

音楽療法介入中の注意の働きに関する考察： 自閉スペクトラム症児を対象とした活動の分析を通して

Does music enhance attention skills of children with autism spectrum disorder?
Analysis of music therapy intervention

糟谷由香¹
Yuka KASUYA-UEBA¹

注意の問題は、認知機能だけでなく、社会性やコミュニケーション能力の発達にも影響をおよぼす。自閉スペクトラム症（ASD）研究においてこれまで、注意の問題を呈する割合の高さが報告されており、注意機能の改善が障害の複雑さや重症度を低下させ、中核症状とされる社会性やコミュニケーションの困難などの改善をもたらす可能性が示唆されてきた。注意機能に与える音楽の影響に関する報告はあるものの、音楽療法介入がASD児の注意の改善にもたらす影響を直接調べた研究は少ない。ASD児に対する音楽療法は従来、社会性やコミュニケーション能力に対処する介入が多く、注意に焦点を当てた報告が少ない要因のひとつとして、こういった介入の中で注意機能が間接的に訓練され高められている可能性が考えられる。そこで本研究では、ASD児の社会性とコミュニケーション能力の改善を目的とした音楽療法活動を分析し、活動参加に求められる注意の働きについて調べた。結果、ASD児の機能改善を目的とした音楽療法活動への参加には、持続性注意、選択性注意、および注意制御を含む注意機能全般の働きが求められることがわかった。また、これらの活動では聴覚的注意と視覚的注意を要することもわかった。これらの結果は、ASD児の中核症状の改善を目的とした音楽療法介入が、注意機能を訓練し促進する可能性があることを示唆している。注意の問題の重症度に応じた音楽療法介入での直接的および間接的アプローチ、ASD児が示す社会的刺激に対する困難、および音楽がもたらすクロスモーダル効果についても考察した。

Abstract

Attention deficits in children impact the development of higher cognitive function, social skills, and communication skills. Previous research report the high rates of attention problems in individuals with autism spectrum disorder (ASD) and suggest that attention improvement may decrease the complexity and intensity of disability and may lead to improved functioning in social and communication areas. Despite the reported effect of music on attention function, only a few studies have directly investigated the effectiveness of music therapy on attention deficits in children with ASD. It may be because music therapy for ASD that has traditionally focused on social and communication skills inherently and indirectly enhances and trains attention skills. The purpose of this study was to analyze activities aimed at improving social and communication skills in music therapy intervention to investigate attentional requirements to children with ASD. The analysis of the music therapy activities showed that participation in the activities demanded the use of overall attention function in participants, including sustained attention, selective attention, and attention control. These activities also engaged auditory attention and visual attention of the participants. These results suggest that music therapy intervention aimed at improving core symptoms of ASD may also have the potential to train attention function. The ability of music therapy to address the severity of attention deficits, difficulties with social stimuli faced by children with ASD, and cross-modal effects of music are also discussed.

¹ Music Therapy Course, Music Department, Kurashiki Sakuyo University

1. Introduction

Autism spectrum disorder (ASD) is one of the major clinical populations that utilize music therapy [1]. The importance of early intervention for children with ASD has been widely recognized [2] and many music therapists work with young children with ASD. Individuals with ASD are characterized by two cardinal clinical features: persistent deficits in social communication and interaction, and restricted, repetitive, and stereotyped patterns of behavior [3]. Cognitive deficits, including attention difficulties, are generally regarded as secondary impairments or comorbidities in ASD, however, a number of researchers have pointed out that attention deficits may be the core symptom and the repetitive or obsessive behaviors, social-interactive responses, and hypersensitivity observed in ASD may result from attention problems [4, 5]. Evidence shows that individuals with ASD display a wide range of attention deficits across various domains of attention function, such as orientation, disengagement, shifting or switching, and selective attention [4, 6-11]. In a study by Mayes and Calhoun, of the 143 children with ASD and normal intelligence, 93% exhibited some form of attention deficit [12].

Attention function is generally comprised of three distinct components: sustained attention, selective attention, and attention control/switching [11, 13]. These attention skills develop in a stepwise fashion from early childhood by engagement with one's environment. If the development of these basic skills that underlie higher brain functions are hindered or do not develop appropriately, cognitive, social, and communication skills are adversely affected [6, 11]. Children with ASD who show attention problems are likely to experience difficulties participating in group play and performing tasks in daily life and school, which can collectively lead to cognitive and social difficulties [14]. It has been reported that attention improvement may decrease the complexity and intensity of the ASD disability and may lead to improved functioning in other areas including social communication [15, 16].

Music can be a suitable tool to enhance and train attention skills [13], however, few clinical studies have investigated the effect of music on attention in children with ASD [17]. Kim et al. examined the effect of improvisational music therapy sessions in ten autistic children aged 3 to 5 years [18]. Behavioral tests and observations found that participants demonstrated significantly more attention behaviors in the music therapy sessions than in the toy play conditions. Lee reported a case study of a 5-year-old child with ASD receiving weekly, hour-long, music therapy sessions [19]. As a result of 20 sessions, the child showed improved attention span and language skills in behavioral observations. Recently, Pasiali et al. examined the effects of music therapy using a standardized attention test in nine adolescents, aged 13 to 20 years, with neurodevelopmental delays [20]. Results showed that they demonstrated significant improvements in selective attention and attention control after eight music therapy group sessions. The limited number of studies show that music therapy intervention may positively impact different subtypes of attention in children with ASD.

In light of such a small number of studies evaluating the influence of music directly on the attention skills of children with ASD and the high rates of their attention problems [12], Kasuya-Ueba has pointed out two possibilities: one is that attention skills in children with ASD may be indirectly enhanced and trained in music therapy interventions that primarily address deficits in social and communication domains, and the other is that attention problems of children with ASD may be overlooked or hard to detect during the assessment process because behaviors caused by attention problems can be misattributed to the classic signs of ASD [17]. Music therapy for children with ASD has traditionally focused on social interaction, verbal and nonverbal communication skills, and social-emotional behaviors. Therapists usually set treatment goals in these domains based on obtained information and observation during the assessment process for children with ASD. In the clinical practice of music therapy, however, therapists often observe that music stimuli and activities designed for each child's needs and characteristics in these domains improve his or her attention function. Music therapy intervention that focused on social and communication skills may inherently and indirectly enhance and train

attention skills in children with ASD. To participate in music therapy activities aimed at improvements in any areas, children are typically required to (1) orient to and maintain their attention to music, (2) select stimuli (sound or voice) that they need to respond to from multiple sound layers, (3) shift and control their attention between the therapist's voice/singing and instrumental sounds (the piano and the guitar are most often used by the therapist). Music structured with multiple elements, such as beats, meter, rhythm, pitch, melody, harmony, phrase, and dynamics, provides both verticality (simultaneity) and horizontality (sequentiality) at the same time. One hypothesis is that the attributes of music may lead to the improvement of attention skills of clients actively participating in the activity. Thaut and Gardiner proposed that multidimensional stimuli in music facilitates alternating and divided attention, that timing, grouping, and organization in music sustains attention, and that music stimulates dimensions of emotion and motivation that help to facilitate concentration for a specific task [13]. These attributes and motivational factors of music may contribute to improvements in attention, including sustained, alternating, and divided attention. To illustrate the effect of music therapy on the attention of children with ASD, it is important to analyze the music therapy activity with the focus on its attentional requirements.

The purpose of this study was to analyze activities aimed at improving social and communication skills in music therapy intervention to investigate attentional requirements to children with ASD, such as sustained attention, selective attention, and attention control. Music therapy is defined as the use of evidence-based music interventions to accomplish individualized goals while in a therapeutic relationship with a professionally trained music therapist. Accordingly, music therapy activities are defined, in this study, as activities with a therapeutic purpose, in which a therapist intentionally and flexibly uses music to encourage appropriate responses to meet the treatment goals, reflecting the participant's responses, behaviors, and moods that change from moment to moment. In the music therapy intervention, the whole period of the session time is considered as a therapeutic experience, including the time in between activities that do not have music. Only the activity parts, however, were extracted for analysis in this study because the purpose of the study was to investigate components of music therapy activities that may enhance and train attention skills in children with ASD. Hopefully, this work will contribute to a deeper understanding of how music therapy influences the attention of children with ASD and how their attention skills are required to work in order to participate in the therapeutic activity.

2. Methods

The video-recorded music therapy interventions, held in an institution that supports child development, were analyzed to determine attentional requirements to participants during the music therapy activities. The activities were semi-structured (not improvisational), and three or four 4-5-year-old boys with ASD underwent the music therapy. The participants regularly attended the institution for a few days per week after preschool, and all activities were led by a board-certified music therapist (the author) in a group setting. The semi-structured activity means that the therapist planned a song and procedure prior to the session based on therapeutic goals and objectives, but still remained flexible to the participants' states and responses. All participants did not have any hearing impairments or hyperacusia, and were capable of verbal expression. Their receptive language skills and intellectual abilities were slightly delayed compared to typically developed peers, however, none had any problems while participating in the activities analyzed in the study. All activities were conducted using simple and clear verbal directions that were given step-by-step along with modeling, visual cues, and musical facilitation. The participants did have varying degrees of attentional difficulties; therefore, the therapist used therapeutic techniques, such as verbal, visual, physical prompts, and musical manipulations, when needed to regain or hold their attention. Four activities were analyzed in this study, including a greeting song activity, an instrumental activity with Suzuki tone chimes, a movement activity, and a good-bye song activity that were selected from two different music therapy sessions. These activities are typically implemented in music therapy sessions for children. Types and detailed descriptions of activities analyzed, tasks for the participants, and

therapeutic techniques used to enhance appropriate responses are described in Table 1.

The environmental setting for the music therapy sessions consisted of a room with an area of about 4 meters by 5 meters. The room was separated from the next room by an accordion curtain, which was closed during the sessions. Children participating in the next session usually waited in the next room and played with blocks, therefore, though it was not loud, some sounds unrelated to the session were audible for the participants in the session room. In the session room, there was a keyboard set in front left of the room facing the participants and was next to the therapist. An organ stood in the right corner of the room. A standing whiteboard with the date and weather of the day stood behind the therapist, and musical instruments and materials for use in the session were set in the left corner from participants. A video camera was placed on a chair placed next to the organ and was used to record the sessions. Glass doors to the outside play area were on the right side from participants. The doors were closed when the therapy was in session.

During the seated activities, participants were seated in a row about 0.8 m away from therapist, who held a guitar and faced the participants. During the movement activity, participants and the therapist stood around the circle, marked by color string, in which musical instruments were placed randomly. The therapist held the guitar while standing with the help of a strap.

Subdomains of attention in this study were described by Cornish and Wilding [11] and are as follows:

- Sustained attention: the ability to maintain focused attention within the context of multiple distractions or while waiting for a significant event (vigilance)
- Selective attention: the ability to selectively attend to or orient to the most important sources of information in the environment, and to filter out potentially extraneous stimuli
- Attention control/Switching: the ability to exert control in order to inhibit a dominant response, to hold newly relevant rules in working memory in order to suppress or activate previously learned responses, and to shift attention between tasks

The four music therapy activities were recorded, and the therapy sessions were viewed and repeatedly analyzed to review attentional requirements to the participants according to the three subdomains of attention as well as therapeutic techniques that the therapist used and step-by-step procedure in the activities.

3. Results

Analysis of the music therapy activities showed that sustained attention, selective attention, and attention control were necessary for participants to actively participate in all of four activities. Types of activities, detailed descriptions of the activity, tasks for the participants, therapeutic techniques used to enhance appropriate responses, and attentional requirements for the participants per activity are described in Table 1. In the room where sessions were conducted, participants were able to see equipments related and unrelated to the therapy activities. There were also noises from the next room, separated by the accordion curtain, that were audible for the participants. In the environment, participants needed to selectively attend to or orient to the most important sources of information and to filter out extraneous stimuli in order to participate in all of the activities.

A greeting song activity, using an original simple greeting song sung at the start of every session, encouraged participants to make simple movements to the music such as clapping while singing or saying “hello” at a specific point in the song. The purpose of this activity was to welcome and engage participants to participate in the session with an appropriate mood and arousal level for the intervention to be effective. The welcome song also allowed the therapist to quickly assess the participants at the start of the session. Therefore, in this activity, music was matched with the initial mood and arousal level of the participants, and then the therapist gradually altered the volume, rhythm, and tempo of the music in order to elicit the desired state in the participants. The desired state was achieved by observing the facial expression and behaviors of the participants. Participants were required to focus their auditory attention on the therapist’s singing and/or music, to follow directions for

movements, and to sing or say “hello” at certain times during the activity. The welcome activity included moving and singing parts for participants, who needed to actively listen to the therapist’s singing and playing on the guitar to get directions and cues. This activity employed attention control skills throughout the activity; participants used switching auditory attention to follow the therapist’s directions for movements and to follow the cues for clapping or stomping back and forth rapidly. Participants performed the activities while shifting their visual attention between their own movements and saying/singing “hello” according to visual and musical cues from the therapist; shifting auditory attention between the sung melody and the rhythm of the guitar was required so that the participants could sing the melody in time.

A familiar children’s song was used in the instrumental playing activity, and the participants played and sang along with Suzuki tone chimes. A song sheet, presented on the whiteboard in front of the group, displayed lyrics in colors of red, blue, and black. After dividing participants into two groups, one group was tasked with playing chimes on red, while the other group played on blue. During the part of the song with the black lyrics, participants took turns selecting and playing musical instruments placed at the front of the group. This activity challenged the participants to play chimes in coordination with the group cooperatively, including starting and stopping at appropriate places, by following the lyrics on the whiteboard. The participants were asked to follow the lyrics on the whiteboard to know when to play the chimes. The instrumental activity required attention control because the participants needed to hold the rules of this activity in working memory (i.e., when to play and stop chimes). In the process of developing the activity over the sessions, participants were required to control their auditory and visual attention by looking at physical cues from the therapist. Hand signals guided the participants to stop playing while singing to the music, and shift auditory and visual attention between the therapist’s singing to sing along and the lyrics and colors on the whiteboard. Participants were also required to shift their attention between their hands movement to play, lyrics to sing and colors to play or stop, and possibly between the therapist’s hand signals or eye contacting to know when to play or stop and the sheet. Participants also needed to shift auditory and visual attention to the peer taking a turn playing a solo in the middle part of the song while singing to the music and then focusing back on the sheet and their chimes. When the participant performed a solo, the activity required him to shift auditory and visual attention between playing freely in front of others, listening to the music for cues to stop and return to his seat, and to visually shift his attention towards selecting and playing one of three instruments. Throughout the activity, participants were required to repeatedly switch their attention between the Th, the whiteboard, the peer playing as the group, and the peer performing a solo.

The movement activity used more space than the seated activities and the participants moved around a circle in which music instruments, such as cabasas, lollipop drums with mallets, and pairs of claves, were randomly placed. The therapist first introduced the instruments and sang an original song while playing the guitar and moving with the children. After stomping on the steady beats, the participants were asked to walk to the music. The participants walked around the circle with cautions not to bump into the peer in front or pass them. The therapist sang the directions of stopping when music stopped and starting walking again when music started again. After repeated stop-and-start cues for random intervals so that the participants were not be able to anticipate the cues and required sustained attention, the therapist introduced the next part of the song singing to find one of the instruments in the circle through song, and to play it until the music stopped. In the process of developing the activity, various movements, such as walking faster, running, and tiptoeing, were introduced while the music changed tempo, volume, and rhythm to facilitate their movements. The song was repeated several times, and each participant had the opportunity to decide how to move around the circle in turn. For the part of playing instruments, the therapist added extra directions (i.e., “play it loudly/slowly/high in the air”) to the song as variations. To motivate participants for this self-regulation activity, the therapist used humor, such as feinting to pause in the middle of the song, not stopping where the music likely stopped, or going to the next

part of instrumental playing. These actions provided unpredictability in the predictable song structure, and participants were required to maintain their attention on the music and the therapist's singing directions that varied throughout the activity. Their attention control skills were also required to pay attention to the person in front while simultaneously moving in time with the beat. This activity also required to follow the rules of the activity switching attention between the music, the therapist's singing directions, one's own movements, peers, and instruments that required attention control skills. The movement activity challenged the participants' attention control skills, which were required to inhibit continuous motions, and to switch attention from the therapist to the peer when he announced the next movement and then switch back to the therapist.

In the good-bye song activity, an original, simple, good-bye song was used that was sung in every session. Participants were encouraged to sing along with the therapist and to say or sing "bye bye" to the therapist and their peers whenever their name was called. The purpose of this activity was to have the participants respond at appropriate times by saying good-bye and making eye contact with the therapist or peers and to remember the song in order to participate in the activity. The therapist randomly called names during the song; therefore, participants needed to maintain their focused attention while waiting for being called to respond, which is the sustained attention skill specifically called vigilance. This sing-along activity also required participants to maintain visual attention on the therapist, and auditory attention on the therapist's singing and guitar music to sing along throughout the song despite multiple distractions. This simple activity also allowed the participants to use their attention control skills and working memory because they were required to shift auditory and visual attention and remember cues, such as when to keep singing, when to pause singing because the therapist called a peer's name, and when the named participant responded to his name.

In summary, all of the music therapy activities analyzed in this study required sustained attention skills, selective attention skills, and attention control skills of the participants for active participation. These activities also demanded visual attention and auditory attention throughout the activities.

4. Discussion

The purpose of the present study was to investigate how the attention of children with ASD functioned in the music therapy intervention aimed at social and communication improvements through analysis of music therapy activities. The analysis of the video recordings showed that participants had to use overall attention function, including sustained attention, selective attention, and attention control, in all four activities. All the children participating in the music therapy activities displayed some form of attention problems, therefore, visual and verbal prompts and encouragement and musical stimulation were necessary for the therapist to gain and hold their attention. Activities were structured so that tasks were introducing gradually and would not to overwhelm considering the participants' comprehension ability. Participants displayed the typical characteristics seen in children with ASD, such as difficulties to keep eye contact, weakness in language understanding, and weakness in response to unstructured tasks, however, severe autistic symptoms, such as lack of eye contact, lack of verbal expression, avoidance of social interaction, and engagement in restricted and repetitive behaviors were not present in the children that took part in this study. The severity of symptoms of ASD displayed by the participants greatly influences the purpose and complexity of the therapeutic activity in the therapy session. The activities analyzed in this study, which required complex attention control, were viable for the participants because those were suitable to the participants' degree of disability and developmental level. It can therefore be assumed that music therapy activities designed for specific participants allow them to function and potentially train their attention skills in music therapy intervention regardless of what the primary treatment goals are.

Analysis in this study showed the possibility that the therapeutic activities in music therapy intervention for children with ASD, whose primary treatment goals were to improve social and communication skills, may enhance and train their attention skills. The participants in this study might benefit from those activities that

required their overall attention skills. There may be, however, a certain population of children with ASD who can benefit from directly targeting their attention problems that may result in lessening the core symptoms associated with ASD [15, 16]. For example, children with severe attention problems and severe autistic symptoms may not be able to benefit from intervention without first treating the attention dysfunction. Previous studies have shown that directly targeting a specific cognitive ability through repetitive, graded exercises produces promising results in various clinical populations. Kerns et al. found that using a process-specific approach, using a computer game to target attention and working memory, significantly improved those skills in children with ASD [15]. Once the attention dysfunction is addressed with direct approach, higher functions, such as social interaction, nonverbal and verbal communication, and social-emotional reciprocity could be enhanced in a more effective way. High functioning children with mild attention problems, similar to the participants in this study, may benefit from therapeutic activities aimed at improving social and communication skills as long as the therapist taking into account the participants' attention deficits. A basic ability to focus and maintain attention for a period of time, without being distracted, is required to participate in any therapeutic activity, therefore, music therapists with the knowledge and clinical techniques how to engage children with attention deficits in the intervention may unintentionally enhance and train their attention skills. Setting the therapeutic goals for the intervention, however, is the crucial process that affect the outcome of a course of the therapy. A careful and multidimensional approach for clinical assessment including not only the core symptoms of ASD but also attention skills should take into account in order to set the appropriate treatment goal and design effective therapeutic interventions [16], since attention is a foundational skill for higher functions and reports confirm that attention deficits may affect one's ability to learn, process, and engage in social interaction and communication [6, 11]. In addition, therapists must know how each activity, or even each step of the activity procedure, requires the participant to use the attention skills, especially when the participant has attention deficits.

In music therapy intervention, regardless of the treatment goal, a therapist employs similar techniques, as detailed in Table 1, to facilitate active participation by gaining and holding the participants' attention in order to develop their understanding. The therapist with professional training in music therapy is considerate of differences in the behavioral characteristics of children with disabilities, and offers tailored approaches and musical applications to address each participant's individual characteristics. These involvement may enhance orientation, disengagement, and control of attention that are challenges to individuals with ASD [4, 6-11]. For example, the timing when to make sounds or begin music is an important moment-to-moment decision to make for the therapist to facilitate their attention orientation. Music with a steady, predictable beat, a simple, repetitive melody, and an appropriate amount of unpredictable stimuli enhances the ability of some participants to maintain attention. When the therapist develops each activity, the therapist proceeds in a step-by-step fashion so that the cognitive load of the tasks, the cognitive processing, and the requirement and complexity of attention control is gradually increased. This gradual increase in demand of attention control allows participants to participate in the activity while following the steps and having fun without being overwhelmed. Without the knowledge and clinical techniques used by the therapist, the therapeutic activities would not viable and participants would not function their attention skills efficiently during therapy even if age-appropriate, enjoyable music is presented.

Since music is organized and consists of multiple elements, such as beat, meter, rhythm, pitch, melody, harmony, timbre, phrase, form, dynamics, and texture, for a given period of time, it provided the opportunities to use various attention skills to the children in this study. The perception of the rhythmic, melodic, harmonic, and dynamic patterns of music might, consciously and subliminally, influence on focusing and organizing the flow of attention [16]. Music also provides multidimensional stimuli that demand shifting attention and brings in timing, grouping, and organization that facilitate the maintenance of focused attention [13]. These attributes

of music might encourage the participants in this study to be focused, selectively attend to the most important stimuli, exert effort to inhibit a dominant response, hold the rules of the activity in working memory to suppress or activate previously learned responses, and shift attention between stimuli or tasks. In the activities analyzed, participants needed to use attention skills to sing at least a phrase or phrases of a song, to respond with appropriate timing, and to follow the directions for active participation. Lyrics were added as a musical element to the song. For example, in the activity where the therapist sang directions for movement to the melody, the participants needed to sustain attention for at least one phrase of the given directions, and, possibly, switch attention between the beats to move appropriately in time and the therapist's singing back and forth (Table 1). These results suggest that music itself contains inherent, unique, and effective components for attention control training.

In addition to the influence of musical components, the structure of the activity designed to improve the participants' social and communication skills also inherently contained the elements of attention training. The instrumental activity with tone chimes required participants to concentrate on the lyric sheet, to play and stop playing when appropriate, and look at a peer performing a short solo at the front, and to switch their attention back to the sheet on the whiteboard (Table 1). In this series of repeated tasks, participants needed to selectively orient to and maintain their attention on the most important resources of information in their environment, and to later disengage and shift their attention to another relevant resources of information. Thus, the music therapy can be a suitable intervention for children who have difficulties with complex attention control as well as simple attention.

Music activity is social in nature. Participants in a group activity need to perceive and process social stimuli from the therapist and other participants in order to sing along, play instruments in timing with other participant(s), make movements in a group setting, and wait for his or her turn. It is known that individuals with ASD particularly show difficulty with attending to and processing social stimuli, such as human faces, voices, and social information. In the music therapy activities analyzed in the study, the participants with ASD were required to visually and aurally pay attention to social stimuli and respond to them when appropriate. Viewed in this light, music therapy intervention that inherently contains social aspects may enhance the attention skills of children with ASD.

Analysis of this study shows that music therapy requires both auditory and visual attention of participants. Due to its multimodality, music therapy activity may positively impact both auditory and visual attention [21]. Janzen and Thaut reviewed related literature that showed auditory rhythmic cues entrained visual attention and facilitated processing of visual stimuli [6]. There is a possibility that there may be cross-modal effects of music therapy on attention function, however, there is one study that has previously reviewed the influences of long-term musical training; the study reported that the benefits of musical engagement might be restricted to the auditory domain [22].

5. Conclusion

The present study reported that the music therapy activities aimed at improving social and communication skills of children with ASD required overall attention function to participants and may indirectly train and enhance their attention skills. This study focused on the ability of therapeutic activities to determine attentional requirements to the participants. Clinical studies that systematically analyze participant's responses to attentional requirements during music therapy activity, using qualitative and quantitative analysis, are needed to examine the actual effectiveness of music therapy on attention deficits in children with ASD. By measuring both the severity of attention problems and symptoms of ASD, the correlative or causative relationship between the two can be revealed in relation to the effectiveness of music therapy intervention. The effectiveness of music therapy intervention on attention function should be further investigated by measuring therapy-based

improvements in attention function of children with ASD by using a standardized test battery.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 24700573.

References

1. Geretsegger M, Elefant C, Mössler KA, Gold C. (2014). Music therapy for people with autism spectrum disorder. *Cochrane Database of Systematic Reviews*, 6. Art. No.: CD004381. DOI: 10.1002/14651858.CD004381.pub3
2. National Research Council. (2001). *Educating children with autism*. Washington, DC: The National Academies Press.
3. American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (revised 5th ed.)*. Arlington: American Psychiatric Publishing.
4. Kamio Y. (2010). Autism spectrum disorder and developmental cognitive neuroscience. In: Iwata M, Kawamura M. (eds) *Development and the brain*. Tokyo: Igakushoin. (in Japanese)
5. Goldstein G, Johnson CR, Minshew NJ. (2001). Attentional processes in autism. *J Autism Dev Disord*, 31(4), 433-440.
6. Janzen TB, Thaut MH. (2018). Rethinking the role of music in the neurodevelopment of autism spectrum disorder. *Music & Science*, 1, 1-18.
7. Mutreja R, Craig C, O'Boyle MW. (2016). Attentional network deficits in children with autism spectrum disorder. *Dev Neurorehab*, 19(6), 389-397.
8. Funabiki Y, Murai T, Toichi M. (2012). Cortical activation during attention to sound in autism spectrum disorders. *Res Dev Disabil*, 33(2), 518-524.
9. Landry R, Bryson SE. (2004). Impaired disengagement of attention in young children with autism. *J Child Psychol Psychiatry*, 45(6), 1115-1122.
10. Rinehart NJ, Bradshaw JL, Moss SA, Brereton AV, Tonge BJ. (2001). A deficit in shifting attention present in high-functioning autism but not asperger's disorder. *Autism*, 5(1), 67-80.
11. Cornish K, Wilding JM. (2010). *Attention, genes, and developmental disorders*. Oxford, UK: Oxford University Press.
12. Mayes SD, Calhoun SL. (2007). Learning, attention, writing, and processing speed in typical children and children with ADHD, autism, anxiety, depression, and oppositional-defiant disorder. *Child Neuropsychol*, 13(6), 469-493.
13. Thaut MH, Gardiner (2014). Musical attention control training. In: Thaut MH, Hoemberg V. (eds). *Handbook of Neurologic Music Therapy*. Oxford, UK: Oxford University Press.
14. Sengoku, Y. (2010). From a presenter's viewpoint: development of attention function assessment tool for children with developmental disabilities. (WFOT Conference Report). *Occup Ther J*, 44(11), 1157-1159. (in Japanese)
15. Kerns KA, Macoun S, MacSween J, Pei J, Hutchison M. (2017). Attention and working memory training: A feasibility study in children with neurodevelopmental disorders. *Appl Neuropsychol Child*, 6(2), 120-137.
16. Matson JL, Worley JA, Neal D, Mahan S, Fodstad JC. (2010). The effects of inattention/impulsivity and asd symptom severity on social skills in toddlers. *Dev Neurorehab*, 13(6), 408-412.
17. Kasuya-Ueba Y. (2018). The influence of music on attention function of children. *Kurashiki Sakuyo University Research Bulletin*, 51(1), 51-56.
18. Kim J, Wigram T, Gold C. (2008). The effects of improvisational music therapy on joint attention behaviors in autistic children: A randomized controlled study. *J Autism Dev Disord*, 38(9), 1758-1766.

19. Lee L, (2006). Music therapy enhances attention span and promotes language ability in young special needs children. Commission Seminar in Kuala Lumpur Malaysia, and the Special Session at the 27th ISME World Conference Kuala Lumpur Malaysia.
20. Pasiali V, LaGasse AB, Penn SL. (2014). The effect of musical attention control training (mact) on attention skills of adolescents with neurodevelopmental delays: A pilot study. *J Music Ther*, 51(4), 333-354.
21. Pantev C, Lappe C, Herholz SC, Trainor L. (2009). Auditory-somatosensory integration and cortical plasticity in musical training. *Ann N Y Acad Sci*, 1169, 143-150.
22. Roden I, Könen T, Bongard S, Frankenberg E, Friedrich EK, Kreutz G. (2014). Effects of music training on attention, processing speed and cognitive music abilities-findings from a longitudinal study. *Applied Cognitive Psychol*, 28(4), 545-557.

Table 1. The Music Therapy Activities Analyzed and Their Attentional Requirements

Types of the Activity	Detailed Description of the Activity	Tasks for the Participants	Therapeutic Techniques Used to Enhance Appropriate Responses	Attentional Requirements to the Participants
Greeting song	Th and PtcS first sing a simple, original greeting song to the guitar at the start. Th changes the directions, such as clapping hands, stomping feet, and patting knees, in each verse, and encouraging PtcS to say or sing "hello" with the strong beats of the guitar. Lyrics: "Let's clap your hands, Let's clap your hands, Let's start music time clapping hands, hello, hello."	<ul style="list-style-type: none"> Respond to the one-step directions with movements. Say or sing "hello" to the guitar beats while moving. 	<ul style="list-style-type: none"> Matching music with the mood and arousal level of the PtcS, and then gradually altering the volume, rhythm, and tempo of the music to reach the desired state. Verbally, visually (when modeling is needed), and musically encouraging the PtcS to move to the music with appropriate movements. Use ritardando and gradually increasing the volume (both singing and playing) just before the "hello" to cue the PtcS, while visually opening the mouth to say hello. When there was no response from the PtcS or no attention to the activity, flexibly change lyrics and/or insert extra bars to prompt musical, verbal, and/or visual cues without stopping the music to enhance appropriate responses and regain the PtcS attention. 	<ul style="list-style-type: none"> SeIA to selectively attend to Th, visually and aurally, in the environment; visually filter out objects around the room and aurally the noises from the next room. SusA to maintain the focus of auditory attention on Th's singing and/or music, and to follow the directions with movements and to sing "hello" at appropriate times. AC to shift auditory attention back and forth rapidly between Th's singing, to follow directions with movements, and the guitar beats to clap or stomp to. AC to shift visual attention between their own movements and saying/singing "hello" with visual and musical cues from the Th. AC to shift auditory attention between Th's singing melody, the rhythm and harmony on the guitar in order to sing the melody in time.
Instrumental Playing	Th and PtcS sing a familiar children's song for the activity along with lyrics on the sheet displayed on the whiteboard in the front of the group, following Th tracing with a finger. The lyrics are colored red, blue, and black showing when 2	<ul style="list-style-type: none"> Sing along while the Th traces lyrics on the sheet. Play 2 tone chimes, one in each hand, together. Distinguish 3 colors on the sheet and play only when 	<ul style="list-style-type: none"> Use strong rhythmic foundations to encourage playing on the beats, and enhance playing together with a peer in the same group. Use step-by-step procedures for successful participation, making sure if they understand at each step Give visual cues (hand signal and 	<ul style="list-style-type: none"> SeIA to selectively attend to Th, visually and aurally, in the environment; visually filter out objects around the room and aurally the noises from the next room. SusA to keep eye tracking on the sheet. AC to hold the rules in working

<p>different cords should be played. Then, each Ptc is handed a Suzuki tone chime and plays it to hear how different sounds each makes. Ptc takes one more chime and holds 2 chimes in hands. Th divides 4 Ptc into 2 groups, a red group and a blue group, with a space between groups. Th encourages each group to shake and ring both chimes together while following Th's visual cues. Th traces the lyrics colored red or blue on the sheet with one hand, and provides hand signals to show which group should play. The Ptc play chimes when cued (each cord lasts about 3 or 4 bars). In the middle part of the song, colored black on the sheet, Ptc stop playing, and one of the Ptc comes up and plays 3 kinds of instruments (triangle, tree chime, and bells) freely, while others sing. Each Ptc takes a turn for free improvisational solo playing. Then, Ptc play chimes and sing at the same time to the guitar at</p>	<p>appropriate.</p> <ul style="list-style-type: none"> • Wait for playing when the other group is playing but sing whole song • Recognize the rules of when to play, when to stop, and the structure of the song (includes group parts and a solo part) • Taking a turn to come up to front and play instruments freely as a solo. 	<p>eye contact) accompanied by tracing lyrics when needed.</p> <ul style="list-style-type: none"> • Pause for a moment, making eye contact when the color on the sheet changes, to enhance attention and awareness of the Ptc. • Give stronger beats when Ptc shake chimes, to clearly show the timing and encourage the Ptc to play simultaneously. • Provide clear hand signals a moment ahead so that Ptc can prepare to shake the chimes. • Reduce the tempo, take big pauses, and visually and/or verbally give short and clear directions when Ptc are not responding well or seem to be confused during the song. 	<p>memory, such as when to play and stop chimes.</p> <ul style="list-style-type: none"> • AC to stop playing when the Th's hand signals say stop, while still singing. • AC to shift attention between Th's singing to sing along and eye tracking on the sheet, between their hand movement and the sheet at the beginning, lyrics to sing and colors to play or stop, and possibly between Th's hand signals or eye contacting and the sheet. • AC to switch attention to the peer who is taking a solo in the middle of the song and his playing while singing to Th's singing and playing. • AC for the peer taking a solo, to switch attention between free playing in front of others and listening to music that tells him when to stop and go back to his seat. • AC for the peer taking a solo, to switch attention among three kinds of instruments to play • AC to switch attention among Th and the sheet when playing, the peer, and his playing throughout the activity
---	---	--	---

<p>last verse without hand cues but cues from eye contact.</p>	<ul style="list-style-type: none"> • Follow the directions on how to move and which instrument to play. • Move to the beat of the music while not bumping into or pass the person walking in front • Move and play while listening to the music, while listening to cues of when to start and stop. • Choose the appropriate instrument from others. • Make a decision for the next movement when asked. 	<ul style="list-style-type: none"> • Use strong rhythmic foundations to encourage stepping on beats when moving around the circle. • Present the music clearly to encourage recognition of start and stop cues. • Use humor, such as feinting to pause in the middle of the song or not stopping where the music likely stops or go next part of instrumental playing, which provide unpredictability in the predictable song structure. • Present exaggerated music with the guitar and exaggerated modeling to facilitate appropriate movements that match the beats. • Give an opportunity to Ptc to decide a next movement for taking the initiative • Use the music flexibly or pause when waiting for appropriate responses from the Ptc. 	<ul style="list-style-type: none"> • SeIA to selectively attend to Th, visually and aurally, in the environment; visually filter out objects around the room and aurally the noises from the next room. • SusA to maintain attention on the music that unpredictably pauses to cue stopping and starting movements, according to Th's direction, to decide which instrument to pick up in the song, and to keep playing until the music stops. • AC to pay attention to the person walking in front, not to bump into or pass the person, and to simultaneously move to the tempo and rhythm in the music . • AC to hold the rules (to start, pause, stop, and play) in working memory, and shift attention between the music, Th's singing directions, one's own movements, peers, and instruments back and forth. • AC to exert control in inhibiting continuous motions following "go and stop" cues. • AC to operate instruments while listening to Th's singing directions of how to play and when to stop playing. • AC to shift the focus of attention
<p>Movement ("Go and Stop" plus Play)</p> <p>Ptc stand around the circle marked by a long color string in which musical instruments are placed randomly. Th holds the guitar using a strap. After introducing each instrument, everyone walks around the circle to the beat of the song, which is sung and played by Th. Keep walking until the music pauses and stops, then Th gives a direction to find an instrument in the circle and play it in the song. Ptc play to the music until the music stops. This is repeated with various movements, and other instruments placed in the circle, while changing tempo, volume, and rhythm along with different movements. In other repetitions, Th gives an opportunity to each Ptc to decide the next movement in turn. When instruments should be played, additional directions, such as "Play it loudly (slowly, high in the air)," are added to the song as variations.</p>			

	<p>between Th and the peer when he decided and announced the next movement</p>
<p>Good-bye Song</p> <p>Th and PtcS sing a simple, original good-bye song to the guitar during the last minutes of the session. In the song, Th sings each Ptc's name randomly and asks the Ptc to respond by saying "good-bye," while pausing the guitar music and repeating the song a few times.</p> <p><i>Lyrics:</i> "Good bye everyone, bye bye (bye bye) Good bye everyone, bye bye (bye bye) I will see you again, bye bye bye" or "Good bye Good bye to Edward (bye bye) Good bye Good bye to Michael (bye bye) ..."</p>	<ul style="list-style-type: none"> • Sing along. • Say or sing "bye-bye" to Th when called, and say bye to the peer whose name was called. <ul style="list-style-type: none"> • Verbally, visually, and musically encourage PtcS to sing along with Th. • Encourage verbal responses on the third and first beats, which are the place of "bye-bye" in () of the lyrics, with pausing music just after calling a Ptc's name. <ul style="list-style-type: none"> • SeIA to selectively attend to Th, visually and aurally, in the environment; visually filter out objects around the room and aurally the noises from the next room. • SusA to maintain the focus of attention on the Th and Th's singing (visually), and the guitar (aurally), in order to sing along despite multiple distractions, • SusA (vigilance) when waiting to be called on by the Th. • AC to hold the rules to when to start or pause singing in working memory, such as when the Th calls someone's name randomly and the Ptc responds to it. • AC to shift auditory and visual attention between Th and the Ptc named in the song
<p>Abbreviations: Th – therapist; Ptc(s) – participant(s); SusA – sustained attention; SeIA – selective attention; AC – attention control</p>	