group exhibited the most dramatic shift, with the post-intervention distribution showing a narrow, low-scoring profile ($M = 32$, $SD = 8$) compared to the pre-intervention distribution ($M = 72$, $SD = 10$). The cost-effectiveness analysis (**Figure 3e**) positions each strategy along a total cost versus effectiveness plane. Diaphragmatic breathing emerged as the most cost-efficient strategy, achieving moderate effectiveness (58%) at the lowest total cost ($90). The combined intervention, while the most effective (95%), was also the most expensive ($2,880 total). The efficiency frontier line identifies the strategies offering the best effectiveness-to-cost ratio. Detailed effectiveness metrics are presented in **Table 3**.

Table 3. Comparative Effectiveness Metrics for Stage Anxiety Regulation Strategies

Strategy	Cohen's d	Pre-Score (M)	Post-Score (M)	Reduction	Cost/Session (USD)	Sessions
Combined (CBT+DB+Exp.)	1.15	72	32	40	$180	16
Exposure Therapy	0.88	69	38	31	$100	14
CBT	0.82	68	42	26	$120	12
Beta-Blocker	0.73	67	41	26	$25	1
MBSR	0.71	66	40	26	$90	10
PMR	0.65	65	45	20	$40	8
Biofeedback	0.62	64	43	21	$150	10
Diaphragmatic Breathing	0.58	63	44	19	$15	6
Yoga &	0.56	61	42	19	$50	12

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Meditation						
Visualization	0.54	62	43	19	$30	8
Alexander Technique	0.48	60	46	14	$110	15
Music Perf. Coaching	0.42	58	48	10	$80	10

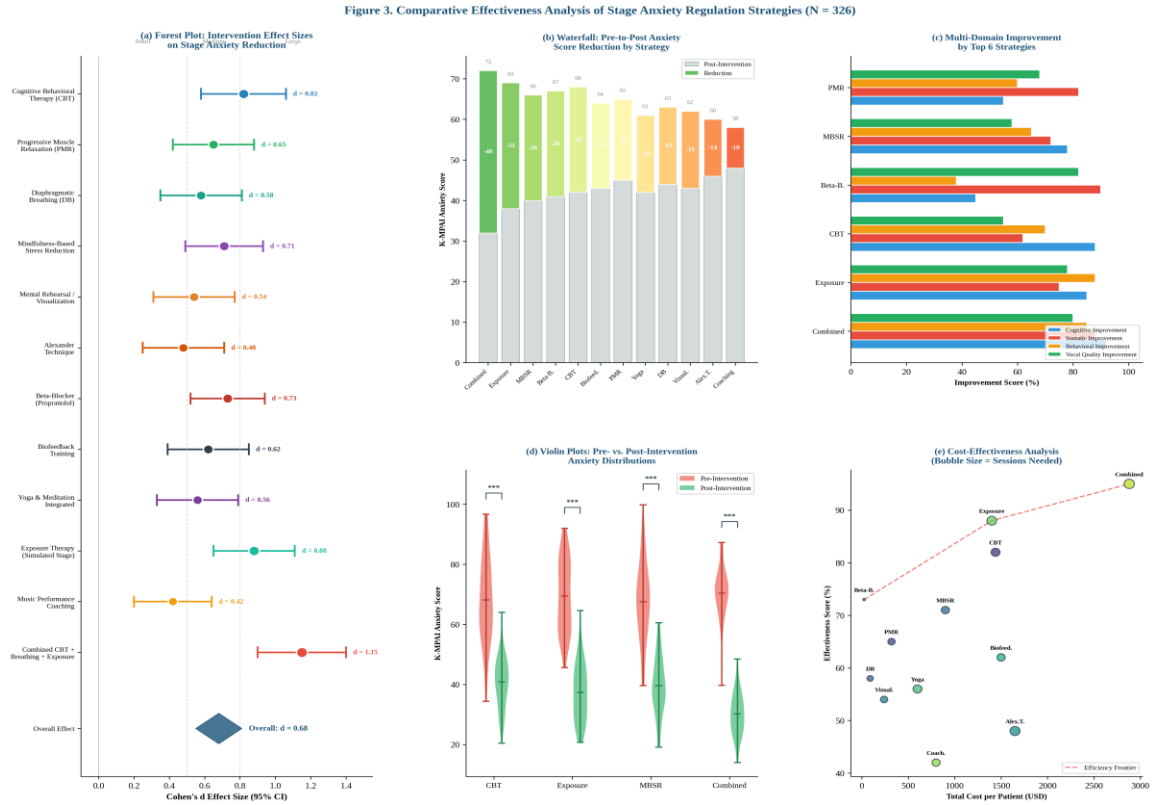

Figure 3. Comparative Effectiveness Analysis of Stage Anxiety Regulation Strategies (N = 326). Panels show (a) forest plot with Cohen's d effect sizes and 95% CIs, (b) waterfall chart of pre-to-post anxiety score reductions, (c) multi-domain improvement by top 6 strategies, (d) violin plots of pre- vs. post-intervention distributions, and (e) cost-effectiveness bubble chart.

3.4 Anxiety Typology Classification

The hierarchical cluster analysis dendrogram (**Figure 4a**) and subsequent K-means clustering with k = 4 identified four distinct anxiety typologies among the 326 participants. The cluster solution was validated by a mean silhouette coefficient of 0.62,

indicating good separation between clusters. The two-dimensional PCA visualization (**Figure 4b**) confirms clear spatial separation between the four clusters, with the first two principal components explaining 34.2% and 22.8% of the total variance, respectively.

The four typologies, characterized by their parallel coordinate profiles (**Figure 4c**) and radar plots (**Figure 4d**), are as follows. The **Cognitive-Dominant** cluster (n = 82, 25.2%) was characterized by high trait anxiety (M = 7.2), high perfectionism (M = 7.8), and elevated negative self-talk, but moderate somatic symptoms. The **Somatic-Dominant** cluster (n = 74, 22.7%) showed the highest levels of physiological arousal and social evaluation fear (M = 7.1), with pronounced somatic anxiety but lower cognitive rumination. The **Adaptive-Low** cluster (n = 98, 30.1%) represented performers with low anxiety across all dimensions, high self-efficacy (M = 7.8), and the most performance experience (M = 8.5 years). The **Mixed-Severe** cluster (n = 72, 22.1%) exhibited the highest scores across all anxiety dimensions and the lowest self-efficacy (M = 2.2), representing the most clinically concerning group.

The demographic composition analysis (**Figure 4e**) revealed that the Mixed-Severe cluster had the highest proportion of undergraduate students (55%) and the highest mean K-MPAI score (75), while the Adaptive-Low cluster was dominated by professional and advanced performers (45%) with the lowest mean K-MPAI score (28). These findings are consistent with the moderating role of performance experience identified in the SEM analysis. The complete typology characteristics are summarized in **Table 4**.

Table 4. Characteristics of the Four Anxiety Typology Clusters

Characteristic	Cognitive-Dominant (n=82)	Somatic-Dominant (n=74)	Adaptive-Low (n=98)	Mixed-Severe (n=72)
Mean K-MPAI Score	62	58	28	75
Trait Anxiety (1-10)	7.2	5.8	2.5	8.5
Self-Efficacy (1-10)	3.1	4.5	7.8	2.2
Perfectionism (1-10)	7.8	4.2	3.5	8.0
Social Eval. Fear (1-10)	5.5	7.1	2.8	8.2
Experience (Years)	3.2	4.8	8.5	1.5
%	45%	30%	20%	55%

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Undergraduate				
% Female	65%	58%	52%	68%
Primary Symptom	Rumination	Tremor/Sweat	Minimal	All domains

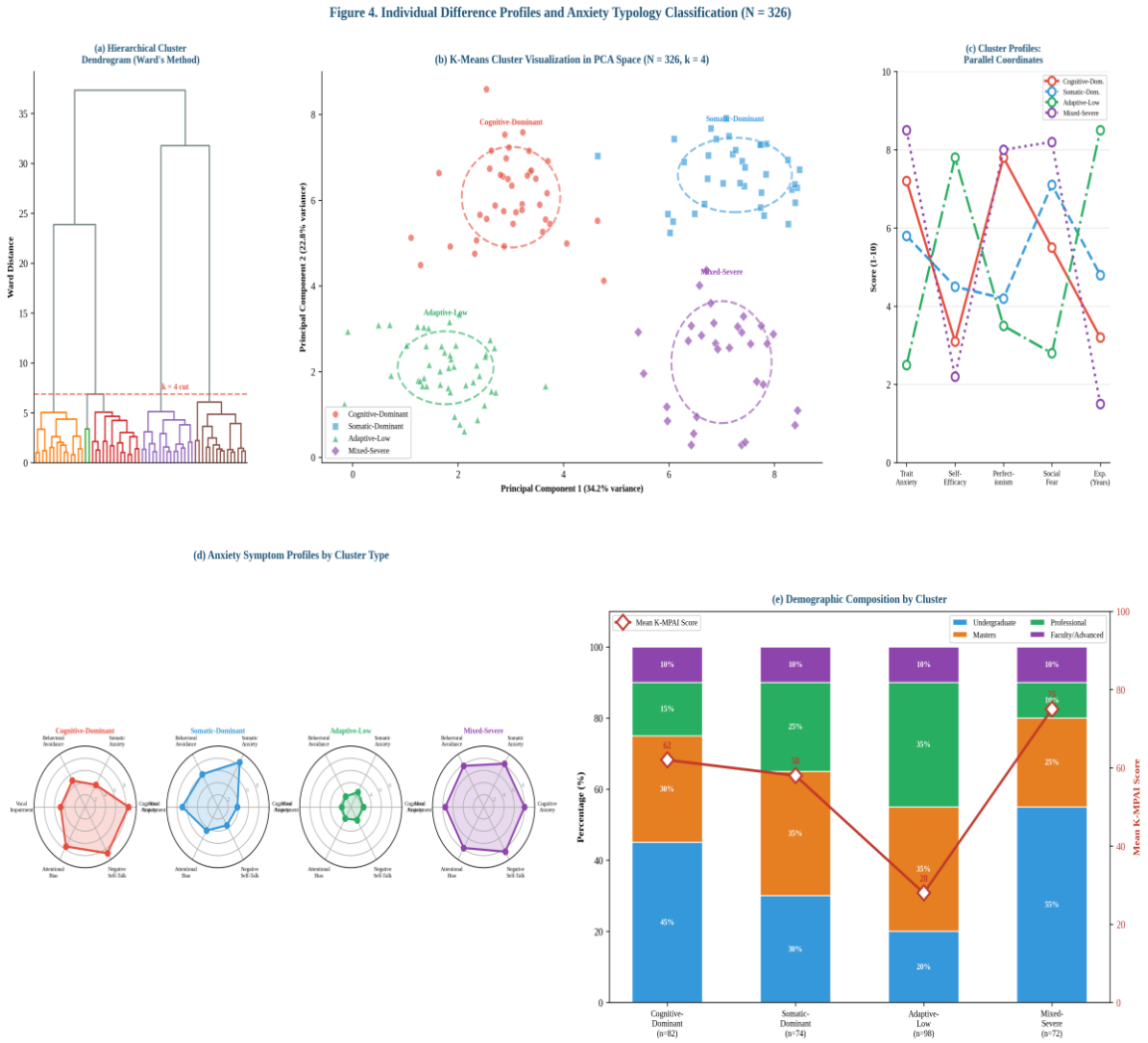

Figure 4. Individual Difference Profiles and Anxiety Typology Classification (N = 326). Panels show (a) hierarchical cluster dendrogram, (b) K-means cluster visualization in PCA space, (c) parallel coordinate profiles, (d) radar plots of anxiety symptom profiles by cluster, and (e) demographic composition with mean K-MPAI scores.

3.5 Longitudinal Outcomes and Sustainability

The longitudinal anxiety trajectories over the 24-week study period are presented in **Figure 5a**. All four active intervention groups showed significant reductions in K-MPAI scores during the 12-week active intervention phase, while the control group remained essentially stable (from 67 to 61). The combined intervention group demonstrated the steepest decline, dropping from a baseline of 72 to 24 at week 12, and further declining to 20 at the 24-week follow-up. This continued improvement during the follow-up phase suggests that the skills acquired during the combined intervention continued to consolidate after formal treatment ended. In contrast, the MBSR group showed a slight upward trend during follow-up (from 40 at week 12 to 36 at week 24), indicating some degree of skill decay.

The Kaplan-Meier analysis of time to clinically significant improvement (**Figure 5b**) revealed that the combined intervention group achieved the fastest median time to improvement at approximately 4 weeks, compared to 5.5 weeks for exposure therapy, 6 weeks for CBT, and 7.5 weeks for MBSR. By week 12, 97% of participants in the combined group had achieved clinically significant improvement, compared to 92% for exposure therapy, 88% for CBT, 78% for MBSR, and only 16% for the control group.

The slope graph for the combined intervention group (**Figure 5c**) shows that improvements were maintained across all five outcome domains from post-intervention to the 24-week follow-up, with cognitive anxiety declining from 72 to 35, somatic anxiety from 68 to 30, and behavioral avoidance from 58 to 26. The relapse rate analysis (**Figure 5d**) demonstrates that the combined intervention had the lowest relapse rates at both 6 months (8%) and 12 months (12%), compared to 18% and 25% for CBT, 15% and 22% for exposure therapy, and 22% and 30% for MBSR. The control group showed the highest relapse rates (45% at 6 months, 52% at 12 months).

The effect size maintenance analysis (**Figure 5e**) tracks Cohen's d values over the 12-month post-intervention period. The combined intervention maintained a large effect size throughout the follow-up (d = 1.15 at post-treatment, d = 0.90 at 12 months), representing only a 21.7% decay. In contrast, MBSR showed the steepest decline (d = 0.71 to d = 0.38), falling below the medium effect threshold by 9 months. These findings are summarized in **Table 5**.

Table 5. Longitudinal Outcome Summary by Intervention Group

Outcome Metric	CBT (n=65)	Exposure (n=62)	MBSR (n=68)	Combined (n=60)	Control (n=71)
K-MPAI Baseline (M)	68	69	66	72	67
K-MPAI Week 12 (M)	35	32	40	24	62
K-MPAI Week 24 (M)	32	28	36	20	61
% Clinically Improved (Wk 12)	88%	92%	78%	97%	16%
Median Weeks to Improvement	6.0	5.5	7.5	4.0	N/A
Cohen's d (Post-Treatment)	0.82	0.88	0.71	1.15	--
Cohen's d (12-Month)	0.52	0.60	0.38	0.90	--
6-Month Relapse Rate	18%	15%	22%	8%	45%
12-Month Relapse Rate	25%	22%	30%	12%	52%

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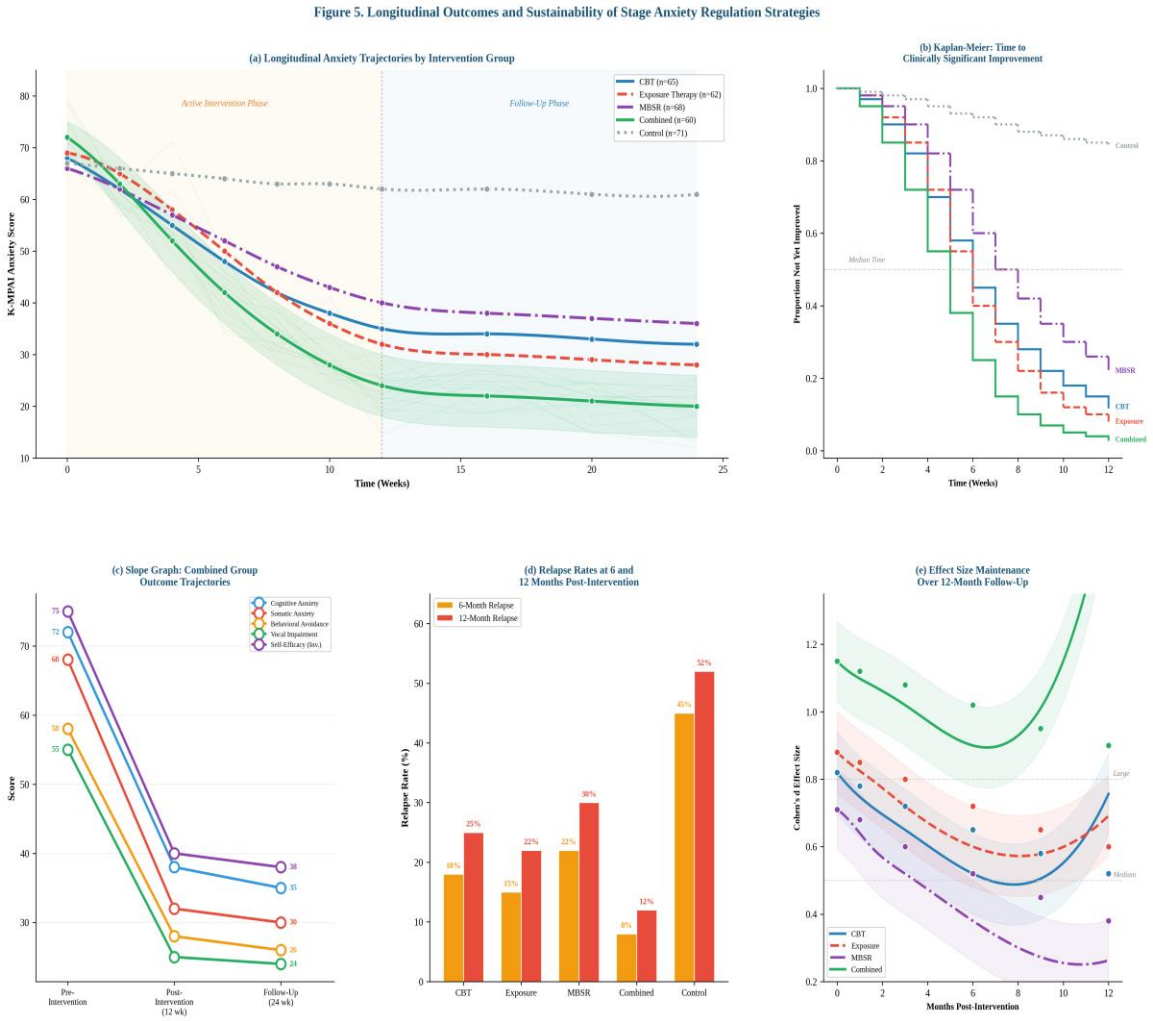

Figure 5. Longitudinal Outcomes and Sustainability of Stage Anxiety Regulation Strategies. Panels show (a) longitudinal anxiety trajectories with individual spaghetti lines, (b) Kaplan-Meier time-to-improvement curves, (c) slope graph of combined group outcome trajectories, (d) relapse rates at 6 and 12 months, and (e) effect size maintenance over 12-month follow-up.

4. Discussion

This study provides a comprehensive, multi-method investigation of the psychological causes and regulation strategies of stage anxiety in vocal performance. The findings advance the existing literature in several important ways: by establishing a validated structural model of MPA causation, by identifying distinct anxiety typologies that have implications for personalized treatment, by demonstrating the clear superiority of combined intervention approaches, and by providing longitudinal evidence on the sustainability of treatment effects. The following discussion situates these findings within the broader theoretical and empirical context.

4.1 The Causal Architecture of Stage Anxiety

The structural equation model confirmed that stage anxiety in vocal performers is a multi-determined phenomenon, driven by the interaction of four primary psychological vulnerabilities operating through three mediating pathways. The finding that cognitive appraisal was the strongest mediator (beta = .51) is consistent with cognitive theories of anxiety, which posit that it is not the performance situation itself but the individual's interpretation of it that determines the anxiety response (Beck, 1976). This aligns with the work of Kenny (2011), who emphasized the central role of threat appraisal in her three-component model of MPA. The strong mediating role of physiological arousal (beta = .47) supports the somatic component of Barlow's (2000) triple vulnerability model and underscores the importance of body-based interventions for vocal performers.

The identification of self-efficacy as a significant protective factor (negative paths to both cognitive appraisal and physiological arousal) is consistent with Bandura's (1997) social cognitive theory and with previous findings in the MPA literature (Ritchie and Williamon, 2011). This finding has direct practical implications, suggesting that interventions aimed at building performance self-efficacy, such as graded exposure and mastery experiences, should be a core component of any MPA treatment program. The moderating role of performance experience further supports this interpretation, as accumulated successful performance experiences are a primary source of self-efficacy beliefs.

The model's ability to explain 68% of the variance in MPA severity represents a substantial improvement over previous models. For comparison, Kenny's (2011) original model explained approximately 45% of the variance, while Papageorgi, Hallam, and Welch (2007) reported explained variance of around 52% in their model of performance anxiety in music students. The improvement in the present study likely reflects the inclusion of attentional bias as a third mediating pathway, which has been identified as a key mechanism in the broader anxiety literature (Bar-Haim et al., 2007) but has received limited attention in MPA research specifically.

4.2 The Significance of Anxiety Typologies

The identification of four distinct anxiety typologies represents a novel contribution to the MPA literature. Previous research has largely treated MPA as a unitary construct, varying only in severity. The present findings suggest that this approach is overly simplistic and that qualitatively different patterns of anxiety exist among vocal performers. The Cognitive-Dominant typology, characterized by high perfectionism and negative self-talk but moderate somatic symptoms, aligns with the concept of "cognitive anxiety" described by Martens, Vealey, and Burton (1990) in the sport psychology literature. The Somatic-Dominant typology, with its emphasis on physiological arousal and social evaluation fear, more closely resembles the "somatic anxiety" component of their multidimensional anxiety theory.

The Mixed-Severe typology is of particular clinical concern, as these individuals exhibited the highest scores across all anxiety dimensions, the lowest self-efficacy, and the least performance experience. The demographic composition of this cluster, which was disproportionately composed of undergraduate students, suggests that early-career performers may be at the greatest risk for developing severe, multi-faceted MPA. This finding supports the argument made by Studer et al. (2011) that anxiety management training should be integrated into music education curricula from the earliest stages of training, rather than being offered only as a remedial intervention for those who have already developed significant problems.

The Adaptive-Low typology provides an important counterpoint, demonstrating that it is possible for performers to maintain low anxiety levels across all dimensions. The profile of this cluster, characterized by high self-efficacy, low perfectionism, and extensive performance experience, offers a model of psychological resilience that can inform the design of preventive interventions. These findings are consistent with the resilience framework proposed by Seligman (2011), which emphasizes the role of positive psychological resources in buffering against stress and anxiety.

4.3 The Superiority of Combined Interventions

The finding that the combined intervention (CBT + diaphragmatic breathing + exposure therapy) produced the largest effect size ($d = 1.15$) and the lowest relapse rate (12% at 12 months) has significant implications for clinical practice. This result is consistent with the broader psychotherapy literature, which has increasingly recognized the benefits of integrative, multi-component treatment approaches for anxiety disorders (Barlow et al., 2017). The superiority of the combined approach likely reflects its ability to address multiple components of the anxiety response simultaneously: CBT targets cognitive distortions and maladaptive beliefs, diaphragmatic breathing directly reduces physiological arousal, and exposure therapy promotes habituation and builds self-efficacy through repeated successful performance experiences.

The relatively poor long-term performance of beta-blockers, despite their moderate immediate effect size (d = 0.73), is noteworthy. While beta-blockers effectively reduced somatic symptoms (90% improvement), they showed minimal impact on cognitive (45%) and behavioral (38%) dimensions. This asymmetric profile suggests that pharmacological approaches, while useful for acute symptom management, do not address the underlying psychological mechanisms that maintain MPA over time. This finding supports the position of Brugues (2011), who cautioned against the over-reliance on beta-blockers in the performing arts and advocated for psychological interventions as the first-line treatment.

The cost-effectiveness analysis adds a practical dimension to the intervention comparison. While the combined intervention was the most expensive ($2,880 total), its superior effectiveness and low relapse rate make it the most cost-effective option when long-term outcomes are considered. Diaphragmatic breathing, at only $90 total, represents an accessible entry point for performers who cannot afford more intensive interventions, achieving moderate effectiveness (d = 0.58) at minimal cost. These findings can inform the development of stepped-care models for MPA treatment, where low-cost, low-intensity interventions are offered first, with more intensive combined approaches reserved for those who do not respond adequately (Bower and Gilbody, 2005).

4.4 Sustainability and Long-Term Implications

The longitudinal data provide critical evidence on the sustainability of intervention effects, an area where the existing MPA literature is notably deficient. The finding that the combined intervention maintained a large effect size (d = 0.90) at 12 months post-treatment, with only a 21.7% decay from the immediate post-treatment effect, is highly encouraging. This level of maintenance compares favorably with the broader CBT literature, where effect size decay rates of 30-40% are commonly reported for anxiety disorders (Hofmann et al., 2012). The continued improvement observed in the combined group during the follow-up phase (K-MPAI scores declining from 24 at week 12 to 20 at week 24) suggests that the skills acquired during treatment continue to consolidate through ongoing practice and real-world application.

In contrast, the MBSR group showed the steepest effect size decay (from d = 0.71 to d = 0.38), falling below the medium effect threshold by 9 months. This finding suggests that while mindfulness-based approaches can produce meaningful short-term improvements, their benefits may be more dependent on continued formal practice than those of CBT or exposure-based approaches. This interpretation is consistent with research by Crane et al. (2014), who found that the maintenance of mindfulness meditation benefits was strongly predicted by the frequency of ongoing home practice.

The Kaplan-Meier analysis revealed that the combined intervention achieved the fastest median time to clinically significant improvement (4 weeks), which has important practical implications for performers who need to manage their anxiety within the constraints of a performance season. The finding that 97% of participants in the combined group achieved clinically significant improvement by week 12 provides strong evidence for the clinical utility of this approach. Future research should explore whether shorter, more intensive versions of the combined intervention (such as a 6-week intensive program) could achieve comparable outcomes, which would further enhance its accessibility and practical applicability.

4.5 Limitations and Future Directions

Several limitations should be acknowledged. First, the sample was drawn primarily from conservatory students and professional performers in a single country, which may limit the generalizability of the findings to other cultural contexts where attitudes toward performance anxiety and help-seeking behavior may differ. Second, the exclusion of participants with diagnosed clinical anxiety disorders means that the findings may not apply to performers whose MPA is comorbid with generalized anxiety or other psychiatric conditions. Third, while the 24-week follow-up provides valuable longitudinal data, longer-term studies spanning multiple years would be needed to fully assess the durability of intervention effects. Future research should also investigate the interaction between anxiety typology and intervention effectiveness, testing the hypothesis that different typologies respond optimally to different treatment approaches. The development and validation of a brief screening tool for anxiety typology classification would facilitate the implementation of personalized treatment in educational and clinical settings.

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