






INDIVIDUAL DIFFERENCES IN RESPONSES TO RHYTHMIC ENTRAINMENT IN MUSIC AND MOVEMENT INTERVENTION AMONG INDIVIDUALS WITH AUTISM

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This study examines the influence of individual differences in sensory sensitivities and motor functions of four individuals with a spectrum of autistic traits on impacting their responses to the music and movement intervention. A multiple case study approach examines the participants' individualised responses to rhythmic entrainment during the six-week music and movement intervention. Sensory sensitivities play a vital role in affecting the four participants entraining their body movements to the rhythmic cues and inducing their auditory-motor mechanism. The findings indicate that each participant with autism has a distinctive response to the rhythmic cues, and this impacts the treatment outcomes of the music and movement intervention. The study recommends future researchers include individual differences in sensory and motor development as part of their investigation. These factors can directly influence the treatment outcomes of music and movement intervention from a neurological aspect.

KEYWORDS: Autism, Rhythmic Entertainment, Sensory Sensitivities, Music and Movement Intervention, Individual Differences

INTRODUCTION

Autism spectrum disorder (ASD) is a complex disorder in which individuals experience abnormalities in their brain connectivity that lead to individual differences in their aetiology, symptoms, and degree of severity (Allely et al.,

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2014; Ha et al., 2015; Kana et al., 2014). Some researchers have highlighted the importance of understanding these individual differences in autism to predict treatment outcomes (Vivanti et al., 2014). People with ASD often experience variances in their motor and sensory disturbances, impacting their capabilities in coordinating and synchronising their body movements to auditory rhythmic cues (Bharathi et al., 2019; LaGasse & Hardy, 2013). Music and movement intervention may well be a potential therapeutic approach in treating people with ASD's sensorimotor impairments by activating their auditory-motor mechanism during rhythmic entrainment (Hardy & LaGasse, 2013). However, people with ASD's responses to the music and movement treatment can vary from one to another, depending on individual differences in their sensory and motor development. Although the benefits of music and movement intervention in treating people with ASD's sensorimotor disturbances are widely recognised, a study gap has occurred in linking the influence of people with ASD's differences in motor development to the therapeutic outcomes of rhythmic entrainment during the intervention. Thus, this study explored how three children and one adolescent with ASD's differences in sensorimotor impacted their distinctive reactions to rhythmic entrainment during the six-week music and movement intervention. This study employed a multiple case study approach to observe and study in detail the participants' behaviours and capabilities in entraining their bodies to the rhythmic cues throughout the treatment sessions. The findings aim to provide valuable reference points to researchers, therapists, clinicians, and parents on understanding the significance of individual differences in sensorimotor on affecting people with ASD's response to rhythmic entrainment to plan an effective music and movement curriculum according to individual needs to achieve long-term benefits.

REVIEW OF LITERATURE

The heterogeneity in autistic symptoms, comorbidities, and traits among people with ASD often makes it challenging to group these individuals into a specific autism subtype even though they may share the same severity level. Each individual with ASD has unique autistic traits and personal characteristics. None of them shares the same autistic traits and symptoms. These individual differences in autism are vital in predicting individuals' responses to various treatments and treatment outcomes (Trembath & Vivanti, 2014). On the other hand, Greenspan et al. (1998) suggested that individual differences in autism could be investigated from three perspectives: sensory reactivity, sensory processing, and motor planning and sequencing. These individual differences in sensory and motor development provide a basic understanding of the reason behind the variances in the treatment outcomes of rhythmic

entrainment during the music and movement intervention among people with ASD.

Sensorimotor Dysfunctions in Autism

In their recent study, [Harrison et al. \(2021\)](#) highlighted the importance of including sensory processing and motor coordination in the NIMH's original Research Domain Criteria (RDoC) framework as part of the research criteria for the heterogeneity of autism. Previously, [Dawson \(2008\)](#) also found that autistic sub-symptoms, such as poor motor coordination and weak muscle tones, were significant predictors of the study subject's social interaction and communication difficulties in their later life. People with ASD's ability in motor learning can vary from one individual to another due to heterogeneity in their sensory symptom severities and cognitive skills ([Surgent et al., 2020](#)). Human beings depend on their senses to gather information from the environment, directed by the receptor cells to their brain for processing before producing output responses for their survival. The disintegration between human senses can lead to difficulties understanding and making sense of their world. In her study, [Liu \(2013\)](#) associated individuals with ASD's delayed sensory processing in visual, auditory, tactile, and movement stimuli with dysfunctions in their fine and gross motor functions. Thus, individuals with ASD who experience sensory processing difficulties may have higher risks of dysfunctions in their motor perception, execution, and planning.

Rhythmic Entrainment in Music and Movement Intervention

The close association between motor coordination and music training in improving the core symptoms of autism has been emphasised in a few studies ([Imankhah et al., 2018](#); [Sagheer et al., 2018](#)). [Sharda et al. \(2018\)](#) asserted that music intervention could positively impact children with ASD's functional brain connectivity by activating the rhythmic auditory-motor mechanisms to improve their social communication. When individuals move their bodies synchronously with the rhythmic auditory signals, the rhythmic cueing activates the sub cortical and cortical brain networks, including the auditory cortex, basal ganglia, supplementary motor area (SMA), and premotor cortices, and cerebellum ([Bharathi et al., 2019](#)). The periodicity of auditory rhythmic patterns in music provides feedback stimuli for the individuals with movement disorders to entrain their motor coordination and motor execution to work in synchronous with the auditory rhythm ([Bharathi et al., 2019](#); [Hardy & LaGasse, 2013](#); [Thaut et al., 2015](#)).

The rhythmic entrainment involves two or more independent oscillating objects with their rhythm interacting and synchronising to lock into a com-

mon phase. Clayton et al. (2005) pointed out that entrainment could involve self-entrainment and interpersonal entrainment. The self-entrainment consists of synchronisation between two or more oscillatory systems within an individual's body, such as coordinated limb movements, heartbeats, and respiration. On the other hand, interpersonal entrainment occurs when two or more individuals interact to synchronise their body movements with the external rhythmic stimuli to reach a state of socio-motor coupling. An entrainment process involves multiple levels of sensory synchronisation and coupling within one's body parts and with others' movement, rhythm, behaviours, and purposes. These individuals' spontaneous body movements to the music are aligned with the embodied music cognition and sensorimotor synchronisation theory (Gonzalez-Sanchez et al., 2018). According to the embodied music cognition framework, the human body plays a vital role in bridging musical stimuli with the external environment, bodily and perceptual modalities, and innate musical experiences (Leman et al., 2017). Similarly, the sensorimotor synchronisation theory also emphasises physical synchronisation with external stimuli such as rhythmic auditory or visual stimuli. Nordoff and Robbins (1977) proposed that individuals embodied a sensitivity to music and could entrain their body movements to musical stimuli no matter how ill or what disabilities they had. Music and movement intervention can be a practical multiple system therapy in helping individuals with ASD improve their sensorimotor by realising the rhythmic entrainment (Bharathi et al., 2019; Janzen & Thaut, 2018; Srinivasan & Bhat, 2013). The study outcomes of Imankhah et al. (2018) and Nejad et al. (2020) suggested that a combination of music and movement was effective in people with ASD in treating motor disturbances.

RESEARCH METHODOLOGY

This study was conducted as a multiple case study on four individuals with a spectrum of autistic traits to examine their individual sensory and motor responses to the rhythmic cues in the music and movement activities. Triangulation was used to collect the quantitative data from The Institute for Neuro-Physiological Psychology (INPP) Screening Test and qualitative data from the semi-structured interviews, video observation notes, interventionist's weekly personal journals, and video recordings.

PARTICIPANTS

The participants with ASD in this study were recruited through purposeful convenience sampling among the children with ASD attending other therapy sessions at a child development centre in Kuala Lumpur, Malaysia. The criteria for sampling selection were limited to the diagnosis of autism. As the

researcher intended to investigate the four participants with ASD differences as separate cases, the researchers did not target the participants' autistic traits and severity during the selection process. Nevertheless, the researchers excluded individuals with mental problems and violent behaviours. The four participants with ASD were different in age, severity, symptoms, and development in sensorimotor, cognitive, and social functions. This study's researchers had purposely chosen the participants from different subtypes of autism spectrum disorder to investigate how their distinguished individual differences affected their sensorimotor responses to the music and movement treatment from different perspectives. The multiple case study approach allowed the researchers to examine each participant's improvement as an individual without manipulating their behaviours or making any comparisons. All of these participants with ASD had never attended music classes or music therapies before this study.

The selected four participants with ASD included Participant Male A (four-year-four-months) with severe autism, Participant Male B (five-year-four-month), Participant Male C (five-year-seven-month) with mild autism and Participant Female D (fourteen-year-ten-month) with severe autism. These participants were diagnosed at the Hospital Universiti Kebangsaan Malaysia, Kuala Lumpur when they were around two to three years old. The hospital did not issue official reports on these participants' diagnoses due to their confidential policy. Consequently, the researchers had to rely on parents' feedback in the pre-intervention interviews and the INPP Screening Test results to obtain the initial information on the participants' sensory sensitivities and motor development. A summary of the four participants' individual differences in their comorbidities, sensory sensitivities, and motor functions has been presented in Table 1.

RESEARCH DESIGN

This study's researchers had chosen the multiple case study design to investigate how four participants with ASD's differences in sensory sensitivities and motor functions impacted their auditory-motor responses to the rhythmic cues during the music and movement activities. Autism is a spectrum disorder in which individuals experience different abnormal connectivity in their brains, leading to dysfunctions in their sensory processing and motor skills. Individuals with ASD have distinctive individual differences in their autistic symptoms, severity, and comorbidities, and these differences can lead to various treatment outcomes during the music and movement intervention. Yin (2018) proposed that case studies were suitable to be used as a research method when "the intervention being evaluated has no clear, single set of outcomes" (p. 18). During the six-week study period, this study's researchers and observers

Table 1
Participants' Sensory Sensitivities and Motor Development Profile .

Individual Differences and Developmental Trajectories	Participant Male A (4-year-4-month)	Participant Male B (5-year-4-month)	Participant Male C (5-year-6-month)	Participant Female D (14-year-9-month)
Comorbidities	-Hypoactive -Hypotonia	-Hypotonia -Hypermobile and hyperflexible joints	-Hypotonia -Anxiety disorder	-Hypotonia -Nystagmus -Intellectual disability
Motor Functions	-Poor hand grips -Poor motor coordination -Could not stay in an upright sitting position for a long time -Poor balance -Lack of physical stamina	-Poor balance -Unsynchronised limb movements -Poor visual-motor integration -Lack of physical stamina -Limb movements could trigger itchiness on his eyes and nose	-Poor balance -Underdeveloped fine and gross motor skills -Poor hand grips	-Severe motor dysfunctions -Poor postures and body movements -Guidance is needed when moving around due to her nystagmus -Unintegrated oral reflex -Poor balance -Poor visual-motor integration
-Sensory Sensitivities	-Auditory processing disorder -Touch sensitivity	-Deficiencies in sensory sensitivity were mild and these sensitivities did not affect his daily life much	-Auditory processing disorder -Touch sensitivity -Smell sensitivity	-Auditory processing disorder -Touch sensitivity

Note: The participants' sensory sensitivities and motor profiles were obtained from the pre-intervention semi-structured interviews and INPP.

closely examined each individual's responses to the rhythmic stimuli through video observations to gain an in-depth understanding of the similarities and differences between the four cases.

This study's data was collected using a mixed research method. Triangulation was applied to minimise biases when obtaining the valuable data for inquiries. Denzin (2012) suggested that the triangulation approach could build a bridge for cross-validation between qualitative and quantitative data when two or more different methods were found to be congruent and yielded comparable data. The researchers collected the qualitative data through parents' pre and post-intervention semi-structured interviews, three video observation notes, the interventionist's weekly personal journals, and video recordings. On the other hand, the quantitative data was gathered from the INPP Screening Test, assessing the participants with ASD's neuro-motor and visual-perception maturity before and after the intervention. Each of the treatment sessions lasted for half an hour on a one-on-one basis. A video camera was placed at one corner of the treatment room to record all the happenings of the treatment sessions.

Semi-Structured Interviews

The pre and post-intervention semi-structured interviews were conducted by phone for the parents' convenience. Each interview took about one hour to complete. All interviews were tape-recorded for analysis purposes. When preparing the interview transcripts, the researchers had to translate them into English as the interviews were mainly conducted in Mandarin or Cantonese. The translated transcripts were checked a few times against the recorded interviews for accuracy. The pre-intervention interviews were meant to obtain background information from the parents on the four participants' sensory processing skills, motor functions, and other comorbidities. Based on the obtained information from the pre-interviews and the INPP Screening Test, the researchers constructed the participants' profiles on their sensory sensitivities, motor development, and comorbidities in Table 1. Another round of interviews was conducted after the six-week music and movement intervention, gathering parents' feedback on its effectiveness in enhancing their children's sensory and motor development.

Interventionist's Journals

The interventionist prepared her journals following each treatment session to reflect each participant's responses to the rhythmic cues during the music and movement activities. These reflective notes also served as the interventionist's references in revising and modifying her treatment curriculum throughout the

six-week study period. While preparing her journals, the interventionist was able to refer to the video recordings to recapture some of the details that she might have missed during the treatment sessions. The video recordings also allowed the interventionist to verify her reflective notes and check against her self-assessment and participants' observable behaviours.

Video Observation Notes

Three independent observers were invited to prepare the video observations for the first, third, and sixth treatment sessions. The observation criteria included motor planning and coordination, motor synchronisation, balance, gross and fine motor skill, and sensory responses to the rhythmic cues in the music and movement activities.

Video Recordings

During the six-week study, a video camera was placed in a corner of the room to capture each treatment session's happenings. [Asan and Montegue \(2014\)](#) suggested that video recordings could eliminate some of the challenges that researchers faced during direct observations, allowing researchers to verify their observations, capture the clinical events, and encourage the collection of systematic feedback. The video transcripts were used to check against the data obtained from the interventionist's journals. Besides, the three observers also referred to the video recordings when preparing their observation notes.

The Institute for Neuro-Physiological Psychology (INPP) Screening Test for Children Aged 4-7 Years Old

The INPP Screening Test for Children Aged 4-7 Years Old are used to assess an individual's gross muscle coordination, balance, motor development patterns, cerebellar involvement, primitive and postural reflexes, visual perception, and visual-motor integration (VMI). The screening tests were measured on a 5-point Likert scale, with the results being reported as a total raw score and a percentage score. The total raw score was based on the total scores collected from the neuromotor and visual perceptual tests.

RESEARCH PROCEDURE

This study's multiple case study setting allowed the researchers to study each participant's responses to the rhythmic entrainment as a unique case. During the analysis stage, the researchers conducted a cross-study examination to

identify the similarities and differences between each participant's responses to the rhythmic entrainment. Besides, the researchers also attempted to associate how the participants' individual differences led to their differences in response to the rhythmic cues. Considering that this study aimed to investigate the significance of individual differences in autism on the music and movement outcomes, the researchers had purposefully chosen four participants with different severity, symptoms, ages, and deficiencies in motor and sensory abilities using purposeful convenience sampling. These individuals with ASD were selected from a child development centre in Kuala Lumpur based on their parents' consent and agreement to participate in this study. These participants attended six weekly half-an-hour one-on-one music and movement intervention conducted by an experienced music and movement interventionist at the centre. Except for Participant Male A, all participants attended the treatment sessions without their parents' accompaniment. A total of 20 children's songs were chosen for this study. The usage and presentation of each song varied according to the participant's progress and individual needs. The music and movement activities included instrumental playing, fingerplays, chanting, musical games, body movements, dancing, and singing.

The participants' parents had to complete a pre-intervention semi-structured interview one week before the study started. As this study's researchers found it difficult to arrange a convenient schedule to interview the parents, all interviews were conducted by phone. Each of the interviews was tape-recorded and lasted for about an hour. The researchers allowed the parents to complete the interviews in languages, such as Mandarin and Cantonese, that they felt most comfortable. Before the study began, the participants with ASD had to attend the INPP Screening Test that lasted for thirty to forty-five minutes. One of this study's researchers conducted the tests to assess the participants' neuromotor, primitive reflexes, visual integration, and visual-perception maturity.

After each lesson, the interventionist prepared her journal, reflecting on her observations of each treatment session and the participants' responses to her treatments. All treatment sessions were video recorded as references to the interventionist when preparing her journals. Through these video recordings, the three independent observers constructed their observation notes of the first, third, and sixth sessions. The observers could not do any field visits due to conflicts in their daily schedules. Besides, the presence of independent researchers during lessons might also affect the participants' responses and concentration.

At the end of the study period, the parents were required to attend another round of interviews by phone. These post-intervention interviews were meant to obtain their feedback on the treatment outcomes and observations of their

children's sensory and motor progress following the intervention. At the end of the study, the participants with ASD had to attend another round of INPP Screening Test to determine improvement in their motor, visual integration, and visual perception development. The quantitative and qualitative data obtained through triangulation were analysed using inductive coding. The results were reported in a descriptive format.

DATA ANALYSIS PROCEDURE

The quantitative data gathered from the INPP Screening Test were used to support the qualitative information obtained from the semi-structured interviews, video observation notes, interventionist's journals, and video recordings. This quantitative data was not meant to prove a hypothesis or statistical analysis. The participants' total raw score in the INPP Screening Test varied depending on their ages as not all the visual perceptual tests were suitable for their age. For example, Participant Male A was only tested on six items of the age-appropriate visual-perceptual tests with a total raw score of 24. On the other hand, Participant Male B and Participant Male C were tested on all 24 items in the visual perceptual tests with a total raw score of 72. Due to the variations in the total raw score, the percentage score is more appropriate for data interpretation purposes to understand the participants' neuromotor and visual perception maturity. Participant Female D was being assessed with the developmental screening tests for children aged 4-7 years old instead of those tests meant for her age because of her severe sensorimotor deficiencies and visual perception difficulties. Participant Female D only completed the neuromotor tests and none of the visual-perceptual tests.

The data collected from the semi-structured interviews were translated, transcribed, and re-read for detailed analysis. On the other hand, the qualitative data gathered from the semi-structured interviews, personal journals, video observation notes, and video recordings were analysed using inductive coding. The analysis focused on two priori themes: participants' motor and sensory responses to the rhythmic entrainment. The obtained themes, codes, and subcodes were then used to compare the data collected from the INPP Screening Test to answer the research question on the influence of the four participants with ASD's differences on their sensory and motor responses to the music and movement treatment. This study's researchers categorised the obtained data under two main themes:

- (a) sensory sensitivities (balance, tactile, sound, and proprioception); and
- (b) motor skills (motor control, motor coordination, and physical stamina).

RESULTS OF THE STUDY

In our daily life, the brain receives and processes the sensory information gathered from the environment, allowing individuals to regulate their responses to everyday situations. Individuals with ASD who experience dysfunction in sensory integration often find themselves experiencing difficulties in their motor, cognitive and socio-emotional functions. [Guardado and Sergent \(2021\)](#) suggested that dysfunctions in the limbic system and the vestibular and proprioceptive system could lead to individuals' difficulties in registering, processing, and modulating sensory information. In this study, the participants' auditory, tactile, vestibular, and proprioception processing capabilities were vital in realising the rhythmic entrainment during the music and movement intervention. According to Ayres, individuals who experience sensory disintegration often find it challenging to engage in daily activities because they lose the motivation and lack of attribution to respond to the stimuli around them ([Guardado & Sergent, 2021](#)).

The four participants in this study had individual differences in their sensory development, which led to variances in activating their auditory-motor mechanisms. The participants with ASD needed to process the rhythmic cues in music accurately before can entrain their body movements to the rhythmic stimuli. As the researchers could not obtain the participants' medical reports, they had to rely on the parents' feedback to get information on their autistic traits, sensory, and motor capabilities during the pre-intervention interviews. The pre-intervention interview transcripts indicated that Participant Male B was the only participant among the four who faced minor problems in his sensory sensitivities. The other three participants had different levels of deficiencies in their auditory processing functions and were sensitive to loud noises. For example, Participant Female D got distracted throughout the fifth treatment session when the interventionist conducted the session in a bigger room with more echoes. On the other hand, Participant Male A and Participant Male C responded to loud music by covering their ears and crying. Participant Male A, Participant Male C, and Participant Female D also showed different levels of sensitivity to touch. When Participant Male C was overwhelmed with the musical stimulations during the instrumental playing, he would rub his hands against each other and smell the instrument. This disruption of movements had affected his continuous processing of the auditory rhythmic stimuli. Participant Female D showed different reactions when she was overstimulated by the tactile inputs, especially when playing an instrument. She would rub her fingers against the instrument or flap her hands when she got excited. Throughout the treatment period, Participant A, Participant Male B, and Participant Male C tended to lose their balance when they were too concentrated on entraining their body movements with the rhythmic stim-

uli. These participants occasionally fell over to their sides in the middle of a song. However, Participant Female D only lost her balance when she was in an upright standing position. She found it challenging to execute movements like marching, jumping, and running throughout the study period.

The data collected from the INPP Screening Test reflected the participants' neuromotor and visual perception development before and after the music and movement intervention. This data provided valuable information on the participants' progress in their motor development following the music and movement intervention. As the mother refused to bring Participant Male A for the post-intervention tests, his final INPP result was omitted in Table 2. The findings of the INPP Screening Test are presented in Table 2.

The final results of the INPP Screening Tests suggested that Participant Male B and Participant Male C benefited the most from the music and movement treatment. Both participants' parents had also expressed their satisfaction with their children's improvement in motor coordination, motor planning, and attention span following the six-week treatment. Although Participant Male B and Participant Male C found it challenging to entrain their bodies to the rhythmic cues at the initial stage, they learned quickly to make the necessary adjustments to their motor coordinate and motor synchronisation through imitation as they played along with the interventionist during activities.

The findings of the INPP did not only indicate that both Participant Male B and Participants Male C had improved their motor skills but also their visual processing ability. Participant Female D hardly showed any improvement in her sensorimotor functions. Her severe deficiencies in sensory integration had impacted her processing of the stimulants from her surroundings accurately. Her difficulties in visual, auditory, and severe motor disturbances hindered her from entraining her body movements to the rhythmic cues. Participant Male A's case was interesting compared to the other three cases. The collected data suggested his mother's interference could have slowed down his progress in his sensorimotor development during the treatment sessions. His mother's request to stay with him throughout the treatment sessions was one condition she insisted on before agreeing to participate in the study. She argued that he was too young to be left alone. During the treatment sessions, Participant Male A's mother anxiously jumped in to help him when he did not show immediate responses to the interventionist's guidance. Participant Male A seemed to have sensory processing difficulties. He could not take in instructions well nor respond spontaneously to the interventionist's demonstrations. Consequently, the interventionist and his mother had to guide him physically to play along with the music. Participant Male A's case is an excellent example of how family influence could impact his development of individual differences.

To summarise this study's findings, the four participants with ASD's differ-

Table 2
Findings of INPP Screening Test Pre- and Post-Music and Movement Intervention.

	Participant Male A		Participant Male B		Participant Male C		Participant Female D	
	Pre- Inter- vention	Post- Inter- vention	Pre- Inter- vention	Post- Inter- vention	Pre- Inter- vention	Post- Inter- vention	Pre- Inter- vention	Post- Inter- vention
Neuromotor Test	19/68	No data	27/68	9/68	13/68	4/68	50/68	20/68
Visual-perceptual Test	24/24	No data	35/72	16/72	26/72	0/72	72/72	72/72
Total Raw Score	43/92	No data	62/140	25/140	39/140	4/140	122//140	92/140
Percentage Score	46.74%	No data	44.29%	17.86%	27.85%	2.86%	87.14%	65.71%

Note: The percentage score is interpreted at five categories: (a) no abnormality detected (NAD); (b) low score (< 25%); (c) medium score (25-50%); (d) high score (50-75%); and (e) very high score (75-100%).

ences in their sensory sensitivities and motor functions significantly impacted their responses to the rhythmic entrainment during the music and movement intervention. Participant Female D, who had the weakest sensory and motor abilities among the four participants, had difficulty entraining her body movements to the rhythmic cues. She needed the interventionist's help to complete most of the tasks during the intervention. Participant Male A's weaknesses in his sensory sensitivities had become a challenge for him to process and respond promptly to the rhythmic stimuli. His mother's anxiety and eagerness to help him without giving him much opportunity to process the rhythmic stimulations by himself had deprived him of processing the auditory stimuli to entrain his body movements accordingly. On the other hand, Participant Male B and Participant Male C, who was diagnosed with mild autism, achieved the most significant improvement in their sensorimotor development from the six-week treatment. Although both participants faced difficulties in their motor coordination and motor functions, their emotional stability and love of music enabled them to reduce their anxiety while adjusting and refining their movements according to the rhythmic cues.

DISCUSSION

This study's findings asserted that the four participants with ASD responded differently to the rhythmic stimuli in the music and movement activities due to individual differences in their sensory and motor development. Previous studies have highlighted the potential of rhythmic entrainment in improving individuals with ASD's sensory and motor development (Bharathi et al., 2019; Hardy & LaGasse, 2013; Janzen & Thaut, 2018). However, most music and movement intervention researchers did not study in detail how the individual differences impacted people with ASD's sensory and motor responses to the rhythmic entrainment, leading to a variation in treatment outcomes. This study found that Participant Male A and Participant Female D, who faced more challenges in their sensory integration of auditory, tactile, vestibular, and proprioception, tended to have more difficulties in entraining their bodies to the rhythmic cues. The outcomes of this study were aligned with Surgent et al. (2020) and Liu (2013) findings. As the realisation of rhythmic entrainment requires the activation of the auditory-motor mechanism, the impacts of individual differences in sensory and motor development among individuals with ASD should not be underestimated. These factors could lead to different treatment outcomes. Besides, understanding the individual differences in sensory and motor functions can help parents evaluate whether music and movement intervention is suitable for their children with ASD's current development and what their children can gain from this treatment in the long run.

Although this study's findings could not be generalised to the general pop-

ulation with ASD due to its small sample size, the case study approach provided the researchers with the opportunity to investigate the impacts of participants with ASD's differences in responses to the rhythmic entrainment from different perspectives. The participants with ASD's differences in their sensory and motor development were studied as separate cases to understand how their sensory sensitivities led to their different motor responses to the rhythmic cues. This study's researchers urge future researchers on music and movement intervention to consider individuals with autism's sensory and motor functions as part of their investigation because these two domains directly impact the treatment outcomes of the music and movement intervention. This suggestion goes along with the findings of Trembath and Vivanti (2014) that individual differences in autism were good predictors of treatment outcomes.

CONCLUSIONS

The treatment outcomes of music and movement intervention can vary significantly among people with ASD, depending on individual differences in their ability to entrain their body movements to the auditory rhythmic cues. Clinicians and therapists should study people with ASD's differences in sensory sensitivities and motor functions before recommending music and movement treatment to gain long-term benefits from the treatment. People with ASD who experience more sensory and motor disturbances will need a more extended treatment period to synchronise and coordinate their movements to the rhythmic cues before achieving significant results.

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