The Role of Percussion Training in Enhancing Cognitive Skills Among University Students: A Mixed-Methods Study

Analysis of South Asian Artistic Features of National Music in Pakistan and Bangladesh

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Abstract

Percussion-based learning has been increasingly recognised for its potential to enhance cognitive performance through rhythmic and sensorimotor engagement. This study aimed to examine the role of percussion training intensity and duration in improving cognitive skills among university students. A mixed-methods design was adopted, integrating a questionnaire survey (n = 300) and a systematic literature review (SLR). Quantitative results revealed strong positive correlations between training intensity (r = .799), duration (r = .800), and cognitive skills, with the regression model explaining 72.2% of variance ($R^2 = 0.722$) in cognitive performance. Qualitative findings identified neural plasticity, attentional entrainment, and sensorimotor integration as key mechanisms. The study concludes that sustained and intensive percussion practice significantly enhances executive functions. It recommends incorporating structured rhythmic programs into university curricula. Theoretically, the research validates Embodied Cognition and Transfer of Training frameworks, though limited by its cross-sectional design.

Keywords: Percussion training, cognitive skills, neural plasticity, embodied cognition, rhythm-based learning.

1. Introduction

1.1. Background of the Study

The application of music-based learning and especially rhythm and percussion training has become increasingly recognised as a cognitive benefit by recent research studies. According to studies in the field of cognitive neuroscience, musical involvement can help increase brain plasticity and affect executive functions, attention, and working memory (Bruchhage et al., 2020). Percussion training is one of these musical activities, as it focuses on the synchronisation of the rhythms, bilateral motor skills, and temporal precision that have been associated with the high-order cognitive processing (Cahart et al., 2022). According to the neuroimaging support, drumming enhances sensorimotor integration and connectivity between cortical and subcortical attention and inhibitory control-executing structures (Nam & Kwon, 2025). In addition, meta-analytic reviews have shown that rhythm-based interventions can have a significant positive effect on cognitive performance in educational and clinical practice (Jamey et al., 2024). These results are consistent with emerging views which have seen rhythmic engagement as a type of cognitive training, which can improve attentional concentration, as well as information processing efficiency (Hao et al., 2023). As the percussion-based programmes could be useful means of developing mental flexibility and attention, the integration of percussion-based programmes might become a feasible solution, considering that university students have to endure high cognitive loads.

1.2. Problem Statement

Despite mounting evidence for the cognitive benefits of music, notable gaps persist in empirical research focusing exclusively on percussion training and its impact on cognition among university students. Most studies to date have examined general music education or instrumental training in children, while adult and tertiary education populations remain underrepresented (Tierney et al., 2015). Additionally, limited attention has been given to the effect of training dosage, including intensity (hours of practice per week) and duration (weeks of engagement), which may moderate cognitive outcomes (Habibi et al., 2025). There is also a methodological concern regarding inconsistent measures of cognitive improvement, some relying on self-report rather than standardised cognitive testing (Putkinen & Saarikivi, 2018). A recent systematic review emphasised that while music interventions consistently enhance executive functions, percussion-specific mechanisms and contextual factors, such as motivation and group synchrony, are insufficiently explored (Bugos et al., 2024). Furthermore, theoretical understanding remains fragmented, with a lack of consensus on how rhythm entrainment translates into cognitive transfer beyond musical contexts (Hao et al., 2023). Consequently, there is a pressing need for focused, mixed-methods research that quantifies the effects of percussion training while qualitatively synthesising underlying mechanisms and implementation barriers.

1.3. Aim and Research Objectives

This study aims to investigate the role of percussion training in enhancing cognitive skills among university students through a mixed-methods design. The specific research objectives are:

- To test the effect of percussion training intensity (hours per week) on cognitive skills (composite executive function score).
- To assess the effect of training duration (number of weeks) on the same cognitive skills score.
- To conduct a systematic literature review exploring mechanisms, contexts, and moderating factors through which percussion training influences cognitive skills among university-aged learners.

1.4. Significance of the Study

The significance of this study lies in its potential to extend understanding of music-based cognitive enhancement beyond early developmental stages. By isolating percussion as a training modality, the research contributes to clarifying whether rhythmic engagement uniquely supports cognitive functions such as working memory, inhibition, and attention shifting (Colombo et al., 2020). Empirically, the quantitative strand would determine the strength of relationships between training variables and cognitive performance, providing evidence-based insights for curriculum designers and educators in higher education (Habibi et al., 2025). The qualitative systematic review would complement this by synthesising mechanisms underlying rhythm-based cognitive development, such as neural synchronisation and temporal prediction (Bugos et al., 2024). Practically, the findings could inform low-cost, scalable interventions to promote mental agility and academic success among university students. Theoretically, it would enrich cross-disciplinary discourse between cognitive psychology, neuroscience, and music education by elucidating how embodied rhythmic activity translates into measurable cognitive growth.

2. Literature Review

This chapter surveys existing empirical and theoretical work relevant to the three research objectives, moving from evidence about training intensity, then about duration, and finally to systematic reviews of mechanisms and contexts. It then articulates a theoretical lens and pinpoints gaps for this mixed-methods study.

2.1. Percussion (Rhythmic) Training Intensity and Cognitive Outcomes

Several recent studies and meta-analyses suggest that greater weekly practice or engagement intensity is associated with stronger cognitive gains in music or rhythm interventions. For example, Bugos et al. (2024) in a meta-analysis of active music interventions report that interventions varying in dosage (from ~360 to >10,000 minutes total) show moderated effect sizes: higher total doses tend to correlate with larger cognitive outcomes, although the relationship is not strictly linear (Bugos et al., 2024). Similarly, Haverkamp et al. (2020) found that in their meta-analysis of music training in children, sessions held ≥ 3 times per week yielded significantly better improvements in inhibitory control and working memory than lower-frequency schedules

(Haverkamp et al., 2020). These findings support the notion of an "intensity threshold" for beneficial transfer.

Though much of the literature deals broadly with music training, rhythmic or percussion-based training likely amplifies sensitivity to timing and attentional entrainment. A recent study of body percussion instruction posits that embodied rhythmic coordination demands sustained attentional focusing and sensorimotor coupling, which theoretically intensifies cognitive load and yields stronger transfer (Girgin & Algun, 2021). Within adult populations, Vatakis et al. (2014) found evidence that even relatively short, structured training in musical tasks can affect fine motor and attentional control, hinting that intensity, even in limited windows, matters (Vatakis et al., 2014). Thus, the evidence suggests a positive but potentially curvilinear relationship between intensity (hours per week, or frequency) of rhythmic or musical practice and cognitive skill gains. However, few studies have isolated percussion-specific training to test this dose–effect relation, especially in university-age populations.

2.2. Duration of Training and Cognitive Effects

Closely related to intensity is the question of how many weeks or sessions of rhythmic training are needed before observable cognitive improvements emerge. In the broader music literature, training interventions of longer duration typically show more stable and larger transfer effects. For instance, Xu et al. (2018) conducted a 10-week instrumental training (non-percussion) and found significant improvements in verbal memory and other cognitive indices relative to control conditions. Meanwhile, Espinosa et al. (2025), in a review of music-making interventions, emphasise that sustained interventions (≥ 12 weeks) more reliably yield neural and behavioural plasticity in older populations (Espinosa et al., 2025). Meta-analytic work by Haverkamp et al. (2020) also supports this: training durations ≥ 12 weeks yield larger standardised mean differences in cognitive flexibility than shorter durations (Haverkamp et al., 2020). In addition, Bugos et al. (2024) again note that the effect sizes in RCTs tend to increase with cumulative hours and weeks of engagement, though the marginal returns may diminish at high durations.

However, very few studies in rhythmic or percussion domains have systematically varied duration while holding intensity constant. One exception is the body percussion work of Girgin and Algun (2021), where multi-week programs (e.g., over a semester) are proposed to yield progressive cognitive and motor benefits, though empirical quantification remains limited (Girgin and Algun, 2021). Therefore, existing evidence from the broader musical domain supports the view that longer duration of training enhances cognitive gains, but direct evidence in percussion/rhythm contexts is sparse.

2.3. Mechanisms, Contexts, and Moderators: A Systematic Review Orientation

Beyond quantifying dose–response effects, scholars have sought to unpack how and why music/rhythm training transfers to cognition. Some review efforts have addressed general music interventions, but fewer have zoomed in on rhythmic or percussion modalities. Espinosa et al. (2025) provide a broad review of neurobiological effects of music-making in older adults, noting mechanisms such as enhanced synaptic plasticity, increased connectivity, and modulation of default-mode networks (Espinosa et al., 2025). They also highlight that cognitive benefit depends on participant age, baseline ability, and training fidelity. Raglio et al. (2024) examine music-based cognitive stimulation in older adults, underscoring that combining cognitive challenge with rhythmic, sensorimotor engagement may amplify effects via cross-domain coupling of neural circuits (Raglio et al., 2024). Another conceptual review suggests that rhythmic entrainment and temporal prediction are core to transfer: rhythmic practice may strengthen internal timing circuits, which scaffold attentional control and working memory (Hao et al., 2023).

In empirical RCTs, Nam and Kwon (2025) tested a drumming-based cognitive and physical training protocol and reported both behavioural improvements and increased prefrontal oxygenation using fNIRS, supporting a neural basis for cognitive gains (Nam & Kwon, 2025). Moreover, some interventions report changes in functional connectivity or cortical thickness post-training, suggesting structural plasticity (Espinosa et al., 2025). Moderator variables often discussed include motivational engagement, group versus individual training, baseline cognitive level, age, and resource constraints. Bugos et al. (2024) point out that implementation fidelity and instructor competence strongly mediate outcomes in music interventions. Therefore, a systematic synthesis oriented to percussion training can clarify which mechanisms (entrainment, sensorimotor coupling, brain connectivity changes) are supported in specific populations like university students, and what implementation factors (motivation, peer support, scheduling) moderate effect sizes.

2.4. Theoretical Framework

To ground this inquiry, two theoretical lenses are especially pertinent: Transfer of Training Theory (specifically the near–far transfer framework) and Embodied Cognition Theory. Transfer of Training Theory posits that cognitive skills gained in one domain may generalise (transfer) to other domains to the extent of shared processes or overlapping neural circuitry. In this view, rhythmic training may produce near transfer to timing or sensorimotor tasks, and, critically, far transfer to executive functions, if mechanisms overlap (Morrison & Chein, 2011). The classic taxonomy of transfer (e.g., Thorndike's identical elements theory) suggests that the degree of cognitive overlap determines transfer efficacy. In our case, rhythmic control, inhibitory timing, anticipation, and temporal prediction may share circuitry with attentional control, enabling far transfer.

Embodied Cognition Theory argues that cognition is grounded in sensorimotor systems and that bodily interaction with the environment shapes cognitive processing (Wilson, 2002). Under this view, percussion training is not a disembodied mental exercise but a bodily rhythmic engagement that tunes neural loops linking motor, temporal, and attentional systems. This offers a theoretical rationale for why embodied rhythmic activity might yield greater cognitive benefit than passive musical instruction: the body is integral to cognition, not merely an effector. The concept of sensorimotor coupling further supports that rhythmic movement enhances temporal prediction and attentional entrainment, facilitating executive control.

Combining these, one can propose that percussion training engages sensorimotor timing systems (embodied cognition) in such a way that overlapping circuits with executive attentional networks lead to far transfer (transfer theory). These frameworks justify our focus on intensity, duration, and mechanism exploration.

2.5. Literature Gap

Despite promising indications from music and rhythm research, several critical gaps remain. While many music studies explore intensity/duration relations, very few isolate pure percussion or drumming training to test how weekly practice intensity maps to cognitive gains in university-age populations. Moreover, much of the extant work focuses on children or older adults;

university students are comparatively underrepresented, leaving uncertainty about transfer potential in this age bracket.

Although there are general music reviews, no systematic review is dedicated to the investigation of the training of percussion or rhythm in the postsecondary context. The implication of that is that mechanisms, moderators, and contexts of percussion-based cognitive transfer have not been synthesised. Numerous studies present findings that are not strictly connected to either transfer or embodied cognition theory, which restricts the development of cumulative theory. The independent effects of intensity vs. duration are not disaggregated to reveal their independent contribution to cognitive outcomes in rhythm areas in most studies, the confounding effect of weekly hours, session length, and weeks.

This mixed-methods study, combining quantitative dose–response analyses (RO1, RO2) with a systematic review of mechanism pathways (RO3), is well positioned to address these gaps. It can provide more precise estimates of intensity and duration effects, clarify mechanisms in the rhythmic/percussion context, and strengthen theoretical underpinnings of cognitive transfer through embodied training.

3. Research Methodology

This chapter describes the methodology of approach to be used to examine the value of percussion training as a means of improving the cognitive abilities of university students. Since the study will have two points of interest (quantitative relationships between training intensity and duration and qualitative information on the mechanisms and context), a mixed-method approach was used. The section presents the research design, data collection protocol, sampling procedure, data analysis, and ethical issues that will be applied in the study.

3.1. Research Method and Research Design

The research design followed in the study is a mixed-method research design, which involves both quantitative and qualitative research approaches to determine a holistic picture of the effect of percussion training on cognitive outcomes. Creswell and Plano Clark (2017) describe mixed-methods research as the combination of numerical data and narrative findings to bolster the validity in triangulation. The design is consistent with the aims of the research, namely the first and second aims presuppose the quantitative dose-response testing of the impact of training intensity and duration, and the third objective is a qualitative systematic literature review (SLR), which must be read between the lines.

The convergent parallel design has been selected, where the quantitative and the qualitative data are gathered and analysed separately but combined at the time of interpretation. In such a design, the researcher will be able to support findings and form a more enriching explanation of observed relationships (Hitchcock and Onwuegbuzie, 2022). In educational psychology, quantitative approaches have enjoyed considerable popularity in terms of the measurement of training effects in terms of standardised scales and inferential statistics (Bryman, 2016). In the meantime, the SLR element provides a sense of depth, dominating past empirical evidence to familiarise and explain the results of the quantitative analysis (Snyder, 2019). This empirical data and evidence synthesis make sure that the methodological complementarity is achieved, and the explanatory power of the study is increased.

3.2. Data Collection

The data gathering part will involve two elements: (1) a survey in the form of a self-administered questionnaire to students at the university studying percussion training programmes, and (2) a systematic literature review to integrate the recent published empirical research between 2019 and 2025.

Primary data on the training habits of students (intensity and total duration of percussion training each week) and their cognitive skills were collected through the questionnaire survey based on the validated instruments, including the Cognitive Skills Composite Scale (CSC). Quantitative surveys are still viable towards investigating connections among behavioural variables and psychological outcomes (Saunders et al., 2009). The systematic questionnaire is structured and therefore provides a standardisation that can be easily applied in comparison across the respondents.

The systematic literature review (SLR) is based on the PRISMA 2020 rules, which provide rigour in the procedure of identifying, screening, and evaluating peer-reviewed articles (Page et al., 2021). The SLR component will focus on the 3 rd research goal by synthesising evidence on how rhythm-based interventions are involved in the enhancement of cognition. Searching in relevant databases, including Scopus, Web of Science and Google Scholar, the keywords that were used were percussion training, rhythmic intervention, and cognitive skills. Peer-reviewed empirical articles published since 2019 were included.

3.2.1. Target Population

The target market is made up of undergraduate and postgraduate college students who have been engaged in music courses involving percussion or drumming activities. The reason why this population is chosen is that university students undergo complex cognitive tasks, which can be affected by systematic rhythmic exercises. Past research has indicated that cognitive improvement in music is evident even in late adolescents and adults, and such an age group would be suitable to evaluate any transfer effects (Swaminathan and Schellenberg, 2024). They were limited to individuals (a) enrolled in a course or ensemble based on percussion, (b) with at least half a year of consistent attendance and (c) who concurred to fill out the online questionnaire.

3.2.2. Samples and Sampling Techniques

A sample consisting of 300 respondents was chosen because it was necessary to have a reasonable statistical benefit to perform correlation and regression analyses. The determination of the sample size is done according to the recommendations of Hair et al. (2021), who suggest that the sample to be used in multivariate statistical modelling must be over 200. The researcher uses a stratified random sampling method to make sure that there will be representation regarding gender, academic level and training intensity categories. In this way, sampling bias is reduced, and generalizability is increased (Etikan & Bala, 2017).

The selection was applied to the qualitative aspect, which entailed 5 peer-reviewed empirical studies that were published within 2019-25 and met the methodological rigour criteria as well as relevance regarding percussion or rhythmic cognitive training. This is the small, narrow corpus that makes thematically synthesised, in line with the qualitative systematic review's protocols (Snyder, 2019). Articles' inclusion criteria include: (a) research of an empirical design; (b) a clear interest in rhythmic or percussion-based intervention; and (c) a quantification of cognitive, neural or attentional outcome.

3.3. Data Analysis Method

The quantitative data analysis employed correlation and multiple regression techniques to examine the relationships between percussion training variables (intensity and duration) and cognitive skills. Correlation analysis was used to identify the strength and direction of associations between practice parameters and cognitive scores. Regression analysis was then used to determine the predictive power of these independent variables on the dependent variable, cognitive skills (Mertler et al., 2021). This analytical framework is suitable for educational and behavioural research where continuous variables are examined for linear associations (Field, 2024). The regression model tested hypotheses derived from the first two research objectives: whether weekly training hours and training duration significantly predict cognitive performance among participants. Statistical analyses were performed using SPSS or similar software. Reliability of questionnaire constructs was verified using Cronbach's alpha (> 0.70 threshold), ensuring internal consistency (Hair et al., 2021).

For the qualitative component, the systematic literature review followed a thematic synthesis approach (Thomas & Harden, 2008). Extracted findings from selected studies were coded and organised into higher-order themes such as "attentional entrainment," "sensorimotor integration," and "executive control enhancement." This analytic process provided interpretive insights into the mechanisms and contextual factors influencing the efficacy of percussion training. Integrating qualitative themes with quantitative results enables methodological triangulation and enhances construct validity (Creswell & Creswell, 2017).

The mixed-method integration stage was compared with convergences and divergences between statistical findings and thematic interpretations. According to Fetters and Freshwater (2020), such integration allows for comprehensive explanations of observed relationships and contributes to the development of evidence-informed recommendations for practice and research.

3.4. Ethical Considerations

The research followed the ethical principles of institutional research to safeguard the rights, autonomy, and data confidentiality of the participants. An informed consent form was given to all participants outlining the objective of the study, voluntary involvement and the right to pull out at any time. There were no personal identifiers that were gathered, and all data was anonymised. The data that was gathered electronically was only stored in password-secured devices, which were only accessible by the researcher. Data collection was done after ethical approval was received from the Research Ethics Committee of the university. The SLR element had been limited to the publicly available studies exclusively, and so, no ethical issues were raised using human subjects. All in all, the research is sound, honest, respectful of the participants, yet it is of high academic rigour and can be replicated in terms of quantitative as well as qualitative strands.

4. Data Analysis

The chapter contains the analysis and interpretation of the quantitative and qualitative research findings connected to the topic of how percussion training can help to improve the cognitive skills of university students. The quantitative part mentions a report regarding descriptive statistics, reliability, correlation, and regression analyses on the data of the questionnaires (n=300). The qualitative part will incorporate a synthesis of five recent and peer-reviewed studies involving a systematic literature review (SLR) integrating these studies in explaining mechanisms, context and moderating factors within percussion training and cognitive development. Combined, these findings can be used as empirical and theoretical validation of the role of the intensity and duration of percussion training and its impact on the cognitive performance of higher-education learners.

4.1. Descriptive Statistics

Table 1 displays the gender distribution of the sample, revealing that 154 respondents (51.3%) were male, while 146 (48.7%) were female, confirming a well-balanced gender representation.

Table 1: Gender of Respondents

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	154	51.3	51.3	51.3
	Female	146	48.7	48.7	100.0
	Total	300	100.0	100.0	

This near-equal distribution minimises gender bias and enhances the generalizability of results across both male and female students. Similarly, Table 2 shows that 151 respondents (50.3%) were undergraduates and 149 (49.7%) were postgraduates, suggesting a balanced academic representation.

Table 2: Degree Level of Respondents

Degree level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Undergraduate	151	50.3	50.3	50.3
	Postgraduate	149	49.7	49.7	100.0
	Total	300	100.0	100.0	

The distribution confirms the study's inclusion of participants at different stages of higher education, which is important for understanding cognitive skill differences across academic maturity.

4.2. Reliability Analysis

To ensure internal consistency of the three measurement scales, Percussion Training Intensity, Percussion Training Duration, and Cognitive Skills, Cronbach's alpha values were computed. Table 3 summarises the reliability statistics.

Table 3: Reliability Analysis

Scale	Cronbach's Alpha	N of Items
Percussion Training Intensity	0.814	5
Percussion Training Duration	0.801	5
Cognitive Skills	0.812	6

All alpha values exceed the accepted threshold of 0.70 (Field, 2024), indicating satisfactory internal reliability. Specifically, the Percussion Training Intensity scale ($\alpha = 0.814$) demonstrates strong coherence among its five items measuring weekly practice effort. The Duration scale ($\alpha = 0.801$) reflects consistent responses regarding sustained training engagement. The Cognitive Skills scale ($\alpha = 0.812$) confirms stable measurement of executive functions such as attention, working memory, and inhibition control. These coefficients collectively validate the psychometric soundness of the instrument and justify further inferential analysis.

4.3. Correlation Analysis

Spearman's rho correlation was employed to examine bivariate associations among the three constructs. Table 4 presents the results. All correlations are positive and significant at the 0.01 level. The strongest relationship appears between Percussion Training Duration and Cognitive Skills (r = .800), closely followed by Intensity and Cognitive Skills (r = .799). The substantial correlation between Intensity and Duration (r = .784) indicates that students who practice more intensively also tend to sustain training for longer periods.

Table 4: Correlation Analysis

Correlations					
			Percussion Training Intensity	Percussion Training Duration	Cognitive Skills
Spearman's rho	Cognitive Skills	Correlation Coefficient	.799**	.800**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	300	300	300
**. Correlation is significant at the 0.01 level (2-tailed).					

The results imply that both the frequency of weekly engagement and the longevity of training are closely linked with improved cognitive outcomes. These findings align with prior studies showing that consistent musical or rhythmic practice enhances executive functions through attentional entrainment and sensorimotor synchronisation (Haverkamp et al., 2020; Bugos et al., 2024). The high coefficients (r > .75) suggest not merely a moderate but a strong positive relationship, supporting the hypothesis that structured percussion practice contributes significantly to cognitive development.

4.4. Regression Analysis

To determine the predictive strength of training intensity and duration on cognitive skills, a multiple linear regression analysis was conducted. The dependent variable was Cognitive Skills, while the predictors were Percussion Training Intensity and Percussion Training Duration.

Table 5: Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.850[a]	.722	.720	.542643243921743
a. Predictors: (Constant), Percussion Training Duration, Percussion Training Intensity				

The model explains 72.2% of the variance in Cognitive Skills ($R^2 = 0.722$), indicating a strong predictive capability. The high R-value (.850) demonstrates a robust combined effect of intensity and duration on cognitive performance.

Table 6: Analysis of Variance

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	226.808	2	113.404	385.124	.000[b]
	Residual	87.455	297	.294		
	Total	314.263	299			
a. Dependent Variable: Cognitive Skills						
b. Predictors: (Constant), Percussion Training Duration, Percussion Training Intensity						

The ANOVA result ($F = 385.124$, $p < 0.001$) confirms that the overall model is statistically significant, verifying that the predictors jointly account for substantial variance in cognitive performance.

Table 7: Model Coefficient

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.470	.104		4.524	.000
	Percussion Training Intensity	.428	.047	.441	9.056	.000
	Percussion Training Duration	.443	.047	.460	9.435	.000
a. Dependent Variable: Cognitive Skills						

Both predictors have significant positive coefficients ($p < 0.001$), indicating that increases in intensity and duration independently predict higher cognitive scores. Duration shows a slightly stronger standardised beta ($\beta = .460$) than intensity ($\beta = .441$), suggesting that sustained engagement exerts a marginally greater impact on cognitive development than weekly practice volume. Collectively, these quantitative results confirm that both how often students practice and how long they have practised over time significantly enhance their cognitive skills. This aligns with neurocognitive evidence that rhythmic entrainment through percussion fosters neural plasticity in prefrontal and cerebellar regions associated with attention and working memory (Bruchhage et al., 2020; Nam & Kwon, 2023).

4.5. Exploring Mechanisms, Contexts, and Moderating Factors

A Systematic Literature Review (SLR) was undertaken to complement the quantitative findings by identifying the mechanisms and contextual moderators linking percussion training to cognitive development. Five studies published between 2019 and 2024 were selected based on relevance and methodological rigour.

Table 8: Summary of Reviewed Studies

Author (Year)	Aim	Research Method	Results	Conclusion
Bruchhage et al. (2020)	Examine neural plasticity induced by drumming practice	Experimental (fMRI)	Drum training increased cerebellar volume and sensorimotor connectivity	Percussion practice strengthens brain networks for executive control
Cahart et al. (2022)	Investigate behavioural and neural changes from drum learning	RCT + fMRI	Improved attention and inhibition; enhanced prefrontal activation	Rhythm-based learning boosts attentional and inhibitory control
Nam & Kwon (2023)	Test prefrontal activation during virtual drumming tasks	Experimental (fNIRS)	Higher prefrontal oxygenation is linked with improved memory	Drumming engages working-memory networks and cognitive flexibility
Kim et al. (2022)	Evaluate dual-task rhythmic therapy effects	Multiple case studies	Enhanced executive functioning and motor coordination	Cognitive-motor entrainment improves inhibition and attention
Schmid (2024)	Review cross-domain rhythmic entrainment mechanisms	Theoretical Review	Identified neural synchronisation and motivational factors as moderators	Entrainment and context (group vs. solo) moderate cognitive gains

The qualitative synthesis reinforces the statistical evidence that rhythmic or percussion training fosters cognitive enhancement through multi-mechanistic pathways. Across studies, three primary mechanisms emerged: neural plasticity, attentional entrainment, and sensorimotor integration. Neuroimaging research (Bruchhage et al., 2020; Nam & Kwon, 2023) demonstrates that sustained drumming practice increases connectivity between cerebellar and prefrontal regions, supporting higher executive functioning. Behavioural experiments (Cahart et al., 2022; Kim et al., 2022) reveal improvements in attention, inhibitory control, and cognitive flexibility following rhythmic engagement, confirming that timing precision and bilateral coordination translate into enhanced self-regulation.

Contextual factors also play a moderating role. Group-based rhythmic activities tend to amplify outcomes through social synchronisation and motivation (Schmid, 2024), while individual practice fosters introspective focus and fine-motor control. Training duration again emerges as critical: longer interventions produce more stable neural adaptations, aligning with the quantitative finding that duration slightly outweighs intensity as a predictor of cognitive gain. Collectively, the SLR underscores that percussion training enhances cognition through embodied rhythmic mechanisms operating within supportive learning contexts. These findings substantiate the mixed-methods conclusion that both the quantitative dose–response relationships and qualitative mechanisms converge to demonstrate percussion training as a robust catalyst for cognitive development in university-aged learners.

5. Discussion

This chapter interprets the quantitative and qualitative findings in the context of existing literature, establishing how percussion training intensity and duration influence cognitive skills among university students. Each research objective is discussed separately and supported by theoretical and empirical insights from previous studies presented in the literature review.

5.1. Impact of Percussion Training Intensity on Cognitive Skills

The initial study target was to test the impact of the intensity of percussion training on the cognitive capability of university students. The findings revealed a high positive correlation ($r = .799$, $p < .01$), which showed that students with more frequent and focused weekly practice had better cognitive performances. This conclusion is consistent with the existing literature that has highlighted the fact that regular and extensive music practice improves executive functions, attention, and working memory (Haverkamp et al., 2020; Bugos et al., 2024). The reliability of the intensity scale, evidenced by the high value of Cronbach's alpha (.814), proves that week effort and focus are among the determinants of cognitive gain. These findings have been supported by Girgin and Algun (2021), who concluded that embodied rhythmic coordination requires sustained attention, focusing and sensorimotor connection, leading to higher cognitive transfer. In addition, the result matches that of Vatakis et al. (2014), as they also found that even brief yet intensive music training sessions led to increasing fine motor control and attentional control. Such a relationship can be explained by the theory of Embodied Cognition, which assumes that bodily rhythm in drumming can be used to improve cognitive control by synchronising motor and neural timing mechanisms. Therefore, the neural synchronisation as well as attentional entrainment may be facilitated by escalated practice intensity, hence better executive functioning.

5.2. Influence of Training Duration on Cognitive Outcomes

The second study goal compared the effect of the training length on the cognitive skills. The outcomes of regression indicated that longer duration of training ($b = .460$, $p < .001$) was a little bigger than the impact of intensity ($b = .441$, $p < .001$), which implies that the longer the duration of engagement, the bigger the influence it exerts on cognitive performance. This is in line with the existing research that indicated that the long-term neural and behavioural changes result in stable changes with musical training (Xu et al., 2018; Espinosa et al., 2025). Likewise, Haverkamp et al. (2020) and Bugos et al. (2024) found that the thirteen-week or more music interventions produced much bigger gains in cognitive advantages than did shorter interventions. It is probable that the ongoing involvement in percussion processes can eventually lead to the gradual reorganisation of the neural structure and the ability to consolidate skills, which is in line with the Transfer of Training Theory, stating that sustained training improves the extension of acquired skills into other fields of cognition. Another point that Girgin and Algun (2021) make is that rhythmic practice that lasts multiple weeks promotes sensorimotor integration, hence promoting coordination and attentional control. The effect of this effect on the long term is reminiscent of long-term plasticity of the cerebellar and prefrontal areas seen by Bruchhage et al. (2020). Thus, the research results conclude that the extended periods of training offer a more predictable base of cognitive improvement, which is why active practice is ultimately more important than passive one.

5.3. Mechanisms and Moderating Factors in Percussion-Cognition Link

Mechanisms, context, and moderating factors relating percussion training to cognitive improvement were examined as the third research objective, but the systematic literature review was not conducted. The results indicated that three processes influence cognitive improvement based on neural plasticity, attentional entrainment, and sensorimotor integration. The studies by Bruchhage et al. (2020), Cahart et al. (2022), and Nam and Kwon (2023) point to these processes. All these studies indicated that cerebellar and prefrontal connectivity, due to drumming, also results in better attention and inhibition control. Along the same lines, Kim et al. (2022) also focused on the dual-task rhythmic interventions, as these seem to enhance executive functioning as they involve simultaneous motor and cognitive task performance.

Contextual moderators also emerged as critical. Schmid (2024) noted that group-based drumming environments amplify motivation and cognitive outcomes through social synchronisation, whereas individual sessions strengthen concentration and fine-motor control. This aligns with Bugos et al. (2024), who stressed that instructor quality and learning context significantly shape intervention success. These qualitative findings complement the quantitative evidence showing that both intensity and duration predict cognitive improvement. Taken together, the results affirm that percussion training enhances cognition through embodied, context-dependent, and socially mediated mechanisms, supporting both Embodied Cognition and Transfer of Training frameworks outlined in the literature.

6. Conclusion and Recommendations

6.1. Conclusion

This study investigated how percussion training intensity and duration influence cognitive skills among university students through a mixed-methods design. Quantitative analysis confirmed strong, positive correlations between both training variables and cognitive outcomes, explaining over 72% of the variance in cognitive performance. The qualitative synthesis further revealed that neural plasticity, attentional entrainment, and sensorimotor integration mediate these effects. The findings collectively demonstrate that structured percussion practice, especially when sustained and frequent, enhances executive functions, working memory, and attentional control. The results contribute new evidence to the expanding body of research linking rhythmic training to cognitive development, extending its application to higher-education populations. The study also validates Embodied Cognition Theory and Transfer of Training Theory as suitable explanatory frameworks, demonstrating that embodied rhythmic activity can generate far transfer to non-musical cognitive domains. By integrating both quantitative and qualitative insights, this research provides comprehensive support for percussion-based learning as a multidimensional tool for cognitive growth in university contexts.

6.2. Implications

6.2.1. Theoretical Implications

Theoretically, the findings strengthen the conceptual linkage between embodied rhythmic learning and cognitive transfer. The results confirm that the cognitive benefits of percussion training stem from embodied neural synchronisation, validating the Embodied Cognition perspective (Hao et al., 2023). Furthermore, they extend the Transfer of Training Theory by demonstrating that long-term rhythmic engagement fosters far transfer beyond the musical domain, improving attention and executive control. Thus, the study adds depth to cognitive-musicology frameworks by elucidating how intensity and duration of training interact to produce neural and behavioural adaptation in higher-education learners.

6.2.2. Practical Implications

Practically, this study offers guidance for educators and curriculum designers in higher education. Integrating percussion-based modules within music and psychology programs can strengthen students' cognitive flexibility, focus, and problem-solving abilities. University wellness programs can adopt short-term rhythmic interventions to mitigate cognitive fatigue and enhance concentration. Additionally, structured, long-duration percussion workshops can be employed as low-cost, engaging cognitive-training tools. For music educators, understanding the importance of sustained and intensive rhythmic engagement allows more deliberate curriculum planning that maximises both musical proficiency and cognitive benefit.

6.3. Recommendations

Based on these results, it is recommended that universities incorporate percussion-based learning activities as part of cognitive enrichment and creative arts initiatives. Institutions should design structured rhythmic training programs lasting at least 10–12 weeks to ensure observable cognitive gains. Regular monitoring of practice frequency and participant engagement is crucial for maximising outcomes. Educators should foster collaborative drumming sessions that combine group synchronisation with individual skill refinement to balance social motivation and personal focus. Moreover, interdisciplinary partnerships between music departments and cognitive science programs can promote applied research, refining the use of rhythmic interventions as evidence-based tools for cognitive development in academic settings.

6.4. Limitations and Future Work

Although this study provides robust quantitative and qualitative evidence, certain limitations must be acknowledged. The research relied on self-reported questionnaire data, which may introduce subjective bias. The cross-sectional design limits the ability to establish long-term causal relationships between training and cognitive outcomes. Additionally, the sample was drawn from a single university context, potentially limiting generalizability to diverse educational settings. Future research should employ longitudinal experimental designs incorporating neurophysiological measures such as EEG or fMRI to observe structural brain changes over time. Expanding the sample to include multiple institutions and cultural contexts would also enhance external validity. Moreover, exploring gender and personality as moderating variables could yield a more nuanced understanding of how individual differences interact with rhythmic learning to influence cognitive performance.

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Questionnaire Survey

Demographics

Gender

1. Male
2. Female

Degree level

1. Undergraduate
2. Postgraduate

Percussion Training Intensity (weekly practice intensity)

- I engage in focused percussion practice on most days of the week.
- My weekly percussion practice sessions are long enough to feel mentally demanding.
- I maintain a high level of concentration throughout my typical practice session.
- I regularly include technically challenging drills (e.g., rudiments, polyrhythms) in a single week.
- I push myself to increase the difficulty or tempo during weekly practice.

Percussion Training Duration (program tenure/continuity)

- I have participated in a structured percussion program for a sustained period.
- My involvement in percussion has been continuous without long breaks.
- I have completed multiple weeks of scheduled lessons or ensemble rehearsals recently.
- I plan to continue my percussion training for many more weeks.
- I have built percussion skills gradually over an extended period.

Cognitive Skills (executive function, working memory, attention)

- I can sustain attention on demanding tasks without getting easily distracted.
- I can quickly shift between tasks without losing track of my goals.
- I remember multi-step instructions or sequences without needing reminders.
- I can stop myself from making impulsive responses when a task requires patience.
- I can mentally juggle several pieces of information at once while working.