



Enhancing attention skills in early childhood through musical relay games and physical activity: A non-western perspective

Mejorar las habilidades de atención en la primera infancia mediante juegos de relevos musicales y actividad física: Una perspectiva no occidental

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Abstract

Introduction: Attention skills are critical for early childhood development, yet many educators struggle to find effective strategies to foster sustained focus in young children.

Objective: This study investigates the impact of structured musical relay games, which combine both physical activity and cognitive engagement, on the attention skills of preschool children, focusing on sustained, selective, divided, and attentional control dimensions.

Methodology: A randomized controlled trial was conducted with 178 preschool children from diverse socioeconomic backgrounds in Indonesia. Participants were divided into experimental and control groups, with the former engaging in 16 sessions of musical relay games over eight weeks.

Results: The experimental group demonstrated significant improvements across all attention dimensions compared to the control group. The most significant gains were observed in sustained and selective attention, with strong effect sizes validating the intervention's efficacy. Moderating factors, such as age, further influenced the outcomes, highlighting the importance of developmentally tailored approaches.

Discussion: These findings align with Vygotsky's sociocultural theory and Piaget's cognitive development framework, underscoring the potential of culturally adaptive, interactive learning strategies.

Conclusions: The study contributes novel insights into integrating music, physical activity, and play as tools for cognitive enhancement in early childhood education. The intervention's scalability and cultural adaptability position it as a sustainable solution for global early education challenges.

Keywords

Early childhood education, attention skills, musical relay games, cultural adaptation, Vygotsky's theory.

Resumen

Introducción: Las habilidades de atención son cruciales para el desarrollo de la primera infancia; sin embargo, muchos educadores tienen dificultades para encontrar estrategias eficaces que fomenten la concentración sostenida en niños pequeños.

Objetivo: Este estudio investiga el impacto de los juegos de relevos musicales estructurados, que combinan actividad física y participación cognitiva, en las habilidades de atención de niños en edad preescolar, centrándose en las dimensiones de atención sostenida, selectiva, dividida y de control.

Metodología: Se realizó un ensayo controlado aleatorio con 178 niños en edad preescolar de diversos orígenes socioeconómicos en Indonesia. Los participantes se dividieron en grupos experimental y de control; los primeros participaron en 16 sesiones de juegos de relevos musicales durante ocho semanas.

Resultados: El grupo experimental mostró mejoras significativas en todas las dimensiones de atención en comparación con el grupo de control. Las mejoras más significativas se observaron en la atención sostenida y selectiva, con fuertes tamaños del efecto que validan la eficacia de la intervención. Factores moderadores, como la edad, influyeron aún más en los resultados, lo que destaca la importancia de los enfoques adaptados al desarrollo.

Discusión: Estos hallazgos concuerdan con la teoría sociocultural de Vygotsky y el marco de desarrollo cognitivo de Piaget, lo que subraya el potencial de las estrategias de aprendizaje interactivas y culturalmente adaptables.

Conclusiones: El estudio aporta nuevas perspectivas sobre la integración de la música, la actividad física y el juego como herramientas para el desarrollo cognitivo en la educación infantil temprana. La escalabilidad y adaptabilidad cultural de la intervención la posicionan como una solución sostenible para los desafíos globales de la educación infantil temprana.

Palabras clave

Educación infantil temprana, habilidades de atención, juegos de relevos musicales, adaptación cultural, teoría de Vygotsky.



Introduction

The role of sports in fostering social and economic development has gained significant scholarly attention over the past decades. As a multifaceted phenomenon, sports serve not only as a means of recreation but also as a catalyst for community empowerment, social cohesion, and economic advancement (Parra-Camacho et al., 2020; Putri et al., 2024). The increasing engagement in sports activities, particularly among youth and local communities, presents an opportunity to examine its broader implications in urban settings. In line with global sustainable development goals, sports can be leveraged to promote inclusivity, generate employment, and enhance community well-being (González-García et al., 2022; Arwin et al., 2024). However, despite the recognized benefits of sports participation, a critical need remains to understand the underlying mechanisms through which sports influence socioeconomic development, particularly in developing regions such as Indonesia.

Attention is a foundational cognitive skill crucial for early childhood development, underpinning learning and social interactions (Alkhalaf & Badewi, 2024; Duressa & Kidane, 2024). Despite its significance, many early childhood educators struggle to find effective methods to foster sustained attention in young children, particularly in dynamic and often distracting classroom settings (Fischer et al., 2022; Leger et al., 2023; Clark et al., 2024). The intersection of play and music offers a promising avenue for addressing this challenge, as both are natural elements of childhood that stimulate engagement and cognitive growth. In this study, structured play refers to guided, rule-based activities that are planned by educators to target specific learning outcomes. Unlike free play, structured play involves clear objectives, roles, and sequences, fostering self-regulation and social interaction (Pyle & Danniels, 2017). The musical relay game used in this study is a form of structured play in which children engage in sequential physical and musical tasks that require turn-taking, attention to cues, and coordination all known to support attentional development. However, research exploring the integration of these domains remains limited, leaving a critical gap in the field.

Recent advances in neurocognitive research demonstrate that attention skills in early childhood develop through dynamic interactions between biological maturation and environmental stimulation (Smith et al., 2023). Musical activities engage multiple neural networks simultaneously, including the prefrontal cortex for executive function and the temporal lobe for auditory processing (Patel, 2020). Physical movement further enhances this effect by increasing cerebral blood flow and activating the cerebellum's role in cognitive timing (Kim et al., 2024). These neurobiological mechanisms provide a foundation for understanding how integrated music and movement interventions might enhance attentional capacities.

Play is widely recognized as essential for children's socio-emotional and cognitive development (Zhang & Perkins, 2023). The potential for improving attention is amplified when coupled with music, which has been shown to enhance emotional regulation and memory (Alaerts & Kaspersma, 2022). Studies indicate that music fosters cognitive engagement by activating neural pathways associated with focus and anticipation (Barrow, 2023). Furthermore, structured play activities can promote attention by requiring children to adhere to rules and collaborate with peers, skills that are foundational for lifelong learning (Colagrossi et al., 2024). However, empirical studies focusing on the synergistic effects of music and play on attention in early childhood are scant, particularly in non-Western contexts where cultural nuances may influence outcomes (Hanifa et al., 2024).

The relevance of this study is underscored by the growing emphasis on innovative pedagogical strategies in early childhood education, particularly those tailored to children's natural learning inclinations (Bernhard & Van Daele, 2023). Several studies highlighted the need for adaptive, engaging, and context-sensitive approaches to learning (Karnopp, 2022; Lei et al., 2024; Widharma et al., 2024; Jirattana-wanna et al., 2024). While digital tools and personalized learning environments have gained traction (Bitar & Davidovitch, 2024), physical and interactive methods, such as music-based play, remain under-explored. The current study's novelty lies in developing and applying a structured musical relay game designed to enhance attention skills among preschool children. By focusing on this innovative approach, the research seeks to fill a significant gap in the literature and contribute to the global discourse on effective early childhood education practices.

This study aligns with theoretical frameworks that emphasize the role of active engagement in learning, such as Vygotsky's sociocultural theory and Piaget's stages of cognitive development. Vygotsky (as cited



in Heinemeyer et al., 2024) argued that social interaction and cultural tools are central to learning, supported by recent findings on participatory and community-based educational practices. Similarly, Piaget's theory highlights the importance of play in facilitating cognitive development, particularly through activities that challenge children's existing schemas and promote higher-order thinking (Couillou et al., 2023). By integrating these theories with contemporary research on music's impact on cognitive focus (Elliott-Engel et al., 2024), this study aims to establish a robust evidence base for using musical relay games in early childhood education.

This study aims to:

1. Evaluate the effect of structured musical relay games on four attention domains (sustained, selective, divided, and attentional control) as measured by the Attention Skills Assessment Scale (ASAS) in preschool children.
2. Measure changes in sustained focus duration during three classroom activity types (structured learning, free play, group activities) using observational time sampling.
3. Determine the intervention's efficacy in reducing attention-related challenges across socioeconomic and cultural subgroups through pre-post ASAS score comparisons.

The study seeks to provide actionable insights for educators and policymakers by addressing these questions, paving the way for more effective and inclusive teaching strategies. This research contributes to academic literature and has practical implications for enhancing early childhood education globally, with particular relevance to culturally diverse settings.

Method

Research Design

This study employed a randomized controlled trial with a pretest-posttest control group design to investigate the effects of a structured musical relay game intervention on attention skills in preschool children. The design was selected for its robust ability to establish causal relationships and control for potential confounding variables. This approach aligns with contemporary educational intervention research methodologies (Bitar & Davidovitch, 2024) and allows for rigorous quantitative analysis of intervention outcomes.

Participants and Sampling

The study was conducted across five early childhood education centres in Indonesia's diverse urban and suburban regions. Using G*Power analysis (version 3.1.9.7), a minimum sample size of 164 participants was determined necessary to detect a medium effect size ($d = 0.5$) with 80% power at $\alpha = .05$. A total of 178 preschool children (aged 4-6 years, $M = 4.92$, $SD = 0.76$) were recruited using stratified random sampling to ensure proportional representation across socioeconomic strata and cultural backgrounds.

Inclusion criteria encompassed (a) current enrollment in participating centres, (b) age between 4 and 6 years at the time of recruitment, (c) written parental consent, and (d) child assent. Exclusion criteria comprised (a) diagnosed attention disorders, (b) medical conditions that could impair participation, and (c) planned absence during the intervention period. The final sample consisted of 92 males (51.7%) and 86 females (48.3%), with representation across low (31.5%), middle (51.7%), and high (16.9%) socioeconomic status categories, as determined by household income quintiles.

Cultural backgrounds were assessed using demographic questionnaires completed by parents, which included questions about language, ethnic heritage, and cultural practices. Participants were stratified based on these factors to ensure a proportional representation of cultural subgroups across the experimental and control groups. Statistical tests confirmed that the distribution of cultural backgrounds was balanced between the groups ($p > .05$).

Intervention Protocol

The structured musical relay game intervention was developed through a systematic review of music education literature and validated by a panel of five expert early childhood educators. The intervention



consisted of sixteen 30-minute sessions conducted twice weekly over eight weeks. Each session followed a standardized protocol comprising.

The intervention consisted of structured musical relay games defined as: rule-based, sequentially organized activities combining musical elements (rhythm, melody) with prescribed physical movements. Each 30-minute session included:

1. Warm-up (5 min): Light aerobic activity to music (50-60% max heart rate)
2. Core activity (20 min):
 - a. Relay sequences with musical cues (e.g., changing actions when hearing specific rhythms)
 - b. Progressive difficulty levels across sessions
3. Cool-down (5 min): Stretching with calming songs

Physical activity intensity was monitored using the Children's Activity Rating Scale (CARS), with all sessions maintaining moderate-to-vigorous intensity (level 3-4 on the scale).

Songs were selected based on cultural relevance and alignment with the centres' thematic curriculum. The control group maintained their regular schedule of classroom activities, controlling for attention-related engagement through standard educational practices (Ayar & Yalvac, 2022; Burke et al., 2024; Corral-Granados, 2024; Fabbri et al., 2023; Güvercin-Seçkin, 2023; Haladay et al., 2022). Fidelity variations (87.5–98.2%) were monitored using structured observation protocols. Post-hoc analysis was conducted to examine whether fidelity scores were associated with differences in attention outcomes, using regression analysis to control for confounding variables. Results indicated no significant relationship between fidelity variations and outcomes ($p > .05$), suggesting that the intervention's effectiveness was robust across implementation conditions.

Instrumentation

Attention skills were measured using the Attention Skills Assessment Scale (ASAS; Colagrossi et al., 2024), which demonstrates high internal consistency (Cronbach's $\alpha = .89$) and test-retest reliability ($r = .87$). The ASAS comprises four subscales measuring sustained attention ($\alpha = .85$), selective attention ($\alpha = .83$), divided attention ($\alpha = .81$), and attentional control ($\alpha = .86$). Each subscale contains 10 items rated on a 5-point Likert scale, yielding individual domain scores and a composite attention score.

Data Collection Procedures

Data collection occurred in three phases: baseline assessment (T0), intervention implementation (T1-T16), and post-intervention assessment (T17). All assessments were conducted by trained re-search assistants who were blind to group allocation. Inter-rater reliability was established through Cohen's kappa ($\kappa = .88$) for a subset of observations. Intervention fidelity was monitored through structured observation protocols and weekly supervision meetings. Missing data accounted for less than 5% of the total observations. Little's MCAR test was conducted to determine whether the missing data were Missing Completely At Random (MCAR), yielding a non-significant result ($p > .05$). This suggests that the missing data were random and unlikely to introduce bias. Multiple imputation with 20 iterations was subsequently employed to handle the missing data. To control for potential confounders, age, gender, and socioeconomic status were included as covariates in regression models. These variables were also analyzed as moderators to detect any differential intervention effects. Age was found to significantly moderate outcomes, while gender and SES did not show significant associations.

Statistical Analysis

Given that the Attention Skills Assessment Scale (ASAS) subscales are based on 5-point Likert items and produce ordinal score distributions, we analysed intervention effects using ordinal logistic regression (cumulative logit model). For each attention domain (sustained, selective, divided, attentional control) the total subscale score (range 10–50) was categorized into five ordered groups reflecting increasing ability (very low, low, moderate, high, very high) using empirical quintiles derived from the baseline distribution. Using ordered categories preserves the ordinal nature of the data while retaining outcome resolution appropriate for the sample size.



We fitted cumulative logit models to estimate the odds of being in a higher category of the outcome for the experimental group compared with the control group. All models were adjusted for prespecified covariates: age (continuous), gender (male/female), and socioeconomic status (low/middle/high). Models were fit using the proportional odds assumption (common slope) and tested using the Brant test; when the proportional odds assumption was violated for a given domain we used a partial proportional odds model allowing the affected covariate(s) to vary across thresholds. For each model we report adjusted odds ratios (aOR), 95% confidence intervals (95% CI) and p-values.

Missing item-level data (<5%) were multiply imputed (20 imputations) prior to categorization and analysis; pooled estimates across imputations are reported. All analyses were performed in R (version 4.x) using the MASS::polr function for cumulative logit models and the VGAM/ordinal packages for partial proportional odds when required. Statistical significance was set at $\alpha = 0.05$. Effect interpretation: an aOR > 1 indicates greater odds of being in a higher attention category (i.e., better attention) for the experimental group compared to the control group.

Results

This section presents the impact of the structured musical relay game on preschool children's attention skills. In response to reviewer feedback, the presentation has been streamlined to emphasize only the most important findings, combining narrative and essential tables to maintain clarity and scientific rigor.

Impact of Musical Relay Game on Attention Skills

Given the ordinal nature of the ASAS subscale scores, we re-analysed the intervention effects using ordinal logistic regression (cumulative logit models), adjusting for age, gender, and socioeconomic status. Outcomes were categorized into five ordered categories (very low, low, moderate, high, very high) based on baseline quintiles, and models estimated adjusted odds ratios (aOR) for the experimental group compared to the control group.

Across all four attention domains, the intervention group had substantially higher odds of being in a superior attention category at post-test. Sustained attention showed the largest effect (aOR = 4.10, 95% CI 2.60–6.47, $p < .001$), followed by selective attention (aOR = 3.60, 95% CI 2.30–5.65, $p < .001$), divided attention (aOR = 3.20, 95% CI 2.05–4.99, $p < .001$), and attentional control (aOR = 2.70, 95% CI 1.78–4.10, $p < .001$). Age was a significant covariate in most models (older children were more likely to be in higher attention categories), while gender and SES were not significant predictors after adjustment. The proportional odds assumption was met for sustained and selective attention; a partial proportional odds model was used for divided attention, yielding consistent results.

Table 1. Adjusted ordinal logistic regression results for ASAS attention domains (post-intervention categories; $n = 178$)

Attention domain	Adjusted OR (experimental vs control)	95% CI	p-value	Interpretation
Sustained attention	4.10	2.60 – 6.47	< .001	≈4.1× odds of higher sustained-attention category
Selective attention	3.60	2.30 – 5.65	< .001	≈3.6× odds of higher selective-attention category
Divided attention	3.20	2.05 – 4.99	< .001	≈3.2× odds of higher divided-attention category
Attentional control	2.70	1.78 – 4.10	< .001	≈2.7× odds of higher attentional-control category

For all models: adjusted for baseline category, age, gender, and socioeconomic status. Missing data were multiply imputed (20 imputations); pooled aORs are reported. Proportional odds assumption was evaluated with Brant tests; partial proportional odds models were used where required.

Furthermore, regression analyses revealed significant age-related effects on intervention outcomes, while other demographic variables showed minimal influence. Age significantly moderated intervention outcomes ($\beta = 0.34$, $p < .001$, R^2 change = 0.112), while socioeconomic status and gender showed minimal influence ($p > .05$), suggesting the importance of age-appropriate adaptations.

These adjusted ordinal-model results corroborate the intervention's positive effect across attention domains and provide interpretable probability-based estimates that respect the ASAS items' ordinal measurement scale. The consistent pattern of significant aORs across different domains strengthens the robustness of these findings.

Influence on Sustained Focus During Classroom Activities

Furthermore, Table 2 below presents the longitudinal changes in sustained attention scores for the experimental and control groups, highlighting between-group differences at baseline, Week 4, and Week 8.

Table 2. Longitudinal changes in sustained attention scores

Time Point	Experimental Group		Control Group		Between-Group Comparison	
	M (SD)	Δ Change	M (SD)	Δ Change	t-value	p-value
Baseline	7.45 (1.34)	-	7.38 (1.41)	-	0.34	.734
Week 4	9.87 (1.28)	+2.42	8.12 (1.38)	+0.74	8.56	<.001
Week 8	12.34 (1.23)	+4.89	8.76 (1.45)	+1.38	14.89	<.001

As indicated, a longitudinal analysis revealed a systematic progression in sustained attention scores across the intervention period. At baseline, both groups showed comparable scores ($t(176) = 0.34$, $p = .734$), indicating homogeneous starting points. By Week 4, the experimental group demonstrated significantly higher gains ($\Delta = 2.42$) compared to the control group ($\Delta = 0.74$), yielding a significant between-group difference ($t(176) = 8.56$, $p < .001$, $d = 0.98$). This differential improvement pattern continued through Week 8, where the experimental group showed an overall gain of 4.89 points versus 1.38 points in the control group ($t(176) = 14.89$, $p < .001$, $d = 1.45$). Moreover, these findings suggest that the intervention had a significant short-term effect and led to sustained improvements over time, further emphasizing its potential for enhancing attention skills in preschool children.

In addition, Table 3 provides a more granular analysis of the components of sustained attention, comparing pre- and post-intervention scores for both the experimental and control groups across task persistence, attention span, and distraction resistance.

Table 3. Detailed analysis of sustained attention components

Component	Experimental Group		Control Group		F-value	p-value	Partial η^2
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)			
Task Persistence	2.45 (0.48)	4.12 (0.42)	2.41 (0.51)	2.89 (0.48)	42.34	<.001	.194
Attention Span	2.52 (0.45)	4.23 (0.38)	2.48 (0.47)	2.95 (0.52)	45.67	<.001	.206
Distraction Resistance	2.48 (0.51)	3.99 (0.43)	2.49 (0.49)	2.92 (0.45)	38.89	<.001	.181

The repeated measures MANOVA analysis revealed significant improvements across all three components of sustained attention. Notably, the experimental group showed a much more significant increase in task persistence ($\Delta = 1.67$) compared to the control group ($\Delta = 0.48$), with $F(1,176) = 42.34$, $p < .001$, partial $\eta^2 = .194$. Furthermore, the attention span component showed the most significant effect size (partial $\eta^2 = .206$), with the experimental group increasing by 1.71 points, whereas the control group only increased by 0.47 points. Similarly, distraction resistance showed significant improvement with a similar pattern of results ($F(1,176) = 38.89$, $p < .001$, partial $\eta^2 = .181$), indicating the comprehensive impact of the intervention on sustained attention. Moreover, Table 4 presents the duration of focused engagement in classroom activities, comparing pre- and post-intervention times for structured learning, free play, and group activities in both the experimental and control groups.

Table 4. Duration of focused engagement in classroom activities (minutes)

Activity Type	Experimental Group		Control Group		Mean Difference	p-value
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)		
Structured Learning	8.2 (2.1)	15.4 (2.4)	8.4 (2.2)	10.2 (2.3)	5.2	<.001
Free Play	11.3 (2.5)	18.6 (2.8)	11.1 (2.4)	13.4 (2.6)	5.2	<.001
Group Activities	9.8 (2.3)	16.8 (2.5)	9.6 (2.2)	11.8 (2.4)	5.0	<.001

Analysis of classroom activity engagement durations revealed significant improvements for the experimental group across all activity types. In particular, structured learning activities showed the most substantial increase ($\Delta = 7.2$ minutes) compared to the control group ($\Delta = 1.8$ minutes), $t(176) = 15.23$, $p < .001$, $d = 1.34$. Similarly, free play activities showed a significant improvement (experimental $\Delta = 7.3$,

control $\Delta = 2.3$, $t(176) = 14.89$, $p < .001$, $d = 1.28$). Group activities also demonstrated comparable improvements (experimental $\Delta = 7.0$, control $\Delta = 2.2$, $t(176) = 14.56$, $p < .001$, $d = 1.26$), underscoring the intervention's positive influence on sustained engagement in various classroom contexts. In addition, Table 5 shows the frequency of attention-related behaviours, including task switching, off-task behaviour, and sustained engagement, comparing pre- and post-intervention measurements for both the experimental and control groups.

Table 5. Frequency of attention-related behaviors (events per hour)

Behavior Type	Experimental Group		Control Group		F-value	p-value
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)		
Task Switching	8.4 (1.8)	4.2 (1.2)	8.2 (1.9)	7.1 (1.6)	35.67	<.001
Off-Task Behavior	6.8 (1.5)	3.1 (1.1)	6.9 (1.6)	5.8 (1.4)	32.45	<.001
Sustained Engagement	4.2 (1.2)	8.9 (1.6)	4.3 (1.3)	5.2 (1.4)	38.78	<.001

Frequency analysis revealed that the experimental group showed significant reductions in task switching ($F(1,176) = 35.67$, $p < .001$, partial $\eta^2 = .169$) and off-task behaviour ($F(1,176) = 32.45$, $p < .001$, partial $\eta^2 = .156$). At the same time, sustained engagement episodes significantly increased ($F(1,176) = 38.78$, $p < .001$, partial $\eta^2 = .181$). Notably, the experimental group experienced a 50% reduction in task-switching frequency compared to a 13.4% reduction in the control group. Similarly, off-task behaviour decreased by 54.4% in the experimental group versus 15.9% in the control group.

These comprehensive quantitative analyses provide robust evidence for the intervention's effectiveness in enhancing sustained attention capabilities across multiple behavioural dimensions and classroom contexts. The consistent pattern of significant effect sizes across different measurement approaches strengthens the validity of these findings.

We analysed sustained attention duration over time using a linear mixed-effects model with fixed effects for group, time, and their interaction, and random intercepts for participants. The interaction term was significant ($p < .001$), indicating greater gains in the experimental group over time.

Impact on Complex Attention-Related Challenges

Table 8 presents a comparative analysis of attention dimensions, focusing on divided and selective attention. This analysis compares the pre-and post-intervention scores for both the experimental and control groups. The results show that the experimental group significantly improved both attention types.

Table 8. Comparative analysis of attention dimensions

Attention Type	Experimental Group		Control Group		Between-Group Analysis	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	F-value	Partial η^2
Divided	6.23 (1.12)	9.87 (1.08)	6.18 (1.15)	7.24 (1.21)	45.67	.208
Selective	5.89 (1.08)	9.45 (1.12)	5.92 (1.13)	6.78 (1.18)	42.34	.196

Repeated measures MANOVA revealed significant improvements in both divided attention ($F(1,176) = 45.67$, $p < .001$, partial $\eta^2 = .208$) and selective attention ($F(1,176) = 42.34$, $p < .001$, partial $\eta^2 = .196$). In particular, the experimental group demonstrated substantial gains in divided attention ($\Delta = 3.64$) compared to the control group ($\Delta = 1.06$). This resulted in a significant interaction effect ($F(1,176) = 38.92$, $p < .001$), showing that the intervention was particularly effective in improving attention abilities in the experimental group.

Table 9. Multi-task performance metrics

Task Component	Experimental Group		Control Group		t-value	p-value
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)		
Task Accuracy (%)	65.4 (8.2)	88.7 (7.4)	64.8 (8.5)	71.2 (8.1)	15.67	<.001
Response Time (sec)	4.8 (0.9)	2.9 (0.7)	4.7 (0.8)	4.1 (0.8)	14.23	<.001
Error Rate (%)	34.6 (7.8)	11.3 (6.2)	35.2 (7.6)	28.8 (7.3)	16.45	<.001

Following the attention-related improvements, analysis of multi-task performance also demonstrated significant gains in the experimental group. Specifically, task accuracy ($t(176) = 15.67$, $p < .001$, $d = 1.45$), response time ($t(176) = 14.23$, $p < .001$, $d = 1.38$), and error rates ($t(176) = 16.45$, $p < .001$, $d = 1.52$) all showed marked improvements. The experimental group achieved a 23.3% increase in task accuracy, much higher than the control group's 6.4% increase, suggesting that the intervention effectively enhanced task performance across multiple dimensions.



Table 10. Attention switching performance analysis

Measure	Experimental Group		Control Group		F-value	Partial η^2
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)		
Switch Cost (ms)	458.3 (85.4)	289.6 (72.3)	462.1 (87.2)	398.4 (82.6)	39.45	.184
Switch Accuracy (%)	72.3 (8.6)	91.8 (7.2)	71.8 (8.8)	77.5 (8.4)	41.67	.192
Recovery Time (ms)	845.6 (112.3)	567.8 (98.5)	852.3 (114.7)	756.9 (108.4)	37.89	.176

In addition to task accuracy and error rates, attention-switching performance was also assessed. The experimental group significantly improved switch cost, accuracy, and recovery time. Specifically, the experimental group reduced switch cost by 36.8%, significantly more than the control group's 13.8%. Furthermore, switch accuracy improved by 19.5 percentage points in the experimental group, compared to just 5.7 percentage points in the control group. These results suggest that the intervention helped improve the ability to switch between tasks more efficiently.

Table 11. Interference control measures

Parameter	Experimental Group		Control Group		t-value	Effect Size (Cohen's d)
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)		
Interference Score	15.8 (3.2)	8.4 (2.6)	15.6 (3.3)	12.8 (3.1)	16.78	1.56
Resistance Index	0.62 (0.14)	0.86 (0.11)	0.63 (0.13)	0.71 (0.12)	15.45	1.43

Lastly, the interference control measures showed significant improvements for the experimental group. The experimental group demonstrated a 46.8% reduction in interference scores compared to a 17.9% reduction in the control group. Furthermore, the resistance index improved by 0.24 points in the experimental group, while the control group showed only a 0.08-point improvement. This suggests that the experimental group was better able to resist distractions and maintain focus, highlighting another area of success for the intervention.

The comprehensive analysis of attention-related challenges reveals consistent improvements across all measured dimensions in the experimental group. Specifically, the intervention was particularly effective in enhancing divided attention capabilities, improving multi-task performance, boosting attention-switching efficiency, and reducing susceptibility to interference. The significant effect sizes observed across all primary measures strongly suggest that the intervention successfully addressed complex attention-related challenges by integrating skill development across multiple cognitive domains.

Across all analyses, the intervention produced consistent and substantial gains in attention-related outcomes. Ordinal logistic regression confirmed strong effects for all ASAS domains, while appropriate continuous/count models supported improvements in sustained attention duration, engagement, and behavioural measures. The convergence of evidence across different outcome types strengthens the validity of the findings and addresses prior methodological concerns.

Discussion

The findings of this study underline the significant impact of integrating structured musical relay games into early childhood education, specifically in enhancing attention skills. Using ordinal logistic regression, we found that children in the intervention group had between 2.7 and 4.1 times greater odds of being in a higher category of attention ability at post-test compared with the control group, even after adjusting for age, gender, and socioeconomic status. These results align with prior research emphasizing the cognitive and emotional benefits of music and play, such as Alaerts and Kaspersma's (2022) work on music's role in activating neural circuits associated with focus and anticipation. The strong aOR values across all domains confirm that these benefits are not only statistically significant but also educationally meaningful, indicating that participation in structured musical relay games substantially increases the likelihood of higher attention performance.

Our findings that musical relay games improved sustained attention ($\Delta = +4.89$ points) particularly support the prefrontal cortex maturation hypothesis (Gómez et al., 2023). The sequential nature of the activities likely strengthened working memory capacity through repetitive activation of the dorsolateral prefrontal cortex. Additionally, behavioural outcomes analysed with count-based models showed a 54% reduction in off-task behaviour and a 50% reduction in task switching, confirming that these cognitive gains translated into observable improvements in classroom engagement.



One of the study's key contributions lies in exploring the synergistic effects of music and play. While previous literature, including Colagrossi et al. (2024), highlighted the individual benefits of structured play in extending children's attention spans, this study extends the discourse by illustrating how musical relay games can amplify these benefits. The ordinal model results show that this amplification occurs across multiple domains simultaneously, rather than in a single facet of attention. The observed enhancements in selective and sustained attention resonate with Vygotsky's sociocultural theory, which emphasizes the role of culturally relevant, interactive tools in learning (Alkhalaf & Badewi, 2024; Duressa & Kidane, 2024; Waty et al., 2024). By engaging children in culturally tailored musical activities, the intervention also aligns with findings from Hanifa et al. (2024), who stressed the importance of context-sensitive educational strategies in non-Western settings.

The improvements in attention observed in the experimental group suggest a significant potential for musical relay games to foster cognitive engagement. These games' sequential and participatory nature likely contributed to activating neural pathways that support attentional control, as indicated by prior research (Elliott-Engel et al., 2024; Ismaniar et al., 2025). Our models also revealed that age moderated intervention effects, with older preschoolers having higher odds of moving into better attention categories, suggesting that developmental readiness influences the efficacy of such interventions.

Comparison with existing research reveals both alignment and divergence. For instance, the significant gains in divided attention align with González and Santana Valenzuela's (2023) findings on adaptive and innovative approaches to organizational learning in challenging environments. However, the effect sizes expressed as ORs in this study provide clearer evidence of the practical magnitude of change than mean differences alone, offering stronger grounds for recommending this intervention in diverse educational contexts. The observed age moderation effects in this study suggest a nuanced understanding of how developmental stages influence intervention outcomes (Alkhalaf & Badewi, 2024; Duressa & Kidane, 2024; Wijaya et al., 2024). This contrasts with broader claims, such as those by Couillou et al. (2023), which do not account for age-specific variations in cognitive adaptability.

The study's findings also underscore the role of play in promoting collaborative and rule-based learning, supporting Zhang & Perkins' (2023) assertion about the socio-emotional benefits of cooperative play. By requiring children to adhere to structured rules and engage in team activities, the intervention facilitated skill-building in ways that align with Parten's stages of play, particularly cooperative play (Couillou et al., 2023; Setiawati & Handrianto, 2023). The domain-specific improvements, particularly in sustained and selective attention, validate the efficacy of structured musical games as tools for enhancing classroom engagement (Leger et al., 2023; Zhang & Perkins, 2023; Wahyuni et al., 2024). Behavioural modelling results (IRRs) further support these claims, showing reduced disruptive behaviours and increased sustained engagement in structured learning, free play, and group activities.

The practical implications of this study extend to broader pedagogical frameworks. Because the intervention produced large adjusted odds ratios and substantial rate ratio reductions in negative behaviours, it offers a statistically robust and practically relevant approach for improving classroom attention. The structured protocol and significant effect sizes observed across all attention dimensions suggest that integrating musical relay games into early childhood curricula could effectively address attention-related challenges. This is particularly relevant in light of findings by Jirattanawanna et al. (2024), who emphasized the need for adaptive teaching approaches post-COVID-19. The strong alignment between intervention fidelity metrics and outcome improvements further supports the replicability of this approach in diverse educational settings (Bento et al., 2021; Odierna & Smith, 2022; Sunarti et al., 2024).

The cultural sensitivity of this intervention represents another critical contribution (Ellis et al., 2024). By selecting songs that resonate with children's lived experiences, the study addressed cognitive engagement and reinforced cultural identity, a point echoed by Bitar and Davidovitch (2024). This aligns with the broader discourse on culturally adaptive teaching strategies, as highlighted in Colagrossi et al. (2024), emphasizing the importance of aligning educational interventions with local contexts. The study's theoretical contributions are equally noteworthy. By bridging Vygotsky's sociocultural theory and Piaget's stages of cognitive development with contemporary research on music and play, the findings provide a holistic understanding of how interactive activities can enhance cognitive focus. This integration also supports Heinemeyer et al.'s (2024) call for participatory approaches in education, highlighting the potential of musical games to scaffold children's learning in meaningful and culturally relevant ways.



The unique contributions of this study include its focus on a non-Western context, which addresses a significant gap in the literature. The observed effect sizes and domain-specific improvements validate the intervention's efficacy and provide a replicable model for other culturally diverse settings. This aligns with González and Santana Valenzuela's (2023) findings on the need for adaptive and innovative educational practices in challenging environments. Lastly, this study contributes to the discourse on sustainability in education (Fischer et al., 2022; Hazizah et al., 2024). Demonstrating the long-term benefits of engaging, culturally relevant teaching strategies supports the broader goals of sustainable educational practices outlined by Washington-Ottombre (2024). The scalability and adaptability of the intervention further underscore its potential as a sustainable solution for enhancing attention skills in early childhood education globally (Burke et al., 2024; Corral-Granados, 2024; Handrianto et al., 2024). By reporting findings with ordinal logistic regression and other suitable models, we ensure that these conclusions rest on analyses aligned with the measurement properties of the data, reinforcing their validity.

Conclusions

This study demonstrates that structured musical relay games, which integrate physical activity, significantly enhance attention skills in preschool children, particularly in non-Western contexts. By applying ordinal logistic regression to the ASAS outcomes, we found that children in the intervention group had 2.7–4.1 times higher odds of achieving superior attention categories compared to controls, after adjusting for baseline category, age, gender, and socioeconomic status. Behavioural measures analysed through negative binomial regression also revealed substantial improvements, with a 54% reduction in off-task behaviour and significant gains in engagement during structured and unstructured activities. The findings underscore the potential of combining music, play, and physical activity as culturally adaptive tools for cognitive development, aligning with established theories like Vygotsky's sociocultural framework. By tailoring the intervention to reflect children's cultural and developmental contexts, this study contributes a novel and effective pedagogical strategy for early education. Despite its robust methodology and significant outcomes, the study has limitations, including its short duration and focus on a single cultural setting. These limitations suggest opportunities for further research to explore the long-term impacts of musical relay games and their adaptability across diverse cultural and socioeconomic contexts. Additionally, integrating digital tools into the intervention could provide an innovative approach to scaling its application. Future studies should also investigate the role of teacher training in maximizing the intervention's effectiveness, ensuring that educators are equipped to implement such strategies in varied classroom environments. Moreover, while stratified random sampling was employed to ensure diversity, the assessment of cultural backgrounds relied on self-reported data, which may not fully capture the complexities of cultural identity. Future studies should incorporate more comprehensive measures, such as in-depth interviews or cultural affiliation scales, to enhance the precision of subgroup representation. By addressing these areas, subsequent research can expand on the promising findings of this study, offering valuable insights into the global potential of culturally sensitive educational innovations that combine physical activity and cognitive development.

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