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Rhythmic Auditory Stimulation in Gymnastics Learning: Enhancing Movement Creativity in Primary School Gymnastics through Music-Based Pedagogy

ABSTRAK

Physical education in primary school gymnastics frequently falls into a mechanical, repetitive approach that constrains the originality and fluency of students' movement creativity. This study aims to examine the effectiveness of Rhythmic Auditory Stimulation (RAS) interventions via Orff music-based pedagogy in enhancing the movement creativity of gymnastics students at a public primary school in Majalengka. To isolate the direct impact of this external stimulation on a homogeneous group of subjects without inter-group variable distortions, this research utilizes a One-Group Pretest-Posttest experimental design. This design is robustly strengthened by strict control over audio tempo standardization (120–130 BPM) and the elimination of visual instructions from the teacher to ensure internal validity. The results of the data analysis demonstrate a statistically significant increase in motor creativity, even though the intervention's effectiveness is constrained within the moderate category, yielding an average N-Gain score of 35%. This efficiency limitation reflects an internal constraint consisting of the biological motor maturity of middle childhood students and the brief duration of the intervention (3 weeks). Theoretically, this study contributes to the ecological dynamics paradigm by proving the function of external audio rhythm structures as an affordance that manipulates children's kinetic action spaces while simultaneously constructing on-field psychological safety. Practically, this research offers a new physical education curriculum model that positions music as a measurable motor behavior control instrument rather than merely a background soundtrack for classroom ambience.

Keywords: *Ecological Dynamics, Movement Creativity, Rhythmic Auditory Stimulation, Primary School Gymnastics.*



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INTRODUCTION

Primary school gymnastics education currently faces serious pedagogical barriers characterized by low levels of student movement creativity, a direct consequence of the dominance of rigid, conventional instructional methods. This barrier is evident from preliminary observations conducted at SD N Prapatan 3, where 35 students demonstrated limited variation in movement responses during gymnastics activities, with the majority tending to replicate the teacher's demonstrated movements rather than developing independent motor solutions. Ideally (das sollen), modern curricula demand that Physical Education, Sports, and Health (PESH) serve as a dynamic vehicle that triggers originality, free expression, and motor problem-solving skills in children from an early age. In reality (das sein), however, field observations reveal that gymnastics instruction remains trapped in a linear, teacher-centered approach that relies heavily on monotonous movement imitation. This restrictive conventional approach has been shown to significantly suppress creative thinking potential and limit students' autonomous exploration within physical activities (Rink, 2021; Ward et al., 2023). Consequently, rather than fostering adaptive and confident students, gymnastics instruction produces repetitive movement patterns that trigger a decline in learning motivation. This sharp disparity between progressive curricular demands and rigid conventional teaching practices underscores the critical urgency of implementing an alternative pedagogical intervention in the field.

The tangible barriers encountered in the field necessitate the formulation of an instructional methodology that is not only adaptive but also capable of directly intervening in children's motor limitations during tactile practice. Rather than focusing on theoretical digitalization that distances students from the intensity of physical activity, pedagogical solutions

must target external media stimulation that integrates seamlessly with the students' physical responses. In this context, music emerges as a highly relevant external medium because it possesses rhythmic components that serve as a temporal determinant of bodily movement (Thaut & Hoember, 2025). Auditory cues from music function as a neuro-stimulus capable of breaking down the rigidity of conventional methods through the mechanism of auditory-motor entrainment or auditory-motor synchronization (Shafron et al., 2022). Specifically, this entrainment mechanism directly counteracts the rigid, teacher-centered imitation pattern described earlier: rather than waiting for and copying a visually demonstrated movement cue, students' motor responses become automatically synchronized to the auditory rhythm, replacing the linear command-response structure with a more internally-driven, anticipatory movement response. This subconscious synchronization reduces students' psychological tension arising from the obligation to imitate rigid movements, transforming it into a more flexible and fluid physical response (Damm et al., 2020). This pattern is also reflected in the local Indonesian context, where music- and song-based movement activities (*gerak dan lagu*) have been shown to develop children's gross motor skills more effectively than conventional instruction (Kevin et al., 2024). Consequently, the utilization of music acts as a crucial instructional bridge that breaks through the mechanical constraints of gymnastics toward a more explorative learning ecosystem.

To actualize such an explorative environment, primary school gymnastics instruction must be underpinned by a play-based approach and the application of nonlinear pedagogy. This nonlinear approach positions students as active subjects who discover adaptive movement solutions based on the dynamic interaction between their bodies and environmental constraints (Button et al., 2024; Chow et al., 2023). Within this ecosystem, the play approach, which is conventionally stimulated verbally, is reinforced through the presence of music as a primary open stimulus. Rather than dictating specific movements, music liberates children to interpret beats into autonomous forms of physical expression (Damanik et al., 2023). The urgency of this transformation aligns with the demands of 21st-century skills, where the integration of music-based pedagogy specifically enhances indicators of divergent thinking and motor originality. Through flexible rhythmic stimuli, students are trained to cultivate the courage necessary to solve movement problems instantaneously and independently.

Although studies on psychomotor creativity continue to expand, the precise design of learning environments capable of intervening in the creativity of primary school-aged children still leaves an empirical gap. Within the local context, Suherman et al., (2024) found that a reflective learning approach effectively improves movement skills and the ability to creatively choreograph gymnastics. However, that study differs from the present research in two fundamental respects: first, its subjects were pre-service physical education teachers rather than elementary school children, whose motor development phase and creative-cognitive capacities differ substantially; and second, the intervention relied on verbal reflective discussion as its primary stimulus, rather than the rhythmic, auditory-motor mechanism of music proposed in this study. This leaves a major question regarding the effectiveness of a reflection-based approach when applied directly to children's motor development phases, as well as an unexplored opportunity to test a sensory-based rather than verbal-based stimulus. On the other hand, the current global research trend is dominated by the utilization of digital ecosystems to stimulate students' movement variations (Zhang et al., 2024). This screen-based approach has drawn criticism for overemphasizing purely cognitive-visual aspects while failing to touch upon the intense, direct kinesthetic experiences on the field that children desperately need; unlike screen-mediated movement cues, direct kinesthetic experience allows the child's motor system to receive real-time proprioceptive and auditory feedback simultaneously, enabling immediate self-correction and embodied problem-solving that a purely visual-cognitive stimulus cannot replicate. This positions the present study within the global research map of Ecological Dynamics, which emphasizes that movement creativity emerges from the direct, reciprocal coupling between the learner's perception and action within a real physical environment, rather than from externally imposed digital or purely cognitive representations of movement.

This is precisely where the novelty of this study lies. The novelty does not merely rest on the general utilization of music in the classroom, but on the deconstruction of music's role from a

simple background accompaniment into a structured pedagogical intervention that targets specific audio characteristics. Through this approach, formal musical elements, namely tempo manipulation (fast-slow), rhythmic synchronization (constant beats), and dynamics (volume accentuation), are systematically analyzed as primary stimulants that map variations in children's motor responses. This positioning aligns with Septika et al., (2025) findings on how structured physical activity stimuli shape early childhood motor development, through which auditory structure is translated into embodied action. Among these elements, tempo is positioned as the primary control variable, deliberately manipulated across sessions to observe its direct effect on movement quality: a fast tempo is employed to stimulate explosive, wide-amplitude movements and rapid spatial displacement, encouraging children to explore larger movement ranges within a limited time frame, while a slow tempo is employed to stimulate controlled, sustained movements with greater attention to body posture, balance, and the elaboration of movement detail. By systematically alternating between these two tempo conditions, this study maps a direct correspondence between auditory tempo and specific dimensions of motor creativity, namely fluency and originality under fast tempo, and flexibility and elaboration under slow tempo. This mapping is consistent with findings from (Kholiq, 2025), who demonstrated that a rhythmic gymnastics model can be used to systematically develop and observe fundamental motor skills in young children through structured movement-to-music training. This study offers a new theoretical contribution to the psychomotor domain, particularly regarding how formal auditory structures control physical exploration spaces and trigger movement originality during the developmental phase of primary school children.

From a neuroscience perspective, the effectiveness of Rhythmic Auditory Stimulation (RAS) in breaking down movement rigidity is based on the ability of rhythmic stimulation to bypass complex cognitive pathways, heading directly toward immediate motor responses. As the musical beat enters through the auditory cortex, the sound signal is immediately distributed to the motor areas of the brain, including the cerebellum, premotor cortex, and basal ganglia, without waiting for slow verbal processing (Pranjić et al., 2024). This auditory-motor entrainment process forces the motor nervous system to constantly align its movement frequency with the heard external tempo. In the context of movement creativity, this neural synchronization lowers functional tension in the prefrontal cortex, the brain area that typically triggers self-censorship, anxiety, and the fear of making incorrect movements. The reduction of this inhibitory activity, described in the literature as a state of transient hypofrontality (Dietrich, 2024), opens up space for the emergence of a kinesthetic flow state, wherein the child's bodily coordination becomes more fluid and adaptive, allowing them to instantaneously map out variations, improvisations, and choreographic originality on the field.

This field-based RAS intervention substantively supports the achievement of the Sustainable Development Goals (SDGs). Its contribution to SDG 4 (Quality Education) is realized through a shift from conventional instructional models toward an inclusive, participatory pedagogy centered fully on students' movement agency. Meanwhile, its connection to SDG 3 (Good Health and Well-Being) specifically targets the enhancement of children's emotional well-being. The freedom to explore movement without the constraints of rigid instructions, facilitated through rhythmic stimulation, has been shown to reduce motor anxiety, foster self-confidence, and adaptively channel children's positive emotional expressions. Based on the empirical gap, the urgency of sustainable development, and these neurological mechanisms, the research question posed in this study is: How does the application of Rhythmic Auditory Stimulation (RAS) through music-based pedagogy influence the enhancement of movement creativity in primary school students' gymnastics?

METHOD

This experimental study applies a quantitative approach utilizing a One-Group Pretest-Posttest Design to measure the impact of the intervention on primary school students' movement creativity in gymnastics, transforming psychomotor performance into objective numerical data. All procedures complied with the ethical standards of human experimental research, securing official permission from school authorities and written parental informed consent prior to data

collection (Creswell & Creswell, 2020). The research site was selected purposively at a public primary school in Majalengka Regency, chosen for its availability of field audio facilities and the constraints of its existing gymnastics teaching methods, which remain conventional and instructional. Through a total sampling technique, 35 fourth-grade students (N = 35) were selected as a single sample meeting the inclusion criteria: a record of full attendance, a healthy physical condition for rhythmic activities, and non-participation in any extracurricular dance or gymnastics training outside of school (Cohen et al., 2020). The demographic characteristics of the subjects place them in the developmental phase of gross motor coordination maturity typical of middle childhood, with an average biological age of 9–10 years, distributed by gender across 15 male students (42.86%) and 20 female students (57.14%); this demographic control is crucial as the rate of motor maturation in children of this age is heavily influenced by gender differentiation. In terms of daily physical activity background, all subjects were confirmed to receive a homogeneous level of structured movement exposure, limited solely to the standard 4 hours per week of in-school Physical Education instruction, with no subject reporting participation in external sports clubs, structured physical training, or sedentary-dominant daily routines that could confound baseline motor creativity; this homogeneity in daily physical activity exposure was verified through a brief informal interview with the school's physical education teacher, who confirmed that students received an average of only 4 hours of structured physical activity per week, entirely accounted for by the standard in-school PJOK curriculum, prior to sample selection.

The intervention protocol was conducted systematically over a 3-week period with a frequency of twice a week, amounting to a total of 6 structured sessions, each lasting 2 x 45 minutes from 07:30 to 09:00 WIB to eliminate confounding bias from children's physical fatigue (Rink, 2021). The research site in Majalengka Regency was also selected for a sociocultural rationale relevant to the musical intervention itself: as an area within the West Java (Sundanese) cultural sphere, students in this region are presumed to have had prior informal exposure to Kendang Jaipong percussion rhythms through community and cultural contexts, which was expected to facilitate more natural auditory-motor engagement compared to students entirely unfamiliar with the rhythmic idiom used in the treatment. Treatment fidelity was strictly maintained by appointing a single, permanent physical education teacher as the model instructor on the field, while the researcher acted as the compliance supervisor for the instructional module (Supriyadi et al., 2020). The experimental procedure commenced with a pretest phase, during which students explored autonomous gymnastics movements guided solely by verbal counts without any external sound stimuli. During the treatment phase, students received gymnastics instruction utilizing rhythmic auditory stimulation through music that integrated dynamic traditional Sundanese genres (Kendang Jaipong) and electronic children's pop with a 4/4 time signature and a distinct downbeat accentuation on counts 1 and 3. The tempo characteristics were adjusted through progressive tempo overload as detailed in Table 1, before concluding with a posttest phase using identical experimental music accompaniment; a tempo scheduling protocol proven to optimally trigger motor adaptation in children (Damm et al., 2020).

Session	Week	Phase	Tempo (BPM)	Duration	Stimulus Focus
Pretest	—	Baseline	No music (verbal counts)	2 x 45 minutes	Autonomous movement exploration without auditory stimulus
Session 1	Week 1	Treatment	100–110	2 x 45 minutes	Initial adaptation to constant beat
Session 2	Week 1	Treatment	100–110	2 x 45 minutes	Reinforcement of basic auditory-motor synchronization
Session 3	Week 2	Treatment	115–125	2 x 45 minutes	Increased movement variation following tempo acceleration

Session 4	Week 2	Treatment	115–125	2 x 45 minutes	Exploration of directional and level flexibility
Session 5	Week 3	Treatment	130–140	2 x 45 minutes	Stimulation of explosive movement and originality
Session 6	Week 3	Treatment	130–140	2 x 45 minutes	Consolidation of overall movement creativity
Posttest	—	Evaluation	Identical to experimental music accompaniment	2 x 45 minutes	Final measurement of movement creativity

Table 1. Intervention Session Schedule

Movement creativity data were collected through structured direct observation of recorded student performance videos using an evaluation rubric with a 1–5 interval scale (Likert Scale) covering three primary psychomotor indicators. The fluency indicator measured the quantity of functional movement variations within a single rhythmic cluster; the flexibility indicator assessed the ability to simultaneously alter movement directions and levels; and the originality indicator evaluated the level of unique, purely autonomous movement creation free from peer imitation (Torrents et al., 2021). Data objectivity and quality (trustworthiness) were guaranteed through two stages of statistical standardization. First, content validity was established via expert judgment from three sports pedagogy and music specialists, yielding an Aiken's V index range of 0.83 to 0.91, which is categorized as highly valid. Second, inter-rater reliability was tested across two independent observers using Cohen's Kappa statistics, which produced a coefficient of $k = 0.86$. This confirmed an almost perfect agreement, thereby minimizing the subjectivity bias of a single evaluator on the field (O'Donoghue, 2022).

All numerical data were processed using IBM SPSS Statistics v26 software, where a post-hoc Statistical Power Analysis using G*Power at a significance level of $\alpha = 0.05$ confirmed that the sample size of $N = 35$ provided adequate statistical power (> 0.80) for parametric analysis. Threats to internal validity were controlled through a short experimental duration to mitigate natural maturation effects, alongside the use of distinct yet tempo-equivalent track lists between the baseline and final sessions to mitigate testing effects (Thomas et al., 2022). To further minimize rater subjectivity when scoring the recorded performance videos, a single-blind observation procedure was applied: the two independent raters scored the pretest and posttest videos in a randomized, unlabeled order without access to session identifiers (i.e., unaware of which footage corresponded to the baseline or final phase), thereby preventing expectation bias from influencing the assigned scores. Within this gymnastics-specific context, the three psychomotor indicators were operationally defined as follows: fluency was measured by the number of distinct functional movement transitions a student could produce within a single 8-count rhythmic phrase without pausing or repeating an identical motion; flexibility was measured by the student's capacity to alter movement plane (high, medium, low level) and directional orientation (forward, lateral, rotational) within a single continuous movement sequence; and originality was measured by the proportion of movement elements performed by a student that were not observed in any other student's performance within the same session, as cross-checked against the full cohort's recorded movement repertoire. The data analysis steps were carried out hierarchically, encompassing descriptive statistics to map scores profiles, the Shapiro-Wilk normality test as a prerequisite for parametric procedures, and the Paired Sample T-Test to verify the significance of the mean differences in students' creativity scores (Rahman & Aeni, 2020). To satisfy international publication standards, the researcher also calculated the Cohen's d value to measure the practical effect size of the musical intervention, and conducted a Normalized Gain (N-Gain) analysis classified according to Hake's (1998) global standards into high-gain, medium-gain, and

low-gain zones to comprehensively determine the efficiency level of students' movement creativity enhancement.

RESULTS

Data analysis commenced with descriptive statistical mapping to numerically identify the profiles of students' baseline performance (pretest) and final achievement (posttest) in movement creativity. The descriptive calculation results indicate a highly substantial surge in the mean score of movement creativity after the implementation of the music-based Rhythmic Auditory Stimulation (RAS) intervention. The students' average score increased from 12.43 during the pretest session to 16.86 during the posttest session, accompanied by a data distribution that became increasingly solid and homogeneous on the field. The range of students' minimum and maximum scores also shifted toward higher thresholds, confirming a collective expansion of children's divergent motor abilities post-treatment; this pre-inferential descriptive reporting is crucial to prevent data outlier bias within small sample sizes (Thomas et al., 2022). A comprehensive summary of these descriptive parameters is presented in Table 2.

Activity	Mean	Standard Deviation (SD)	Minimum Score	Maximum Score
Pretest	12,43	1,42	10,00	15,00
Posttest	16,86	1,18	15,00	19,00

Table 2. Descriptive Summary of Students' Movement Creativity Scores (N = 35)

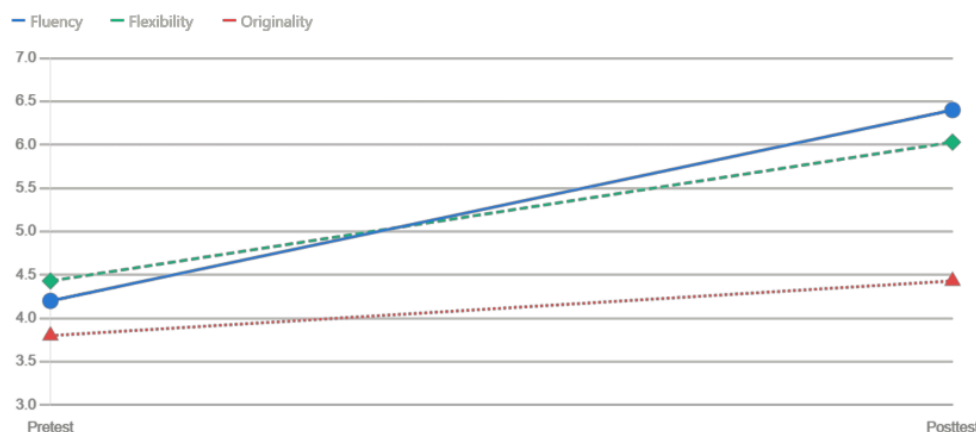


Figure 1. Trend of Movement Creativity Score by Indicator (Pretest-Posttest)

Beyond the aggregate score, a more granular indicator-level analysis reveals a meaningful gap in the magnitude of improvement across the three psychomotor dimensions, as illustrated in Figure 1. The Fluency indicator recorded the steepest upward trend, followed by Flexibility, while the Originality indicator exhibited the most modest gain among the three. This pattern suggests that the RAS intervention exerted its strongest effect on students' capacity to generate a greater quantity of movement variations, whereas the capacity to produce genuinely unique, non-imitative movement forms developed more gradually, indicating that originality may require a longer exposure period or a more advanced tempo-manipulation stage to fully manifest.

Prior to conducting inferential testing, a normality test, as an absolute prerequisite for parametric statistics, was calculated using the Shapiro-Wilk method, given that the sample size was under 50 subjects (N = 35). The normality test results confirmed that the pretest data yielded a significance value of 0.085 ($p > 0.05$) and the posttest data yielded a significance value of 0.110

($p > 0.05$). Because all significance values are well above the 0.05 threshold, the data distribution for this study is mathematically declared to be normally distributed (O'donoghue, 2022). The validity of meeting this normality assumption provides a solid foundation for the researcher to proceed with hypothesis testing using the inferential Paired Samples T-Test to observe the pure impact of the intervention.

Variable	Statistic	df	Significance (Sig.)	Conclusion
Pretest Score	0.946	35	0.085	Normally Distributed
Posttest Score	0.951	35	0.110	Normally Distributed

Table 3. Summary of Shapiro-Wilk Normality Test Results (N = 35)

Hypothesis testing was conducted to verify the influence of applying rhythmic auditory stimulation through music-based pedagogy on the enhancement of primary school students' gymnastics movement creativity. Based on the Paired Samples T-Test results, a calculated t-statistic of -16.419 was obtained, with 34 degrees of freedom ($df = 34$) and a two-tailed significance value (Sig. 2-tailed) of 0.000. This significance value, which is substantially smaller than 0.05 ($p < 0.001$), firmly rejects the Null Hypothesis (H_0) and statistically validates the Alternative Hypothesis (H_a) (Cohen, et al., 2020). The direction of the mean difference, valued at -4.429, empirically proves that the music-based RAS intervention exerts a massive, directional positive impact on enhancing students' movement creativity from the baseline to the final condition.

Data Comparison	Mean Difference	t	df	Sig. (2-tailed)	Conclusion
Pretest vs Posttest	-4.429	-16.419	34	0.000	H_a Accepted (Significant)

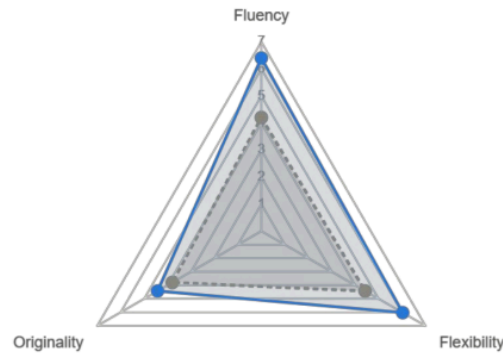
Table 4. Summary of Hypothesis Testing Results (Paired Samples T-Test)

The efficiency analysis of the post-treatment enhancement in students' movement creativity was calculated using the Normalized Gain (N-Gain) formula, converted according to Hake's (1998) global classification, whose continued validity and relevance for analyzing pretest-posttest intervention data has been reaffirmed in more recent psychometric literature (Coletta & Steinert, 2020). The accumulative calculation results show an average N-Gain score of 0.35 (35%), which places the effectiveness of the intervention within the Medium Gain category. This value does not occur in isolation but is driven by a healthy data distribution on the field, where the achievement distribution indicates that not a single student (0%) fell into the Low Gain category ($g < 0.3$). A total of 28 students (80%) experienced an enhancement within the Medium Gain category ($0.3 < g < 0.7$), and 7 students (20%) successfully reached the High Gain category ($g > 0.7$), as summarized in Table 5.

Analysis Component	Achievement Value	Classification (Coletta & Steinert, 2020)	Data Interpretation
Pretest Mean Score	12.43	—	Baseline ability prior to musical intervention
Posttest Mean Score	16.86	—	Final ability post musical intervention
N-Gain Mean Score	0.35	Medium Gain	Stable and consistent improvement

Table 5. Summary of Cumulative N-Gain Effectiveness Analysis (N = 35)

■ Pretest ■ Posttest



The wider gap on the fluency axis versus the narrower gap on the originality axis visualizes the disparity in intervention effectiveness across indicators.

Figure 2. Trend of Movement Creativity Score by Indicator (Pretest-Posttest)

To observe the dynamics of creativity development more specifically, the N-Gain scores were deconstructed into three primary psychomotor indicators of middle childhood: fluency, flexibility, and originality, classified according to the normalized gain thresholds validated in (Coppola et al., 2024). The indicator-specific analysis presented in Table 6 demonstrates that fluency recorded the highest enhancement efficiency with an N-Gain score of 0.46 (Medium Gain), followed by flexibility at 0.34 (Medium Gain). Conversely, the originality indicator recorded the lowest enhancement value at 0.22, falling into the Low Gain category. As visualized in Figure 2, this disparity manifests as a pronounced widening along the fluency and flexibility axes between the pretest and posttest profiles, while the originality axis remains comparatively constricted, a visual signature of uneven developmental response across indicators. This disparity in achievement provides critical insight: while rhythmic auditory stimulation is instantly highly effective at stimulating the quantity of movement variations (fluency), a longer intervention duration is required to foster pure movement uniqueness (originality) in primary school-aged children (Torrents et al., 2021).

Psychomotor Indicator	Pretest Mean	Posttest Mean	N-Gain Value	Category (Coletta & Steinert, 2020)
Fluency	4.20	6.40	0.46	Medium
Flexibility	4.43	6.03	0.34	Medium
Originality	3.80	4.43	0.22	Low

Table 6. Profile of N-Gain Score Achievement per Movement Creativity Indicator

Overall, the quantitative findings and direct field observations confirm that the application of music-based rhythmic auditory stimulation operates at a medium level of effectiveness in triggering students' movement creativity. This linear enhancement achievement, which was constrained at the intermediate level (N-Gain 35%) was operationally caused by limiting factors such as the relatively short duration of the experimental intervention (3 weeks) and the complexity of the children's adaptation to high-paced tempo accentuations in the final sessions (Damm et al., 2020). Nevertheless, qualitative observational data recorded consistent changes in motor behavior across the majority of subjects on the field. Students demonstrated a significant

improvement in the aspect of bodily rhythm synchronization to the musical beat (auditory-motor entrainment) as well as fluidity in changing compass directions while moving; however, their ability to generate purely novel and truly unique movement variations (motor originality) was observed to be highly limited and tended to recur in stereotypical basic gymnastics patterns.

DISCUSSION

The substantial focus of this section is directed toward synthesizing why rhythmic auditory stimulation proved particularly effective in reconstructing students' gymnastics movements at this SDN in Majalengka, rather than merely restating the observed outcomes. Neuromotor (14), music-based rhythmic auditory stimulation acts as a temporal pacemaker that stimulates the supplementary motor area (SMA) and the cerebellum through the phenomenon of auditory-motor entrainment (Damm et al., 2020). And this mechanism appears to have found particularly fertile ground in the present research site: students in this Sundanese cultural setting carry prior, informally-absorbed familiarity with the syncopated, downbeat-accented rhythmic idiom of Kendang Jaipong, such that the experimental music was not a wholly novel auditory stimulus but one that resonated with an existing internalized rhythmic schema. This pre-existing rhythmic familiarity plausibly lowered the threshold for entrainment to occur, allowing synchronization between the auditory beat and motor output to be established more rapidly than would be expected in a culturally unfamiliar rhythmic context (Slamet et al., 2023). This entrainment mechanism, however, did not exert a uniform effect across the three movement creativity indicators central to this study. Its influence was strongest on fluency, the indicator with the highest N-Gain (0.46): a constant, predictable beat structure lowers the cognitive load required to initiate each successive movement, freeing children to generate a greater quantity of movement variations within a single rhythmic cluster rather than expending cognitive resources on timing alone. Its influence on flexibility (N-Gain 0.34) operated more indirectly, primarily through the accent-based dynamics of the music, which cued children to shift movement plane and direction at specific downbeats, evident in the emergence of pivoted arm swings, torso twists, and patterned grapevine steps. Its influence on originality (N-Gain 0.22) was the weakest of the three, suggesting that while entrainment successfully liberated children from dependence on the teacher's visual instructions and habitual imitation, the generation of genuinely unique, non-imitative movement forms depends on cognitive-creative processes that operate on a slower developmental timescale than the auditory-motor synchronization mechanism itself.

Within the framework of ecological dynamics, the formal auditory element consisting of a stable tempo structure ranging from 120 to 130 BPM (Beats Per Minute) acts as a primary affordance for primary school students aged 9–10 years. This tempo range provides the most ideal action possibilities to manipulate children's spatial directions and bodily levels without overloading their cardiorespiratory capacity. The children's cognitive flexibility is stimulated to chase the downbeat accentuations, which directly explains why the fluency indicator recorded the highest enhancement efficiency in this study. Auditory stimulation at this specific BPM frequency successfully constructs a learning environment rich in kinesthetic stimuli, prompting children to rapidly transition from one movement variation to the next. This freedom to explore movement variations linearly reflects the core principle of the Orff Schulwerk approach, wherein rhythm functions as the primary catalyst to liberate children from the dictates of conventional gymnastics movements (Coppola et al., 2024; Torrents et al., 2021).

Although external music-based stimulation proved effective in triggering motor creativity, cumulative findings indicate that the class average N-Gain score was constrained at 35%, falling into the medium category. This limitation of efficiency at an intermediate level demonstrates that while external auditory stimulation acts as a powerful catalyst, its effectiveness remains internally bounded by the students' innate motor maturity variables (Gallahue et al., 2021). During middle childhood, the process of neural pathway myelination and sensory-motor integration is not yet fully mature enough to execute purely novel, original movements. This biological constraint was further compounded by the relatively short duration of the experiment (3 weeks); consequently, the auditory stimulation was only capable of optimizing movement quantity (*fluency* and

flexibility) without having sufficient time to foster the development of pure movement uniqueness. As a result, when confronted with fast tempos exceeding 140 BPM, the children's neuromuscular coordination experienced cognitive distortion, causing their movements to revert to stereotypical patterns of *Senam Pramuka* or *Senam Kesegaran Jasmani* (SKJ) that they had previously memorized.

This study serves to bridge the methodological research gap left by previous investigations, such as that of (Suherman et al., 2024). While the research by Suherman et al. focused on a reflective approach to equipping pre-service teachers with the skills to design choreography structurally, the present study zeroes in on the practical implementation and actual kinetic responses of primary school children as the primary learners in the field. The positioning of this study reinforces the notion that music-based pedagogy must not stop at the teacher's conceptual level; rather, it must be transformed into a direct stimulation method within basic gymnastics circuits. By focusing on children as the subjects, this research provides empirical evidence that adjustments in musical tempo can actively manipulate the difficulty level of children's motor coordination in real time. This approach offers a novel instructional model within the primary school physical education curriculum, wherein music is positioned as a scientifically measurable instrument for controlling motor behavior, rather than merely a background sound to fill the classroom atmosphere.

From a psychological dimension, the successful optimization of movement variations is fully supported by the capacity of rhythmic auditory stimulation to establish psychological safety on the field at this public elementary school in Majalengka. An auditory structure that is rhythmic and familiar to children's ears reduces mental blocks, negative affect, and motor anxiety when they are required to explore original movements in front of their peers. When shyness and the fear of making mechanical errors are minimized by a relaxed classroom atmosphere, students gain a safe space to express their kinetic responses adaptively without feeling judged by rigid performance standards (Bravo-Fuentes, A., & Pastrano-Gavilanes, 2025). This inclusive learning 19nate contributes directly to enhancing children's emotional well-being during physical activity, which in turn boosts their intrinsic motivation to engage actively in physical education units (Likesas et al., 2023; Minh, 2022). It is this sense of psychological safety that underpins the children's courage to activate divergent thinking, allowing them to liberate their bodies from the doctrines of conventional visual instructions.

CONCLUSION

17Based on the results and discussion, this study concludes that the application of the Rhythmic Auditory Stimulation (RAS) method through Orff music-based pedagogy significantly reconstructs students' gymnastics movement creativity at a public elementary school in Majalengka. Neuromotorly, rhythmic auditory stimulation acts as a temporal pacemaker that deconstructs rigid and mechanical movement patterns into more expressive, fluid, and autonomous explorations of both locomotor and non-locomotor variations. Audio characteristics within the ideal tempo range of 120 to 130 BPM are proven to provide the best affordance for primary school-aged students (9–10 years old) to manipulate directions and movement levels without triggering cognitive distortion or overloading their physiological capacity.

Nevertheless, 12his intervention yielded an enhancement in motor creativity that was constrained within the medium category, with an average N-Gain score of 35%. This result confirms the presence of internal boundaries in the form of children's innate biological motor maturity during middle childhood, alongside experimental duration constraints (3 weeks) that limited the emergence of pure movement originality, particularly when confronted with fast tempos exceeding 140 BPM. From a psychological dimension, the effectiveness of expanding movement variations was fully supported by the establishment of psychological safety on the field, where music successfully reduced students' motor anxiety and shyness while simultaneously constructing emotional well-being that triggered the children's courage to activate divergent thinking. This study successfully bridges the methodological gap by positioning music as a scientifically measurable instrument for controlling children's motor behavior within the primary school physical education curriculum.

These findings carry a direct pedagogical implication for PJOK (Physical Education, Sports, and Health) teachers in Indonesia: tempo should be repositioned from a merely decorative accompaniment into a deliberate evaluative instrument embedded within lesson planning. Rather than selecting background music arbitrarily to fill silence during practice, teachers can structure tempo progression as a diagnostic tool, a slower tempo range (100–110 BPM) may be used at the outset of a unit to observe and assess students' baseline synchronization and flexibility, functioning as an informal formative assessment of a student's readiness before progressing to more demanding stimuli. As tempo is incrementally increased across subsequent meetings, teachers can simultaneously observe which students sustain fluency and coordination under greater temporal pressure and which require additional scaffolding, effectively transforming tempo manipulation into a built-in differentiation mechanism rather than a uniform, one-size-fits-all accompaniment. However, this study's finding regarding the constrained development of originality under fast-tempo conditions (exceeding 140 BPM) also signals a practical boundary that teachers must observe: tempo should not be pushed indiscriminately for its own sake, as excessively rapid stimuli may compress the cognitive space children need to generate genuinely original movement, causing them to default to safer, more repetitive responses instead. Accordingly, PJOK teachers are encouraged to treat tempo as a calibrated instructional variable, deliberately paced, monitored, and adjusted according to observed student response, rather than a static playlist selected without pedagogical intent.

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