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Research on the Development of Music Rhythmic Movement Scales for Infants and Toddlers

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Abstract

This study focuses on developing an Infant and Toddler Rhythmic Movement Scale. Given the considerable interest in the relationship between music and infant development and the scarcity of relevant measurement tools, we followed Churchill's three-step method for scale development. Initially, we generated an 18-item scale through literature research, semi-structured interviews, open-ended questionnaires, and content analysis. We recruited parents of infants and toddlers aged 3 months to 3 years in China as participants and collected 194 valid questionnaires. Through item analysis and exploratory factor analysis, we determined the scale's dimensional structure. Ultimately, we extracted two factors: "Expression" and "Perception," consisting of 10 items, with a cumulative variance contribution rate of 51.467%. Confirmatory factor analysis yielded satisfactory fit indices. The scale's convergent validity, discriminant validity, and reliability all reached acceptable levels, indicating its effectiveness and reliability in assessing infants' and toddlers' musical rhythmic movement abilities.

Keywords

Infants and Toddlers; Musical Rhythmic Movement; Scale Development; Validity and Reliability

1. Introduction

In today's academic research field, the exploration of infants and toddlers' musical rhythmic movement abilities has increasingly highlighted its importance. Current research focuses on filling a critical gap - the lack of assessment and measurement tools for infants and toddlers' musical rhythmic movement abilities. It should be noted that rhythmic movement plays a pivotal role in the development of early language, cognitive, emotional, and motor skills of infants and toddlers (Turner, 1998; Boll-Avetisyan et al., 2024; Nguyen et al., 2023; Frischen et al., 2022).

There are intricate connections between music and the development of infants and toddlers. In particular, how musical rhythmic affects infants' perception of rhythmic and their motor skills has attracted extensive attention in various fields such as education, psychology, and child development. The infant and toddler stage is a crucial period for the germination and growth of language, cognition, emotion, and motor abilities. Infants' responses to external stimuli and their learning tendencies lay the foundation for their future growth paths. Against this backdrop, developing a precise scale to assess infants' musical rhythmic movement ability aims to measure their performance in this area in a scientific and systematic manner, thereby deepening our understanding of how music specifically impacts infants' perception of rhythmic movements and the development of their motor skills.

Dating back to the fetal stage, infants have already shown natural responses and acute perception of musical rhythm. Existing research indicates that fetuses can perceive external sounds, especially their mothers' voices and musical rhythms, and react accordingly while in the womb (Panicker, 2002). After entering infancy, they further demonstrate

their strong interest and in-depth perception of musical rhythm through babbling and body movements. Numerous studies have revealed the progressive development paths of infants' and toddlers' rhythmic movement perception and participation abilities at different age levels, clearly showing that they can perceive rhythm early on and express it through movements (Lewkowicz, 2003; Moog, 1976). By the age of five months, infants begin to respond to regular rhythms with spontaneous movements, although they are not yet synchronized with the beat precisely, and there are minimal changes in the subsequent months. Notably, compared with slow-paced music, infants exhibit more rapid and frequent body movements when exposed to fast-paced music (Cirell, 2019). According to Gordon's music learning theory and musical aptitude test data, six-month-old infants can briefly follow their parents' tapping, which is a powerful example of their early rhythm response-ability. Gordon also proposed that the ability to extract beats from auditory stimuli is an innate human perceptual skill (Chen, 2019). Nevertheless, although infants have a certain level of awareness of rhythmic movements, the precision of their rhythmic movement perception will gradually improve with age and vary among individuals.

As infants and toddlers grow, their rhythmic movement perception and participation abilities continue to advance. Research shows that around 18 months old, toddlers can coordinate their body movements with rhythmic changes (Moog, 1976), which means that toddlers begin to attempt to align their movements precisely with the rhythm. A case study also found that a 19-month-old toddler's rhythmic engagement significantly improved after becoming familiar with a song, implying that familiar melodies may help toddlers predict and follow the music's rhythm, strengthening their interaction with music (Cirell, 1976). This finding emphasizes the crucial significance of early music exposure and experience in cultivating infants' and toddlers' rhythmic movement perception and participation abilities. By the age of 2.5 years, although toddlers can maintain the coordination of their body movements with the rhythm, the duration of their synchronous movements is still relatively short (Gembris, 2006; Zentner, 2010). This is probably due to the immaturity of their motor control abilities at this stage. In addition, other research indicates that when infants are guided by others at a specific rhythm, they will exhibit auditory-motor rhythm interaction, which, to some extent, shows that they have the ability to perceive and respond to rhythm (Phillips-Silver, 2005). The reason may be that although the interaction between the auditory and motor systems emerges early, the motor control abilities at this stage are still underdeveloped.

Despite the fact that infants and toddlers have shown certain potentials in the development of rhythmic movement perception and participation, how to assess these abilities in a scientific and precise manner and how musical rhythmic movement specifically affects infants' motor skill development remain important research topics that require further exploration. At present, most of the existing studies on infants' and toddlers' musical rhythmic movement mainly rely on experimental and neuroscientific methods, but precisely lack effective measurement tools specifically for infants' and toddlers' musical rhythmic movement abilities. In view of this, this study is committed to creating an efficient and reliable parent-report measurement tool to accurately evaluate infants' and toddlers' musical rhythmic movement abilities. To achieve this goal, the research process includes generating a series of test items and applying them to a large sample of participants. The exploratory factor analysis method is used to explore the underlying dimensions of the items and streamline the initial item pool to make its size more manageable. Moreover, the data from different samples of participants will be used to establish the convergent validity, discriminant validity, and reliability of the new tool, thus helping us gain a more in-depth and thorough understanding of infants' and toddlers' musical rhythmic movement abilities.

2. Materials and methods

In the development of the scale, we adhered to the three essential procedures for scale development and validation outlined by G. A. Churchill (1979): item generation, structure exploration, and validity verification. This study will employ these steps to create the Infant and Toddler Rhythmic Movement Scale.

First, the initial scale items will be generated using literature research, semi-structured interviews, open-ended questionnaires, and content analysis. Second, we will use SPSS 27.0 to filter and analyze the valid questionnaire data, conducting item analysis and exploratory factor analysis to establish the scale's dimensional structure. Third, we will utilize SPSS 27.0 and AMOS 24.0 to perform reliability and validity tests, confirming the scale's structure and reliability.

We developed a total of 17 items, encompassing a broad definition of rhythmic movement musical experiences at home. This was defined as: "Performing rhythmic movements or dancing in response to music, expressing rhythm through physical actions." The selection of items was based on a review of relevant literature and preparatory work

conducted in the year preceding the project. This included informal discussions with parents of infants, outreach through personal networks and nurseries across various Chinese provinces, and a video recording of music-related rhythmic movements from one family, recruited via personal connections, with an infant. Notes from these discussions and the video recording were compiled into a list, forming the foundation for item generation.

The initial 17-item list concentrated on three distinct aspects of rhythmic movement, deemed relevant to our working definition: music rhythm perception, music rhythm expression, and music rhythm coordination. A 7-point Likert scale, ranging from Completely Disagree (1) to Completely Agree (7), was applied to all items. Scores for negatively worded items were reverse-coded, ensuring that a score of Completely Disagree (1) corresponded to a score of Completely Agree (7) on the positive end of the scale.

3. Participants

Participants were recruited through convenience sampling. The link to the survey was distributed via scholars, colleagues, and friends as well as Chinese social media and generated large interest. To be eligible, participants needed to be parents of children aged between 3 months and 3 years. Initially, 211 individuals participated, but 17 were excluded for the following reasons: [i] their children were outside the specified age range (either under 3 months or over 3 years), or [ii] they provided the same answers for most questionnaire items or displayed an obvious pattern.

Consequently, 194 participants were included in the analysis of the "Infant and Toddler Rhythmic Movement Scale." The primary caregiver completing the survey was mostly the mother (n = 93, 47.7%), followed by the father (n = 88, 45.1%), and in a few cases, (grand)parents (n = 14, 7.2%). The participants' ages varied widely, but the majority were between 26 and 35 years old, accounting for over half (58%). Most participants had high educational attainment, with 66.2% being undergraduates and 13.8% being postgraduates. In contrast, only 7.2% had a high school/technical secondary school education or lower. The gender distribution of the children was balanced, with slightly more boys (50.3%) than girls (49.7%). The children's ages were mainly between 1 and 3 years old, with the highest proportion (51.3%) being between 2 and 3 years old. Overall, the sample characteristics were normal and highly representative. Detailed demographic information for the participating parents and children is provided in Table 1.

Table 1. Demographic information for participating

Feature	Sub-sample	Number	%
Relationship with the child	Father	88	45.1
	Mother	93	47.7
	Grandparents	14	7.2
Age of parents	≤25	32	16.4
	26-30	54	27.7
	31-35	59	30.3
	36-40	25	12.8
	≥41	25	12.9
Educational background of parents	High school and below	14	7.2
	Junior college	25	12.8
	University undergraduate	129	66.2
	Postgraduate	27	13.8
Gender of the child	Male	98	50.3
	Female	97	49.7
Age of the child	3m-1y	26	13.3
	1-2y	69	35.4
	2-3y	100	51.3

4. Procedure

The level of musical rhythm in infants and toddlers correlates with their behavioral proficiency and expressions during musical activities, necessitating precise behavioral observations for evaluation.

Using the three key dimensions of infants' and toddlers' musical rhythm as a framework, we gathered behaviors reflecting each dimension as initial sample elements for the evaluation criteria. The evaluation items were designed by compiling relevant behavior manifestations through interviews and observations, ensuring the evaluation content's effectiveness and alignment with infants' and toddlers' real situations.

Regarding literature: Although direct evaluation items for infants' and toddlers' musical rhythm are lacking, existing literature on musical activities and behavior manifestations provided guidance. We identified main behavior types within each dimension and collected specific manifestations as sample items. This process resulted in three evaluation items.

For observation and interviews: To validate and enrich the sample items, we conducted observations and semi-structured interviews with infants and toddlers. From November 30, 2021, to November 30, 2024, a male infant's musical rhythm manifestations were recorded, generating ten evaluation items. Additionally, ten parents underwent in-depth interviews to obtain valuable information on infants' and toddlers' musical rhythm abilities. After presenting the definition and examples, in-depth interviews explored two aspects affecting musical rhythm, with parents recalling relevant experiences. This resulted in 24 specific examples, which were used to develop an initial scale through content analysis, later verified by multiple researchers.

The collected examples underwent preliminary screening based on two criteria: excluding deviated answers and removing ambiguous expressions. This yielded 18 valid examples, classified to form specific measurement statements. After adjustments, the examples were grouped into five measurement items. A team, including two master's students and two parents, tested the classification's validity, discussing and resolving inconsistencies. Ultimately, four evaluation items were obtained.

The survey on infants' and toddlers' rhythmic movement was constructed using the Wenjuanxing online survey tool, targeting the primary caregiver. Parents were invited via social media to complete the survey, which included informed consent, the Rhythmic Movement items, and a short demographic questionnaire. The survey took approximately 5 minutes to complete without pauses.

5. Statistical analyses

Import the sample data into SPSS software. First, calculate the total score for each questionnaire and sort them in ascending order. Designate the top 27% as the high-score group and the bottom 27% as the low-score group. Perform an independent-samples t-test on the scores of each item between the high-score and low-score groups. The results indicate significant mean differences in scores for each item between the groups ($P < 0.01$), suggesting that the high-score group scores significantly higher on each item than the low-score group. This implies strong discrimination between the groups for each item, obviating the need to remove any items.

Next, use correlation analysis to determine the correlation coefficient between each item and the total score, and eliminate items with a coefficient below 0.3. The analysis reveals that all correlation coefficients range from 0.536 to 0.665, exceeding 0.3 at a significance level of 0.01, indicating an ideal correlation. Thus, no items need removal.

Table 2. Item Analysis

Items	CR	Items	CR	Items	CR
Q1	-8.424**	Q7	-7.588**	Q13	-7.382**
Q2	-7.916**	Q8	-9.316**	Q14	-7.476**
Q3	-9.248**	Q9	-9.254**	Q15	-5.825**
Q4	-9.412**	Q10	-9.527**	Q16	-9.225**
Q5	-7.752**	Q11	-8.879**	Q17	-9.431**
Q6	-8.111**	Q12	-8.123**		

Note: **$P<0.01$.

Table 3. Item - Total Correlation

Items	*r*	Items	*r*	Items	*r*
Q1	.624**	Q7	.560**	Q13	.556**
Q2	.580**	Q8	.619**	Q14	.582**
Q3	.560**	Q9	.596**	Q15	.562**
Q4	.536**	Q10	.647**	Q16	.665**
Q5	.639**	Q11	.630**	Q17	.604**
Q6	.641**	Q12	.618**		

Note: **$P<0.01$.

To establish the structural dimensions of the Infant and Toddler Rhythmic Movement Scale, we divided 194 valid samples into two equal groups, Sample 1 and Sample 2, each containing 97 samples. Sample 1 underwent exploratory factor analysis, meeting the requirement of a sample size at least three times the number of items.

Prior to exploratory factor analysis, we conducted Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure. A higher KMO value indicates more common factors among variables, and suitability for factor analysis, while a value below 0.5 suggests unsuitability. Our results showed Bartlett's test chi-square value of 492.707 ($df = 45$) with a significance level below 0.001, and a KMO value of 0.830, indicating strong interconnections among indicators and suitability for analysis (Table 4).

Table 4. KMO and Bartlett

KMO	Bartlett		
	χ^2	*df*	*p*
0.830	492.707	45	<0.001

We then employed principal component analysis with varimax orthogonal rotation to extract factors with eigenvalues exceeding 1, conducting exploratory factor analysis on the initial scale. We iteratively removed irrational items based on the following criteria: items with loading values below 0.4 in all factors; items with loading values above 0.4 in two or more factors and a difference of less than 0.2; factors with fewer than three items; and items inconsistent with factor meanings. This process continued, removing one item at a time and reinitiating factor analysis, until achieving the optimal structure.

Table 5. Rotated Component Matrix

Items	1	2
A1	.762	
A2	.757	
A3	.749	
A4	.628	
A5	.568	
B1		.790
B2		.712
B3		.681
B4		.603
B5		.550

Ultimately, after removing seven items, we extracted two factors comprising ten items in total. The cumulative variance contribution rate was 51.467%, surpassing the 40% standard, indicating comprehensive information coverage. Post-varimax rotation, item loading values ranged from 0.550 to 0.790, all exceeding the 0.4 threshold. Based on item content, we named the factors "Expression (A1-A5)" and "Perception (B1-B5)" (Table 5).

6. Results

To verify the internal structural stability of the revised scale, we employed confirmatory factor analysis. Sample 2, comprising 97 participants, was utilized for scale validity verification. The sample-to-item ratio was approximately 10:1, surpassing the typical reference standard of 4:1, thus ensuring an adequate sample size.

Using Amos software, we designated the 10 items identified through exploratory factor analysis as observed variables. Additionally, two factors were set as latent variables, and a structural equation model was subsequently constructed. The relevant test results and data are presented in Figure 1 and Table 6. Regarding standardized factor loadings, each item's loading ranged from 0.52 to 0.71, all exceeding the minimum requirement of 0.3 and achieving significance. As for the fit indices of the structural equation model, the χ^2/df value was 1.952 (less than 3), the RMSEA value was 0.07 (less than 0.08), the GFI value was 0.937 (greater than 0.9), the CFI value was 0.929 (greater than 0.9), and the IFI value was 0.931 (greater than 0.9). All fit indices indicated a good model fit, suggesting that the model performed well.

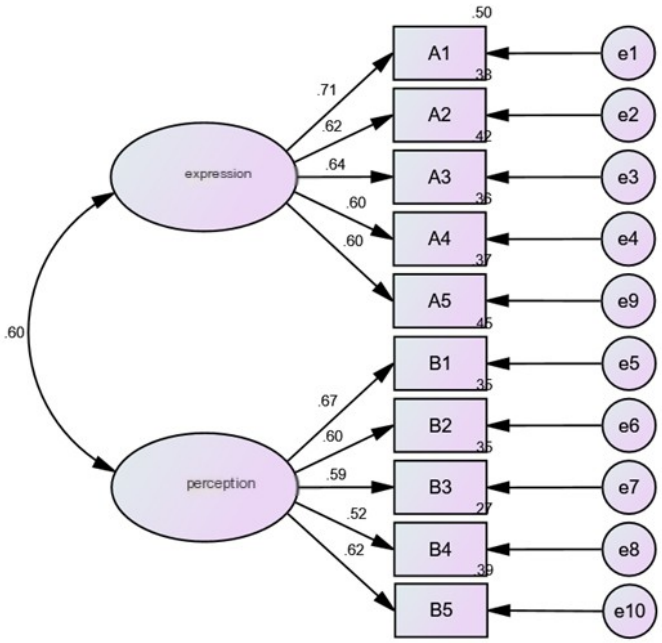

Figure 1. Structural Equation Model.

Table 6. Fit indices tested in CFA

χ^2/df	RMSEA	GFI	CFI	IFI
1.952	0.07	0.937	0.929	0.931

Table 7 below shows that the factor loadings for each item related to the latent variables "Expression" and "Perception" are all above 0.5. This indicates that each latent variable effectively represents its corresponding items. The average variance extracted (AVE) for each latent variable is between 0.3623 and 0.4037, and the composite reliability (CR) exceeds 0.7, all meeting acceptable standards.

Table 7. Convergent Validity

Road			Estimate	AVE	CR
A1	<---	Expression	.706		
A2	<---	Expression	.616		
A3	<---	Expression	.645	0.4037	0.7713
A4	<---	Expression	.599		
A5	<---	Expression	.605		
B1	<---	Perception	.668		
B2	<---	Perception	.596		
B3	<---	Perception	.592	0.3623	0.7384
B4	<---	Perception	.521		
B5	<---	Perception	.623		

Table 8 below shows a significant correlation ($P < 0.01$) between "Expression" and "Perception." However, the correlation coefficients are all lower than the square roots of the respective average variance extracted (AVE) values. This suggests that, while the latent variables are correlated, they also exhibit a satisfactory degree of discrimination. Consequently, the discriminant validity of the scale is strong.

Table 8. Discriminant Validity

	Expression	Perception
Expression	0.40	
Perception	0.60	0.36
AVE√	0.64	0.60

Reliability assessment encompasses two aspects: overall reliability and latent variable reliability. Overall reliability is evaluated using the Cronbach's α coefficient, while latent variable reliability is assessed using both the Cronbach's α coefficient and the composite reliability (CR) value. According to Fornell and Larcker (1981), a CR value exceeding 0.7 indicates strong internal consistency among latent variables. Our analysis reveals the following:

The Cronbach's α coefficient for the Infant and Toddler Rhythmic Movement Scale is 0.807. For the "Expression" dimension, the Cronbach's α coefficient is 0.765, and the CR value is 0.7713. For the "Perception" dimension, the Cronbach's α coefficient is 0.734, and the CR value is 0.7384.

All these values surpass acceptable standards, confirming the scale's good reliability. Table 9 below presents these findings.

Table 9. Estimates of internal reliability

Scale	alpha
Expression	0.765
Perception	0.734
Total Scale	0.807

7. Discussion

The successful development of the Infant and Toddler Rhythmic Movement Scale in this study has several significant implications. In terms of scale structure, rigorous exploratory factor analysis identified two dimensions: "Expression" and "Perception." These dimensions align with infants' ability to express rhythm through body movements and

perceive musical rhythm in rhythmic activities, providing a clear theoretical framework for understanding their musical rhythmic movement abilities.

Regarding validity and reliability, all indices met or surpassed acceptable standards. The confirmatory factor analysis showed a good model fit, indicating a high degree of alignment between the scale structure and actual data. Convergent validity confirms that each latent variable strongly represents its corresponding items, while discriminant validity demonstrates that the latent variables, though correlated, can be effectively distinguished. This proves the scale's good validity and its ability to accurately measure infants' and toddlers' musical rhythmic movement abilities.

In terms of reliability, the high Cronbach's α coefficients for the total scale and each dimension indicate good internal consistency and stable, reliable measurement results. Practically, this scale can serve as a parent-report instrument, aiding parents, educators, and researchers in scientifically and systematically evaluating infants' and toddlers' musical rhythmic performance. This enables a deeper understanding of music's specific influence on their rhythmic movement perception and motor skills, providing a basis for personalized music education interventions to promote their comprehensive development.

However, the study has limitations. The sample, primarily from China and recruited via social media, may have selection bias. Future research should expand the sample's scope and sources to enhance the scale's universality. Additionally, further exploring the scale's applicability across different music types and cultural backgrounds could continuously improve its application value.

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