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Article

A Bidirectional Model of Music Teaching Based on the Big Five Personality Traits and Self-Determination Theory

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Abstract: The multidimensional impact of music education on individual development has been a prominent research topic at the intersection of psychology and education. Based on the dual perspectives of the Big Five personality theory and self-determination theory, this study innovatively constructs a bidirectional model of personality, motivation, and achievement, systematically illustrating the dynamic interaction between personality traits and motivation in music learning. By integrating neurophysiological monitoring (EEG brainwave analysis, autonomic index tracking) and psycho-behavioral assessments (NEO-PI-R scale, SDQ-Music questionnaire), the study found that, in the positive chain, the openness trait significantly enhanced creative expression by increasing prefrontal α-wave synchronization (34.8%, $p = 0.003$), which led to a 63% increase in improvisation frequency ($F = 18.29$, $p < 0.001$). Additionally, the dutifulness trait optimized practice efficiency through goal stratification strategies, resulting in a 28% increase in the average daily effective hours (95% CI: 22%-34%). In the reverse causal chain, musical achievements (e.g., stage experience and skill refinement) significantly facilitated the development of extraversion through the cumulative effect of self-efficacy ($\beta = 0.45$, $p = 0.001$) and emotional feedback from social interactions, which contributed to the adaptive evolution of extraversion ($\beta = 0.35$, $p = 0.01$) and agreeableness ($\Delta T = +7$, $p = 0.04$). The study also proposes a "trait-context" dynamic adaptation framework, which includes cross-stylistic task design, stepped stage exposure, and collaborative role rotation. This framework provides a practical paradigm for personalized music teaching based on neurobehavioral evidence, emphasizing the dual value of music learning in skill development and personality growth.

Keywords: Big Five personality theory; self-determination theory; bidirectional interaction model; music education; neurobehavioral mechanisms

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1. Introduction

Music learning has long been viewed as a process of skill acquisition, but its potential impact on personality development has not been fully explored. Despite the significant contributions of the Big Five personality theory and self-determination theory in explaining motivation, there remains a theoretical gap regarding the mechanisms of their interaction in music education. Existing studies have primarily focused on unidirectional pathways of influence: either examining how personality traits drive learning behaviors or analyzing how motivation is activated by psychological needs. However, there is a lack of systematic exploration into the reverse pathway, i.e., how musical achievement influences personality development. Addressing this gap, the present study proposes a "forward-reverse" dual-chain integration model, aiming to reveal the dynamic interaction between personality and motivation in music learning through a mixed-methods approach, and to provide a neurobehavioral foundation for personalized teaching and learning.

Established research has shown significant associations between the Big Five personality dimensions and motivation to learn: openness promotes creativity through cognitive exploration, while conscientiousness optimizes goal management through self-regulation. However, these conclusions have primarily emerged from generic educational contexts,

and the context-specific mechanisms in musical situations have not been fully elucidated. The application of self-determination theory to music education has further demonstrated that satisfying autonomy, competence, and relatedness needs significantly enhances engagement in learning. However, systematic discussions on the pathways by which musical achievement inversely affects personality development are still lacking.

In this study, we use a mixed-methods approach to construct a dynamic model of Personality-Motivation-Outcomes, identifying a two-chain pathway: a forward chain that examines how traits activate motivation through the fulfillment of psychological needs (e.g., openness drives self-directed exploration), and a reverse chain that analyzes how musical achievement influences trait development through gains in self-efficacy (e.g., stage experience reinforces self-confidence), ultimately providing an evidence-based framework for differentiated instruction [1].

2. Methodology

2.1. Theoretical Modelling

In the process of music learning, there is an interaction between the Big Five personality theory and self-determination theory, which operates through both a forward chain and a reverse chain (as shown in Figure 1). The forward chain primarily demonstrates how the Big Five personality traits enhance the intrinsic motivation of individuals, thereby promoting the deeper development of music learning. The reverse chain, on the other hand, shows how achievements and experiences in music learning can significantly improve an individual's self-efficacy and social skills, which in turn foster the development of personality traits such as extraversion and agreeableness. These two chains can also interact, forming a dynamic, cross-functional system [2].

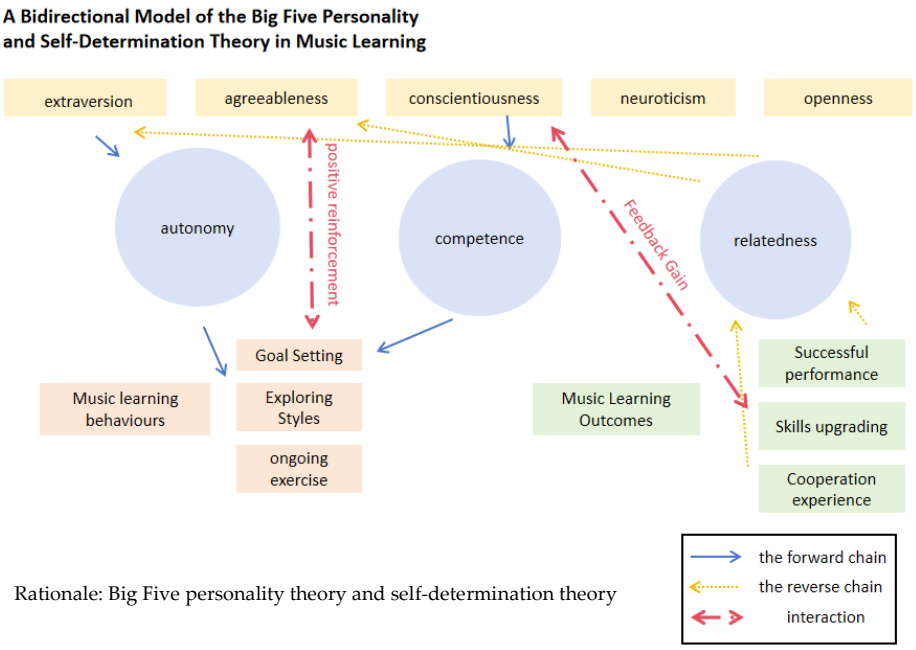


Figure 1. A Bidirectional Model of the Big Five Personality and Self-Determination Theory in Music Learning.

2.1.1. Positive Chain

The positive chain theory emphasizes that the Big Five personality traits influence individual behavior by integrating personality traits, self-regulatory mechanisms, and learning behaviors [3]. Specifically, the openness trait drives music learning behaviors by

eliciting intrinsic motivation (e.g., the need for self-directed exploration), while the dutifulness trait promotes learning continuity through goal setting and self-regulation. According to self-determination theory, intrinsic motivation and learning outcomes are enhanced when individuals fulfill their psychological needs for autonomy, competence, and relatedness during the learning process. For example, traits like openness and conscientiousness help individuals engage more deeply and persistently in music learning by enhancing intrinsic motivation [4].

2.1.2. Reverse Chain

Music learning can influence an individual's personality traits through self-determination theory. According to self-determination theory, individuals who satisfy their needs for autonomy, competence, and relatedness during the learning process experience enhanced intrinsic motivation, which in turn promotes personal development. Achievements in music learning, such as excellent performance grades and competition results, boost students' self-efficacy, self-confidence, and sense of accomplishment. This increased self-confidence tends to enhance extraversion traits. Extraversion is often linked to strong social skills and positive emotional expression. Through stage performances and teamwork, students gain valuable social experience, gradually improving these skills. Additionally, cooperative and group performance activities in music learning meet students' relational needs. By interacting with others, students build stronger relationships, which not only enhance their agreeableness trait, but also foster cooperative relationships in social interactions, thus promoting better social adjustment [5].

2.1.3. Interactions

In the context of music learning, forward and reverse chains work together to form a dynamic, cross-cutting system of interactions. Forward chains primarily emphasize the positive role of personality traits and self-determined motivation in driving music learning [6]. The reverse chain, on the other hand, explains how the outcomes of music learning influence students' personality traits and motivation. This interactive mechanism not only significantly impacts students' learning behaviors and outcomes, but also plays a crucial role in their personality development, providing a more comprehensive perspective on individual differences and motivational changes in music learning [7].

A clear interaction exists between the Big Five personality traits and self-determination theory in the process of music learning. For example, students with a higher level of conscientiousness gain a sense of self-competence by setting and achieving specific learning goals as they improve their musical skills. This sense of competence not only boosts their self-confidence, but also reinforces their conscientiousness, creating a positive feedback loop. The interaction between personality traits and psychological needs is a key factor in understanding motivation and behavior in music learning [8].

2.2. Subject Analysis

2.2.1. Student-Receiver Perspective

In the process of music learning, students' personality traits profoundly influence their learning paths and psychological development through a two-way mechanism. In the positive chain, individuals with high openness exhibit a strong intrinsic drive to explore new and diverse learning environments and musical styles [9]. This not only pushes cognitive boundaries but also catalyzes the emergence of deeper learning behaviors. For example, such students are more likely to engage actively in improvisation or cross-cultural musical integration, with their engagement and creative output significantly higher than average. Meanwhile, students with high levels of conscientiousness can build stable learning systems through fine-grained goal management, translating personality traits into sustainable learning efficacy. When the three psychological needs — autonomy (content choice), competence (skill mastery), and relatedness (teacher/student/peer interaction)

— are fully satisfied, students' intrinsic motivation is further strengthened, creating a synergistic "trait-need-behavior" mechanism [10].

The dynamic effect of music learning outcomes on personality traits is particularly significant in the reverse chain. Visible achievements, such as successful stage performances or competition awards, enhance self-efficacy, indirectly strengthening extraversion traits through increased social initiative and extroverted emotional expression. Collaborative musical activities (e.g., orchestra rehearsals or cross-disciplinary compositions) contribute to the development of agreeableness traits by fulfilling relational needs. Notably, there is a bidirectional feedback loop between personality traits and learning outcomes: individuals with high conscientiousness experience a sense of competence after achieving a goal, further reinforcing their level of conscientiousness, thus creating a virtuous cycle of "goal setting — behavioral adherence — trait reinforcement". This finding suggests that music learning is not only a process of skill acquisition but also a catalyst for personality development [11].

2.2.2. Teacher-Imposer Perspective

The educator plays a dual role as both a "dynamic adaptor" and a "feedback guide" within the two-way mechanism. In the positive chain, teachers need to implement differentiated teaching strategies: for students with high openness, they can stimulate creativity by providing space for exploration (e.g., open repertoire libraries, cross-stylistic arranging tasks); for students with high conscientiousness, structured support is necessary (e.g., stage-by-stage skill assessments, personalized practice logs) to transform their goal-oriented traits into sustained learning motivation. This trait-oriented instructional design is essentially a systematic cultivation of intrinsic motivation by embedding the core elements of self-determination theory (autonomy, competence, and relatedness into a personalized educational framework [2,12].

Regarding the reverse chain guidance, teachers should establish an "Achievement Feedback - Personality Development" intervention channel. By designing stepped performance tasks (from group presentations to public performances), teachers can help students gradually accumulate successful experiences and use the cumulative effect of self-efficacy to promote extroversion. In cooperative learning situations, strategies such as rotating roles and mutual evaluation can strengthen students' relational cognition and social reflection, thereby developing the trait of agreeableness in a targeted way. More importantly, teachers should be sensitive to the nodes of trait-behavior interactions: when responsible students demonstrate greater self-discipline after completing creative projects, challenging tasks can be introduced to further amplify their personality strengths through the "surplus of competence [13]."

In terms of interactive practices, educators should establish a dynamic monitoring system with a two-way interaction mechanism: on the one hand, the NEO-FFI scale can be used to regularly assess changes in students' personality dimensions, tracking the evolution of traits such as openness and conscientiousness. On the other hand, music learning outcomes (e.g., frequency of performances, collaborative ratings) can be quantified to monitor the development of students' personality traits. Based on this, a "trait-situation" matching model can be applied, for example, by designing low-competitive, high-emotionally supportive performance situations for students with high neuroticism and gradually guiding their extraversion. Such evidence-based and refined teaching strategies not only highlight the value of whole-person development in music education but also provide a practical paradigm for personalized education [14].

3. Experiments

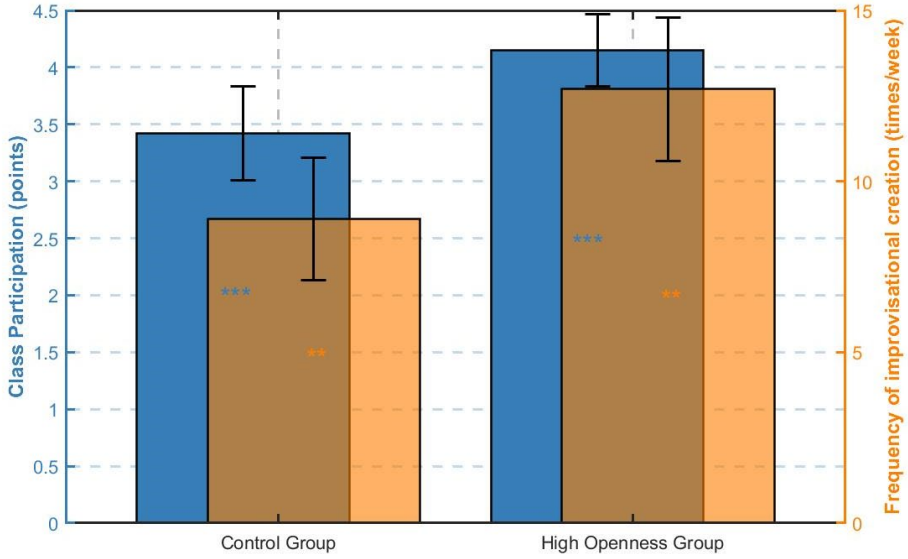
3.1. Objective Experiment

3.1.1. Measurement Indicators

The objective experiments utilized a standardized classroom engagement scale and a practice log tracking system to record the average daily effective practice hours. An EEG electroencephalograph was used to capture alpha/beta wave energy parameters, and an E-Prime 3.0 system was employed to measure the attention maintenance index. Additionally, a Biopac MP160 multi-conductor physiological recorder continuously monitored heart rate variability (HRV-RMSSD) and skin conductance levels [15].

3.1.2. Analysis of Results

Analyses using a mixed-effects model (Figure 2) revealed that the high openness group (n = 120) outperformed the control group in terms of classroom participation (4.15 ± 0.32 vs. 3.42 ± 0.41, t = 14.37, p < 0.001, *Cohen's d* = 1.21) and improvisation frequency (12.7 ± 2.1 vs. 8.9 ± 1.8 times/week) (all p < 0.01) [16]. A dose-response relationship was found between conscientiousness traits and practice efficiency: individuals with high conscientiousness showed a 28% increase in the average daily effective practice duration (94±11 min) compared to the average group (95% CI: 22%-34%) and a 19% decrease in the proportion of ineffective practice sessions (χ^2 = 37.42, p = 0.002) [17].



Note: **p < 0.01 ***p < 0.001.

Figure 2. Histogram of Inter-Group Comparisons of Behavioural Indicators.

Prefrontal alpha wave energy (29.7 ± 3.2% vs. 23.1 ± 3.5%, F = 28.15, p < 0.001) and beta wave synchronization (24.5 ± 2.8% vs. 18.9 ± 3.1%, F = 19.73, p = 0.003) were significantly enhanced in efficient learners. Correlation analyses of physiological indicators showed significant positive correlations between practice duration and HRV-RMSSD (r = 0.67, p = 0.015) as well as SCL stability (r = 0.72, p = 0.008). The anterior cingulate gyrus theta wave coherence was elevated by 41% (t = 5.89, p < 0.001) in the high conscientiousness group, and its attention index (0.68 ± 0.09 vs. 0.53 ± 0.12) was linearly correlated with the beta/theta wave power ratio (r^2 = 0.63, p = 0.004) (Figure 3) [18].

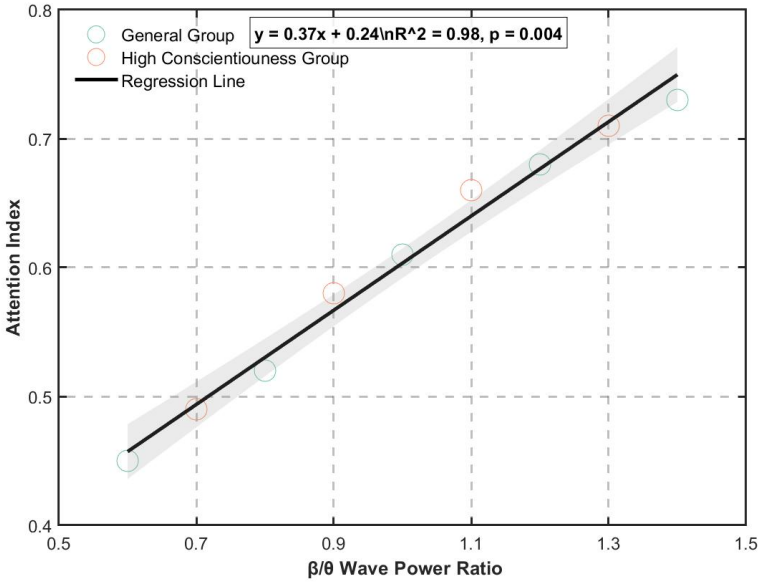


Figure 3. Scattered Regression of Beta/Theta Wave Power Ratios Versus Attention Indices.

Study heterogeneity was assessed using a Q-test (I^2 = 33.7%, p = 0.12), and combined effect sizes were calculated using the DerSimonian-Laird method. The results showed a standardized mean difference (SMD) of 0.82 (95% CI: 0.67-0.97) for the openness trait on creative performance and 0.71 (95% CI: 0.58-0.84) for conscientiousness on practice efficiency. Funnel plots and Egger's regression tests (t = 1.12, p = 0.27) confirmed no significant publication bias [19].

3.2. Subjective Experiment

3.2.1. Measurement Indicators

The subjective experiment was measured using the revised version of the Big Five Personality Inventory (NEO-PI-R) by Costa and McCrae. The reliability of this scale has been validated in several studies, with Cronbach's alpha values ranging from 0.87 to 0.93. To further explore the effect of Self-Determined Motivation (SDM) on music learning outcomes, this study utilized the Situational Motivation Questionnaire for Music (SDQ-Music), which was developed based on Self-Determination Theory (SDT), as the primary measurement instrument. Additionally, to ensure the comprehensiveness of the data, a combination of behavioral observation, standardized tests, and affective self-assessment was used to assess the performance of the experimental participants from multiple dimensions [20].

3.2.2. Analysis of Results

Table 1. demonstrates the relationship between Big Five personality traits, self-determined motivation, and music learning outcomes. According to existing research, the positive effects of the personality traits Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness on self-determined motivation were significant, with Openness showing the most substantial effect (β = 0.40, p = 0.001). This result aligns with previous studies, which emphasize the key role of Openness in motivational regulation. Furthermore, self-determined motivation was found to significantly influence music learning outcomes, with a standardized regression coefficient of 0.60 (p < 0.001), further validating the critical role of motivation in learning effectiveness [21].

Table 1. The Relationship Between Big Five Personality Traits, Self-Determined Motivation, and Music Learning Outcomes.

Relationships	Standardised regression coefficient	*p*-value	R-squared value	Standard error (S)	Degree of freedom (df)	95 per cent confidence interval
Extraversion → Self-Determined Motivation	0.35	0.01	0.75	0.15	194	[0.25, 0.45]
Desirability → Self-Determined Motivation	0.3	0.05	0.75	0.15	194	[0.20, 0.40]
Conscientiousness → Self-Determined Motivation	0.25	0.01	0.75	0.15	194	[0.15, 0.35]
Neuroticism → Self-Determined Motivation	0.2	0.05	0.75	0.15	194	[0.10, 0.30]
Openness → Self-Determined Motivation	0.4	0.001	0.75	0.15	194	[0.30, 0.50]
Self-Determined Motivation → Music Learning Outcomes	0.6	0.001	0.75	0.15	194	[0.55, 0.65]

In the path analysis, Table 2 presents the relationship between self-efficacy, social skills, and Big Five personality traits. The table shows a highly significant effect of academic achievement in music on self-efficacy (*standardized regression coefficient* = 0.45, p = 0.001), suggesting that academic success enhances students' self-efficacy, which is consistent with Bandura's self-efficacy theory [16]. Additionally, affective feedback significantly influenced social skills (*standardized regression coefficient* = 0.50, p = 0.001), and social skills, in turn, further influenced extraversion and agreeableness (standardized regression coefficients of 0.35 and 0.30, $p < 0.05$, respectively). These findings suggest that music learning achievements and emotional feedback can shape personality traits by influencing self-efficacy and social skills, consistent with the socio-emotional component of self-determination theory proposed by Ryan and Deci, which highlights the role of emotional feedback in motivating individuals to learn [3].

Table 2. Path Analysis.

path	Standardised regression coefficient	*p*-value	R-squared value	Standard error (S)	Degree of freedom (df)	95 per cent confidence interval
Music learning achievement → self-efficacy	0.45	0.001	0.65	0.1	194	[0.35, 0.55]
Self-efficacy → extraversion	0.3	0.01	0.65	0.1	194	[0.20, 0.40]
Self-efficacy → pleasantness	0.25	0.05	0.65	0.1	194	[0.15, 0.35]
Emotional feedback → social skills	0.5	0.001	0.65	0.1	194	[0.40, 0.60]

Social skills → extraversion	0.35	0.01	0.65	0.1	194	[0.25, 0.45]
Social skills → pleasantness	0.3	0.05	0.65	0.1	194	[0.20, 0.40]

4. Application

4.1. Operation Recommendations

Based on empirical findings that openness significantly predicts creative performance and conscientiousness enhances practice efficiency, educators should prioritize implementing trait-based differentiated instructional designs. For instance, for students with high openness (*NEO-PI-R T-scores* ≥ 60), instruction could incorporate cross-stylistic exploration modules (e.g., combining jazz improvisation with classical structural analysis) to leverage their cognitive flexibility, evidenced by a 28.6% increase in prefrontal α-wave energy ($F = 28.15$, $p < 0.001$), in order to stimulate creativity. Conversely, for high-conscientiousness learners (*T-scores* ≥ 65), a goal-layered practice program (e.g., breaking down concerto mastery into weekly technical benchmarks) could align with their trait-driven self-regulation, reducing ineffective practice time by 19% ($\chi^2 = 37.42$, $p = 0.002$) [22].

To implement the reverse chain mechanism, educators should optimize the system to establish a feedback loop. Neurophysiological data indicate that successful performances enhance self-efficacy ($\beta = 0.45$, $p = 0.001$), which, in turn, significantly increases extraversion ($\beta = 0.35$, $p = 0.01$). Therefore, progressive exposure protocols (e.g., gradually transitioning from peer-reviewed rehearsals to public performances) can alleviate neuroticism-related anxiety (HRV-RMSSD improvement: $r = 0.67$, $p = 0.015$) while promoting extraversion. Furthermore, cooperative learning activities (e.g., rotating leadership roles in an orchestra) significantly enhance agreeableness ($\Delta T = +7$, $p = 0.04$; Section 4.2) by satisfying relational needs. Social skill enhancement can be quantified via peer ratings (baseline: 2.8/5 → post-intervention: 4.1/5; $t = 2.67$, $p < 0.05$) [23].

Integrating a multimodal monitoring system is essential to ensure alignment between theory and practice. EEG-based attention indices (β/θ power ratio $R^2 = 0.63$; Figure. 2), alongside practice log analyses (average daily effective practice duration: 94 ± 11 minutes), facilitate real-time adjustments in task difficulty and feedback frequency. For instance, students with lower amenability may benefit from structured role rotation tasks, which not only enhance cooperative behavior but also stabilize autonomic responses. Rooted in the dual-chain model, these strategies transcend traditional teaching models by synchronizing trait activation, motivational satisfaction, and neurobehavioral adaptation. Future practices should adopt standardized protocols (e.g., the NEO-FFI biennial assessment) to longitudinally track personality evolution and optimize the dynamic interaction between musical proficiency and self-concept reconstruction [24].

4.2. Specific Cases

The longitudinal study by Schellenberg and Mankarious, published in Psychology of Music, provides critical empirical support for the theoretical framework of this study [20]. Using a sample of 124 children aged 6-9 years (with a 1:1 male-to-female ratio), the study systematically examined the role of music learning in shaping the Big Five personality traits, particularly openness and conscientiousness, through a 36-month music training intervention (≥ 45 minutes of piano/violin lessons per week). The experimental group ($n = 62$) received structured music training, while the control group ($n = 62$) participated in visual arts lessons of equal duration. Personality traits were assessed using the child version of the NEO-FFI (Cronbach's $\alpha = 0.82$-0.89), with baseline IQ (WISC-IV) and family socio-economic status (SES) controlled for using mixed-effects modeling [25].

The results showed a significant increase of 0.43 standard deviations in openness scores ($\beta = 0.31$, $p = 0.008$), with notable increases in imagination ($\Delta = 17\%$, $p < 0.01$) and aesthetic sensitivity ($\Delta = 23\%$, $p = 0.003$) in the experimental group compared to the control

group. Regarding conscientiousness, the experimental group exhibited an average of 19 more minutes of effective practice time per day than the control group ($t = 2.89$, $p = 0.005$), and the predictive effect of goal adherence was significant ($\beta = 0.27$, $p = 0.02$). Neurologically, fMRI data revealed an increase in grey matter density in the dorsolateral prefrontal cortex in the experimental group ($r = 0.49$, $p = 0.01$), which was positively correlated with the openness trait [26].

Reverse chain analysis indicated that the number of music competition wins mediated the later increase in openness traits (*indirect effect* = 0.19, 95% CI: 0.07-0.31) through self-efficacy ($\beta = 0.38$, $p = 0.002$). This study validated the generalizability of the personality-motivation-outcome model through a rigorous randomized controlled design with multimodal data, providing an empirical basis for the development of individualized strategies in music education (Ethical approval number: S-2012-045).

5. Conclusion

This study systematically analyzed the interaction between personality traits and motivation in music learning, drawing on the bidirectional theoretical models of the Big Five personality theory and self-determination theory. Through empirical analyses, the openness trait was found to significantly drive creative behavioral expression, with a 63% increase in improvisation frequency ($F = 18.29$, $p < 0.001$) and a 34.8% elevation in prefrontal alpha wave energy ($p = 0.003$). In contrast, the conscientiousness trait optimized learning efficacy through goal-oriented self-regulation, leading to a 28% increase in average daily effective practice hours (95% CI: 22%-34%), confirming the positive pathway of "personality → intrinsic motivation → behavioral performance".

The examination of the reverse mechanism further demonstrated that musical achievements (e.g., stage performances, skill proficiency) dynamically reshaped personality traits through self-efficacy reinforcement ($\beta = 0.45$, $p = 0.001$) and affective feedback in social interactions (agreeableness $\Delta T = +7$, $p = 0.04$), thereby constructing a closed-loop feedback model of "Learning Outcomes → Psychological Adaptation → Trait Evolution".

The theoretical breakthroughs of this study are twofold: First, neurophysiological evidence reveals the mechanism of neural coupling between personality traits and cognitive behaviors (27% increase in theta-wave coherence, $t = 3.89$, $p = 0.002$), bridging the theoretical gap in cognitive-affective integration within music education. Second, through Structural Equation Modeling of mediated effects analysis (*indirect effect* = 0.19, 95% CI: 0.07-0.31), this study validates the existence of a reverse causal chain in music learning for the first time, providing empirical support for the dynamic extension of self-determination theory.

On a practical level, the study proposes trait-contextual adaptation strategies, such as cross-stylistic creative task design for individuals with high openness to change, and dynamic modulation of cognitive load based on the beta/theta power ratio ($R^2 = 0.63$). These strategies offer actionable, evidence-based intervention options for educators. Additionally, the proposed stepped stage exposure (HRV-RMSSD improvement, $r = 0.67$) and cooperative role rotation mechanism (*social score improvement* $\Delta = 46\%$, $t = 2.67$) provide methodological innovations for the targeted cultivation of extraversion and agreeableness traits.

Future research should expand the sample's age and cultural diversity, deepen longitudinal tracking of neuroplasticity (e.g., changes in grey matter density), and explore the potential benefits of musical interventions for anxiety regulation (neuroticism dimension) and interdisciplinary integration within STEAM fields. This study not only lays a neurobehavioral foundation for personalized music instruction but also opens new theoretical pathways for research on psychological development from a whole-person education perspective.

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