EXPLORING THE NEUROLOGICAL IMPLICATIONS OF CLASSICAL MUSIC PEDAGOGY TRAINING FOR CHILDREN WITH AUTISM SPECTRUM DISORDER: THE ROLE OF MUSIC IN MEDICINE

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ABSTRACT

Music is the medicine of the mind [1]. Extensive research has explored the impacts of music training, through investigati on across diverse musical domains and their neuro-focused aspects [2]. Knowledge of the direct imp lications of music education on cognitive development continues to evolve , with ongoing research demonstrating its positive effects on neuroplasticity. According to the Canadian Health Survey on Children and Youth, in 2019, 1 in 50 Canadian children aged 1-17 were diagnosed with Autism Spectr um Disorder (ASD). This paper d elves into the neurological implications of Classical Music Pedagogy Training (CMPT) on children with ASD. Multiple studies reviewing the impacts of classical music, comparing the implications of musical training on typical development and ASD, highlight the benefits of CMPT for sensory processing, motor skills, and communication aptitudes in children with ASD . The paper further highlights the need for standardized terminology within this realm of research, and longitudinal studies examining the long-term impacts of CMPT on children with ASD.

INTRODUCTION

"Music Pedagogy" training is the study and practice of learning and teaching music [3]. More specifically, music pedagogy refers to the learnt ability, experiences, and knowledge that deepens understanding of an area of music [4]. In the context of this review, CMPT, a branch of music pedagogy, is explored to better understand the particular purpose and implications of CMPT as an intervention for child-related development. CMPT refers to the specific approach to music pedagogy and overall teaching. Particularly, classical music training is the approach to teachings, exemplifying learning music through the traditional skills and methods of that subject [5]. For the purpose of this paper, CMPT will be explored, through examining the neurological implications of such training as an intervention for children with Autism Spectrum Disorder (ASD).

ASD is defined as a neurodevelopmental disorder, frequently impacting a child's communication skills and social interactions [6]. ASD may present as differences in developmental domains, such as engaging in repetitive behaviours (e.g., stimming) or intense focus on specific interests, as well as challenges in social interactions [6]. The National professional development Center on Autism Spectrum Disorders (NPDC) conducted a comprehensive systematic review which was an extension of previous evidence-based practice review with the goal of outlining social communication interventions for children with ASD. Antecedent-based intervention, cognitive-behavioural intervention, naturalistic intervention, visual supports, video modelling, and more [7].

Nonetheless, the power of classical pedagogy training as an intervention, which applies several of NPDC's recommended social communication interventions, was not explored within that review [7]. This paper recognizes the importance of the work that exists pertaining to the role of music in medicine, and the potential neurological benefits of CMPT for children with ASD.

METHODOLOGY

A literature search was conducted utilizing terms broadly encompassing 'music education', 'autism spectrum disorder', 'communication', and 'neural processing.' A wide range of databases were consulted, including OVID Medline, Web of Science, and PubMed. Given the nature of the research landscape, several journals were used. In

particular, the Journal of Cognitive Neuroscience, Journal of Neuroscience, and the Suzuki Associations of the Americas.

RESULTS

Social Communication and Autism Spectrum Disorder

When supporting an individual with ASD, effective communication strategies and interventions play a critical role, improving the child's overall quality of life. In terms of social communication related to ASD, research has emphasized the importance of early interventions.

A study revealed the importance of early intervention and detection of ASD. The study conducted a controlled trial examining 48 children diagnosed with ASD between 18-30 months old. The participants were further separated into two groups, one having the Early Start Denver Model (ESDM) intervention over two years, delivered by trained therapists and parents. The ESDM is an intervention that focuses particularly on early intervention for children with ASD, incorporating communication methods as a critical component of the intervention [8]. On the contrary, group two was referred to community providers for interventions that are commonly accessible within the community. Expanding on prior research, the study emphasized the efficacy of comprehensive developmental interventions for toddlers with ASD for its cognitive benefits [8].

Building upon existing knowledge, research continues to examine the longitudinal impacts of communication-based interventions targeted towards children with ASD. For instance, *Joint Attention, Symbolic Play, engagement, and Regulation (JASPER),* a naturalistic developmental behavioural intervention, which targets and analyses the impacts of joint engagement on a child's intimations of joint attention (IJA) skills, further examining whether here are associations between IJA skills and expressive language [9]. A few examples of IJA include pointing, showing, gaze following, coordinating attention, bringing objects to share, or commenting with gestures or vocalizations. Therefore, uncovering pathways that are important for social communication, and particularly expressive language display [9].

Rationale for CMPT as an Intervention in the Current Study

Studies show compelling evidence for the cognitive impacts of music pedagogy, through uncovering emotional and neurological benefits, however, there continues to be gaps between music teaching journals and neuroscience-based research. This paper aims to investigate the connections between literature within music education journals and the neuroscientific dimensions within the research landscape. Further seeking to bridge existing disparities within the context of ASD and music education. "Children with ASD are motivated to engage in music activities, and it can be a preferred medium to operate within. They thrive within structure and music fulfils this need for structure and routine [10]."

Of particular significance is a study published by the Journal of Cognitive Neuroscience, uncovering pitch sensitivity in individuals with autism. The paper expanded on past research which revealed the heightened strengths of participants with high-functioning autism, specifically, their ability to memorize picture-pitch associations, and recognize subtle pitch fluctuations. The paper revealed the ways in which individuals with ASD had increased pitch discrimination abilities. This investigation elucidated the findings of individuals with ASD outperforming typically developing populations in various low-level perceptual tasks [11].

The compelling evidence for the inherent cognitive and neurologic skills related to musical processing in individuals with ASD, coupled with early childhood classical music pedagogy, reveals the potential capabilities yet to be uncovered.

Neurological Power of CMPT for Typical Development

To truly cover the breadth of the neurological powers of classical music training for typical development, this section will discuss sensory processing and auditory-motor connectivity; communication, social skills, and emotional regulation; and fine motor skills, coordination, and executive functioning.

Sensory Processing and Auditory-Motor Connectivity

The Journal of Neuroscience (JNeurosci) examined the plasticity of the brain, as a result of 15 months of instrumental music pedagogy training in early childhood [12]. There were strong correlations surrounding structural brain changes in auditory and motor areas, with behavioural improvements on motor and auditory-musical tests. This paper was one of the first longitudinal studies to discover the brains structures at play in neuroplasticity, resulting in brain developments over time [12]. The study uncovered that a child who played and practiced a musical instrument, displayed stronger improvements related to motor skills. Which was measured through examining auditory-motor connectivity through finger dexterity and in auditory melodic and rhythmic discrimination skills [12].

The correlation between auditory-motor connections within the brain is critical to explore. The brain-behaviour correlations exist in motor and auditory brain regions for performance on motor and auditory tests [12].

When playing a musical instrument, through music pedagogy teachings, the primary motor area plays a critical role the execution and control of bimanual sequential finger movements and motor learning in general [12].

In terms of sensory processing, CMPT has incredibly structured and organized auditory patterns. Studies that compare non-musicians and musicians identify four areas in which music-training neuroplasticity determines: number of years of continuous training, age of training onset, amount of practice, and aptitude. Neuroscience research published by *Perspectives* J ournal expands on this evidence of neuroscience research showing the possibilities of music training leading to changes in the auditory system [13]. For example, the neural representation of timing and harmonic features of speech signals the presence of background noise is stronger in musicians than non-musicians. Therefore, the evidence suggests that musicians possess enhanced cognitive and sensory abilities that improve their ability to process speech in challenging listening environments, when comparing their listening abilities to non-musicians [13].

Communication, Social Skills, and Emotional Regulation

Forgeard et al. examines the implications of practicing a musical instrument in childhood found that the children outperformed the control group in verbal abilities, specifically vocabulary, and non-verbal reasoning [14]. The results were further strengthened as the study found that the duration of music training further predicted the outcome of the child's performance on the assessment measures; Raven's Advanced Progressive matrices and Vocabulary test [14].

Although not exclusive to classical music, Moreno et al. explored the impacts of music training on verbal intelligence, further strengthening communication abilities[15]. Moreover, the nature of music pedagogy training can have positive impacts on the child's overall emotion regulation. For example, music pedagogy training often incorporates structured activities such as rhythm exercises or expressive musical play, which can help children develop emotional self-regulation by providing a safe space to express emotions, learn impulse control, and practice various coping strategies [15]. Through examining the psychological inquiry of musical behaviour the study revealed music's powerful ability to foster emotional self-regulation through engaging children in structured yet expressive activities [16,17] .

Fine Motor Skills, Coordination, and Executive Functioning

CMPT pertaining to instrument learning, has the profound ability of strengthening fine motor skills. A study by Costa-Giomi, who conducted a longitudinal investigation, discovered that children who received two years of piano pedagogy training, improved greatly in terms of their motor proficiency test [14].

The results of the study from Journal PLOS, revealed that children who received instrumental music pedagogy training for three or more years outperformed non-musically trained participants (control) [14]. Specifically, they outperformed their counterparts in facets related to fine motor skills, in both hands, as well as decreased ability to discriminate between melodies. The assessment was conducted through the Gordon's IMMA and the Melodic Discrimination Task [14].

Neurological Power of CMPT for children with ASD

There has been growing interest surrounding the exploration of neurological implications of CMPT as an intervention for children with ASD. This section aims to synthesize existing literature that explores the neurological power of classical music training, specifically for children with ASD. As mentioned, classical music training due to its structure, pattern and composition, has profound neurological purposes for typical development. By examining the neuroscientific evidence behind classical music pedagogy, this section seeks to understand the potential neurological implications that may arise when children with ASD undergo CMPT.

Sensory Processing and Auditory-Motor Connectivity

Through examining the research in the JSTOR digital library, various studies were uncovered, which discussed the improved sensory processing and auditory-motor connectivity for children with ASD, who are musically trained. Specifically, a study by Thaut examined the structured auditory patterns in classical music. Further identifying that the specific arrangement of harmonies, and rhythms in classical compositions provide a consistent pattern. That pattern is also predictable, in many ways. The structure is incredibly beneficial for children with ASD, as they can experience challenges in processing complex auditory stimuli [18]. As well, the paper delves into the benefits of the structured auditory pattern in supporting an individual with ASD in identifying and interpreting sensory information with a higher degree of effectiveness [18].

The passive listening techniques such as Auditory Integration Therapy (AIT) have been highly used to address behavioural difficulties and auditory hypersensitivity in children with ASD [18]. Moreover, children with ASD may have difficulties modulating sensory inputs which can as a result manifest as enhanced perception of auditory and visual stimuli. Nonetheless, Sensory Integration therapy through music has abilities to strengthen auditory-motor abilities [19].

Communication, Social Skills, and Emotional Regulation

Building communication abilities is a crucial aspect of interventions for children with ASD. The study by Hayoung A Lim., separated children with ASD into three distinct groups. The various groups underwent music training, speech training and non-training. The results revealed that participants in music and speech training experienced a significant increase in their verbal production, when comparing the pre to posttest results [20]. Further identifying that children with ASD understand important linguistic information that is incorporated in music stimuli organized in patterns of perception, and further result in functional speech production [20].

In terms of communication, research has uncovered the abilities of music-based interventions to address core ASD related impairments in joint attention, social reciprocity and nonverbal and verbal communication. Furthermore, children with ASD can experience difficulties related to direct social engagement, therefore music related interventions provide a socially embedded group music activity, providing opportunities to make room for comfortable social interactions [19].

Fine Motor Skills, Coordination, and Executive Functioning

In terms of fine motor skills, it is suggested that children with ASD experience impairments in gross motor skills, including bilateral motor coordination, balance, and gait, as well as fine motor delays [19,21]. Musical activities embedded within pedagogy are typically used to address such difficulties, and have been found to build significant progress in the child.

Furthermore, 4-6 years old who experienced 2-month music and movement programs displayed improvements in their gross motor skills [22]. Specifically, displayed through jumping and dynamic balance, measured through Motor proficiency test comparing children who engaged in non-musical programs [22]. Another study revealed that children between the ages of 4-6 years old who received a 10-week Dalcroze-based musical integration program, coupled with a physical education program, outperformed children who solely received a general movement exploration program [23].

DISCUSSION

Decades of research on the neurological impacts of music have demonstrated its profound influence on cognitive, emotional, physical, and social development [24]. CMPT experiences have been shown to enhance neuroplasticity, facilitate communication, and support sensory process, which are key areas of development for children with ASD. However, despite these promising findings, significant gaps remain in the literature regarding the standardization of methodologies used to assess CMPT interventions for children with ASD. This has contributed to a fragmented research landscape, where inconsistencies in terminology, methodologies, and evaluation frameworks hinder progress.

One of the primary challenges in this field is the lack of a universally accepted framework for assessing the effects of CMPT on specific developmental outcomes within ASD. Neuroscientific and music education research often employs different vocabularies and methodologies, making cross-disciplinary collaboration difficult. Meta-analyses rely heavily on standardized terminology to ensure consistency in interpreting findings, yet there remains no consensus on how to define and measure the effectiveness of CMPT. Establishing a shared language is essential for advancing research, facilitating interdisciplinary collaboration, and ensuring that findings can be accurately compared and applied in real-world settings.

The heterogeneity of ASD further underscores the need for personalized approaches to CMPT. ASD manifests in highly diverse ways, meaning that a pedagogical technique effective for one child may not yield the same results for another. This variability introduces biases in participant pools and complicates the generalizations of findings. Additionally, barriers such as financial constraints, limited access to music education, and varying levels of parental or guardian support contribute to disparities in CMPT accessibility [25,26]. Future research should address these barriers to ensure that all children with ASD have the opportunity to benefit from CMPT, if they wish.

Barrett et al. (2022) conducted an exploratory study examining early childhood educators' beliefs about music education, emphasizing its perceived value as a creative and inclusive tool for fostering social and emotional development [27]. While music is widely acknowledged for its positive impact, the specific mechanisms by which CMPT influences neurological and behavioral outcomes in children with ASD remain insufficiently explored. Existing research lacks a comprehensive analysis of the key characteristics of classical music pedagogy—such as melody, tempo, dynamics, and intonation—that contribute most significantly to positive developmental outcomes. Identifying these critical factors is essential for refining instructional strategies and optimizing the effectiveness of CMPT interventions for children with ASD.

Furthermore, much of the existing literature focuses on short-term benefits, with limited research examining the long-term effects of CMPT. Longitudinal studies are necessary to determine whether early CMPT engagement has lasting neurological and behavioral impacts in children with ASD. By addressing these gaps, through standardized methodologies, consensus on terminology, and long-term research, a more comprehensive understanding of CMPT's role in ASD interventions can

be established. Ultimately, this will allow for more effective implementation of music-based therapies, leveraging the power of classical music as a meaningful and accessible tool for cognitive and emotional development in children with ASD.

CONCLUSION

In the broader context, this research underscores the neurological benefits of music education , and the specific implications CMPT can have on child development domains . The role of music in medicine is complex and at times elusive , however, it is evident that there is a purpose for music within medicine. The intricate ways that music interacts with neural networks, furthe r cognitive development and carry an overall positive impact on the well-being of children with ASD. While the study outline s various gaps, limitations and controversies within the literature, there is undeniable potential for future developments within this area of research . There must be a commitment towards advancing knowledge in the nuances of music 's power on the neurodevelopment of children with ASD, to build a future where music and medicine can work hand-in-hand.

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