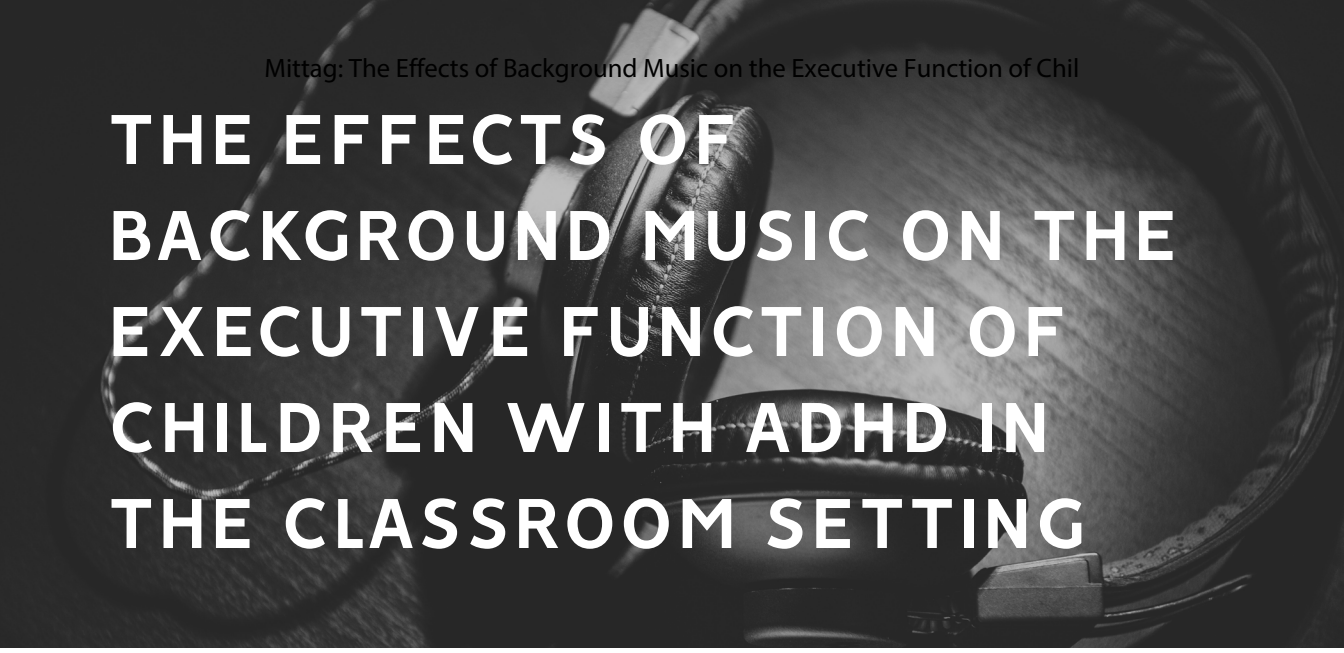
Occam's Razor

Volume 10 *(2020)* Article 4

2020

The Effects of Background Music on the Executive Function of Children with ADHD in the Classroom Setting: A Study Proposal

Jennifer Mittag
Western Washington University, Jennifer.Mittag@wwu.edu



THE EFFECTS OF BACKGROUND MUSIC ON THE EXECUTIVE FUNCTION OF CHILDREN WITH ADHD IN THE CLASSROOM SETTING

A Study Proposal

By Jennifer Mittag

ABSTRACT

The purpose of the proposed study is to determine how children diagnosed with ***Attention-Deficit/Hyperactivity Disorder*** *(ADHD) and* ***neurotypical*** *children will perform on executive function tasks while listening and not listening to music in a classroom setting. Prior research suggests that the presence of background noise improves the executive function performance of children with ADHD during specific memory tasks. In this study, fifty children diagnosed with ADHD and fifty neurotypical children from Bellingham, Washington will take the* ***Working Memory*** *Test Battery for Children (Pickering, 2006), either with or without classical music playing in the background. Scores will be calculated, and an inferential statistical test will be run to identify any statistical significance between the mean scores of the two populations (ADHD vs. neurotypical), the two situations (music vs. no music), and the four different conditions (A, B, C, D). It is hypothesized that low-level music will produce improvements in the executive function of children with ADHD, allowing them to outperform neurotypical children under the same conditions. However, in the absence of music, it is predicted that neurotypical children will perform better on the tests than children with ADHD. Limitations of this research include potential inconsistency or bias in the clinical diagnoses of ADHD and the removal of* ***comorbidities*** *from the scope of the study.*

INTRODUCTION

Numerous studies correlate the diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) with impaired executive function (EF) in children, resulting in lower cognitive achievement test scores, lower academic scores, and higher likelihood of developing a **Learning Disability** (LD) (Mattison & Mayes, 2010; Biederman et al., 2004; Schoemaker et al., 2011). Executive function refers to a set of interrelated cognitive processes, such as working memory, **attentional control**, and **response inhibition,** that enable the control of specific, goal-oriented behaviors (Huizinga et al., 2006). While primary cognitive development occurs throughout childhood and in the transition to

young adulthood, EF remains changeable over a person's lifespan and subject to the influence of adverse or advantageous life events and routines (Harvard University, n.d.). In everyday situations, EF can be affected by environmental factors including background noise, the presence of other people, a natural or urban setting (Schutte et al., 2016), or the mode of learning utilized in a school classroom (Diamond & Lee, 2011). Increasing diagnosis rates, study, and knowledge of ADHD in children—including the identification of issues with executive functions like working memory (Martinussen et al, 2005) and response inhibition (Bunford et al., 2014) —have expanded interest in research aimed at developing methods to aid **neurodivergent** students in neurotypically-privileged academic settings. Following the **social model of disability,** implementing situational or environmental mechanisms to increase attentive tendencies in the classroom setting would improve the accessibility of learning for children with ADHD while also benefiting their overall wellbeing.

While the general link between ADHD and impaired EF in children remains well-supported by evidence, prior research on ADHD and working memory in the classroom setting have been broad in scope and inconsistent in the specificity of findings; many studies are conducted as comorbid studies with a variety of diagnoses and age groups and investigate a generalized range of EF-related skills simultaneously. For example, the Bunford et al. (2014) study on the relationship between ADHD and EF in preschool-aged children suggests that inhibition and working memory are related and "contribute to hyperactivity/impulsivity and inattention." However, this conclusion is contested by Elosúa et al. (2017), a study examining working memory in fourth graders diagnosed and undiagnosed with ADHD. While the latter study confirms that such students struggle with tasks like attentional shifting, updating functions,

ATTENTION DEFICIT/ HYPERACTIVITY DISORDER:

One of the most common mental disorders affecting children. Symptoms of ADHD include inattention (not being able to keep focus), hyperactivity (excess movement that is not fitting to the setting) and impulsivity (hasty acts that occur in the moment without thought). ADHD is diagnosed as one of three types: inattentive type, hyperactive/ impulsive type, or combined type.

NEUROTYPICAL:

The opposite of neurodivergent, having a style of neurocognitive functioning that falls within the dominant societal standards of "normal." The setup of the school system, such as teaching styles and test-taking regulations, privilege the cognitive functions of neurotypical students.

WORKING MEMORY:

Governs our ability to retain and manipulate information over short periods of time.

COMORBIDITIES:

The simultaneous presence of two chronic diseases or conditions in a patient.

LEARNING DISABILITY:

Sometimes abbreviated as LD, can be defined as "a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations" (Martin et al., 2017). LD are not defined by one feature; they vary depending on the study and can affect up to 80% of children with ADHD (Mattison & Mayes, 2010). LD can stem from the lack of EF in children, specifically effecting their inhibition and working memory.

ATTENTIONAL CONTROL:

Involves the ability to direct attention to only those stimuli that are relevant to our current goals.

RESPONSE INHIBITION:

Refers to the suppression or inhibition of actions that are inappropriate in a given context and that interfere with goal-driven behavior.

and inhibition, its results indicate that children with ADHD performed better in the divided attention task than children without an **ADHD diagnosis**. Dividing the children's attention with additional stimulation appears to help them focus on the task at hand. Additional research on divided attention has similarly found that low-level background noise can benefit children with ADHD by improving their EF performance with specific memory tasks (Söderlund et al., 2010). While background noise may distract neurotypically attentive children, it increases dopamine levels in inattentive children, improving their cognitive functions and ability to pay attention (Söderlund et al., 2010). In a follow-up study, Söderlund et al. also observed that the presence of traffic noise improved memory tasks in children with attention difficulties. While such studies have examined the role of various background noises, very few have considered the effects of background music on EF, even though evidence suggests music therapy helps regulate emotions, mood, and behavior (Fernández-Sotos et al., 2016; Uhlig et al., 2016). When listening to music, the **amygdala** registers the sensory input, processing tempo, rhythm, and notes to determine the emotional response and stimulate behavior accordingly (Fernández-Sotos et al., 2016; Uhlig et al., 2016). In the existing research on the topic, participants with ADHD who listened to music while completing mathematical problems solved more problems correctly when compared to the neurotypical control group not listening to music (Maloy & Peterson, 2014; Greenop & Kann, 2007; Zentall, 1993).

Building on such research, this paper proposes a study to examine the effects of playing low-level classical music on the working memory of children diagnosed with ADHD and neurotypical children while they perform divided attention tasks in a classroom setting. I hypothesize that, when listening to low-level instrumental music, children diagnosed with ADHD will present improvement in working memory due to the background noise creating divided attention. Based on previous research, the added stimulation of music should increase the attention of children with ADHD, allowing them to better engage working memory tasks than neurotypical children under the same conditions. Concurrently, in the absence of music, the neurotypical children will perform better on the working memory tasks than children with ADHD.

ADHD DIAGNOSIS:

As knowledge of ADHD becomes more common and detailed, it is more likely to be recognized and diagnosed, increasing the overall rate of diagnosis in the population (Kumar & Gleason, 2019).

NEURODIVERGENT:

Sometimes abbreviated as ND, means having a brain that functions in ways that diverge significantly from the dominant societal standards of "normal."

SOCIAL MODEL OF DISABILITY:

A civil rights approach, the social model of disability proposes that what makes someone "disabled" is not their medical condition, but the attitudes and structures of society. If modern life was set up in a way that was accessible for people with disabilities, then they would not be excluded or restricted. The distinction is made between "impairments," which are the individual problems which may prevent people from doing something, and "disability," which is the additional disadvantage bestowed by a society which treats these "impairments" as abnormal.

AMYGDALA

An almond-shaped cluster of nuclei located within the temporal lobes of the brain. Part of the limbic system, it is known to perform a primary role in the processing of memory, decision-making, and emotional responses (including fear, anxiety, and aggression).

Published by Western CEDAR, 2020

METHOD

PARTICIPANTS

Children diagnosed with ADHD (n = 50) and neurotypical children not diagnosed with ADHD or any other neurodivergent condition (n =50) will participate in this study. The participants will be recruited from five local elementary schools in Bellingham, Washington. Each child will be in the third grade, between the ages of 8 and 9 years old, and will have signed parental consent to allow their participation. Children in the ADHD group will have clinical proof of diagnosis, no diagnoses of other neurodivergent condition, and be on medication for ADHD.

DESIGN

The **between-subjects** design will be a 2 (Population: ADHD and Neurotypical Children) x2 (Music: Instrumental or No music) design. Twenty-five children will be randomly assigned to each condition. During each condition, the children will complete the Working Memory Test Battery for Children (WMTB-C; Pickering, 2006) either with or without music. The study will use four conditions: Children with ADHD listening to music while completing a task (A), children with ADHD not listening to music while completing a task (B), neurotypical children listening to music while completing a task (C), and neurotypical children not listening to music while completing a task (D). An IBM statistical software program (SPSS) will run an algorithm to randomize each group.

RESULTS INDICATE THAT CHILDREN WITH ADHD PERFORMED BETTER IN THE DIVIDED ATTENTION TASK THAN CHILDREN WITHOUT AN ADHD DIAGNOSIS.

BETWEEN-SUBJECTS:

Participants that are participating in one and only one group of the study.

PHONOLOGICAL LOOP:

A part of the working memory that focuses on auditory and verbal information such as language and music.

VISUO-SPATIAL:

Part of the working memory that focuses on visual and spatial information.

MATERIALS

Classroom and Speaker Setup. The experiment will be set up in a classroom that remains consistent for all four conditions: There will be a set number of empty school desks in rows and a large table with two chairs (for the researcher and participant) at the front of the room. The curtains on all windows will remain open. The walls will have simple, non-distracting decorations. Four small speakers will be connected to an iPod and placed in the corners of the room.

Music. The researchers will play downloaded instrumental music from the iPod while the participants perform the WMTB-C. The music will play on loop and at the sound level of 80 dB, matching previous studies with responses to working memory (Belleville et al., 2003; Söderlund et al., 2010). The playlist will be a combination of songs by Mozart and Beethoven: Piano Concerto No. 23 (Mozart), Fur Elise (Beethoven), Salzburg Symphony No. 1 – Divertimento in D major (Mozart), Moonlight Sonata (I) (Beethoven), and Salzburg Symphony No. 3 Divertimento in major (Mozart).

Working Memory Tests. The Working Memory Test Battery for Children (Pickering, 2006) will be used to assess working memory in relation to the **phonological loop**, **visuo-spatial** sketchpad, and central executive functions within the children. The WMTB-C consists of six phonological tests, four visuo-spatial tests, and three central executive functions tests.

The phonological tests are Digit Recall, Word List Recall, Non-word List Recall, Word List Matching, and Children's Test of Non-word Repetition. The tests are span tasks, wherein the participant is asked to repeat the words of the researcher in the same order that they were spoken (Geary et al., 2013).

The visuo-spatial tests are Matrices Static, Matrices Dynamic, Mazes Static, and Mazes Dynamic. The tests include span and memory tasks. In the span tasks, Block Recall, which focus on Matrices Static and Matrices Dynamic, the researcher shows the participant a board with nine blocks on it, in a randomized order. The blocks are numbered but the numbers are only visible to the researcher. The researcher taps a single block and then a series of blocks and the child must correctly repeat the tapping. In the memory tasks, which focus on Mazes Static and Mazes Dynamic, mazes are given to the participants to solve; each maze will have more than one possible solution. After viewing a picture of one way to complete the maze for two seconds, the participant will be asked to recall the method and complete the maze as demonstrated. At different levels, the mazes become increasingly difficult by adding extra walls.

The central executive functions tests are Listening Recall, Counting Recall, and Backward Digit Recall (Pickering, 2006). Each dual-task subtest consists of six items (Geary et al., 2013). During Listening Recall, the child identifies whether a statement is true or false and recalls the last word in each sub-set. In the Counting Recall sub-set, the child recalls the numbers of dots on a set of cards. In the Backward Digit sub-set, the child recalls a span of numbers backward.

PROCEDURE

One set of child participants (Conditions A and B) will be referred to the study by their school counselors because they have an ADHD diagnosis confirmed by a letter from their pediatrician or primary care provider. The other set of child participants (Conditions C and D) will not have any diagnoses of neurodivergent conditions and are not taking any medication regularly. All participants will have signed parental consent in order to partake in the study. The researchers will randomly assign the participants to either a control or experimental group depending on whether they have an ADHD diagnoses or not. The participants will be tested individually in a room with a single researcher in the early morning hours, after breakfast but before lunch. The same researcher will administer the WMTB-C to each child in all four conditions. This researcher will conduct a double-blind test, in which they do not know which child participants do or do not have an ADHD diagnosis.

Children in Condition A and C will enter the room while the music is already playing. Children in conditions B and D will enter the room and no music will be playing. The researcher will sit across from the child at a table and administer the WMTB-C. They will give each sub-test in the same order for each group, starting with the six phonological tests (Digit Recall, Word Recall, Non-word Recall, Word List Matching, and Children's Test of Non-word Repetition), then the four visuo-spatial tests (Matrices Static, Matrices Dynamic, Mazes Static, and Mazes Dynamic) and end with the three central executive functions tests (Listening Recall, Counting Recall, and Backward Digit Recall). The researcher will first read the directions to each sub-test and then give the participant the task to complete. To eliminate the added stress of time restrictions, the children will be able to complete each task at their own pace. After the final sub-test, another researcher will escort the child back to their parents. As compensation, each

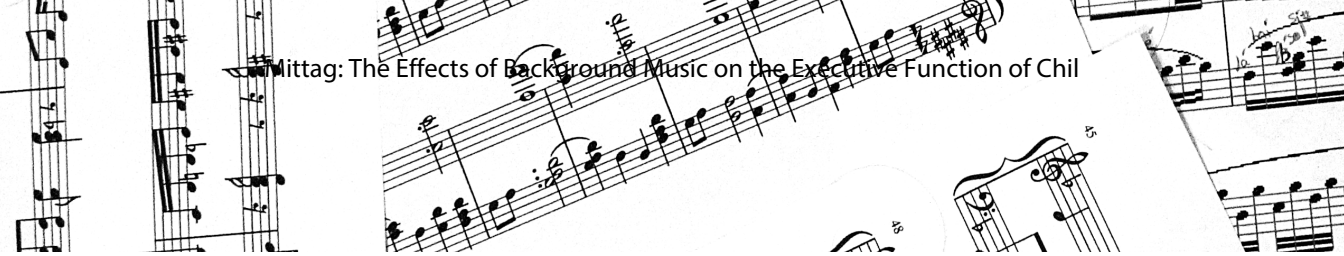
participant will receive a $10 gift card to a local ice cream parlor. Scores will be calculated, and an inferential statistical test will be run to identify any statistical significance between the mean scores of the two populations (ADHD vs. neurotypical), the two situations (music vs. no music), and the four different conditions (A, B, C, D).

PROPOSED BUDGET AND TIMELINE

The proposed timeline to complete this research is one year. This includes time for participant recruitment, the collection of parental consent and clinical documentation, testing, and final analysis. Previous research indicates that testing takes approximately one hour per participant. With two children testing per day over two weeks at each school, the testing procedure will take approximately ten weeks. The proposed budget for this study is $20,000, including items such as classroom rental, gift cards, and supplies.

LIMITATIONS AND FURTHER RESEARCH

Limitations of this study include its dependence on clinical diagnosis of ADHD, as studies suggest racial and gendered bias exists in the subjective interpretations of clinicians, causing them to inconsistently apply the ADHD diagnostic criteria in the Diagnostic and Statistical Manual of Mental Disorders (DSM) (Bruchmuller et al., 2012; Fadus et al., 2019). Fadus et al. (2019) indicates that unconscious bias and racial stereotypes of aggression result in statistically significant misdiagnoses of ADHD as disruptive behavior disorders in "ethnic and racial minority youth" and particularly boys (Fadus et al., 2019). In addition, men and boys are three times more likely to be diagnosed with ADHD than women and girls, with studies demonstrating bias and socialization as the primary explanatory factors (Bruchmuller et al., 2012). Inattentive ADHD, which is the most common subtype diagnosed in women and girls, primarily presents as "inattention and disorganization," behaviors that are more subtle and difficult to recognize than the "disruptiveness and impulsiveness" of the hyperactive subtype common in men and boys (Bruchmuller et al., 2012). Many therapists remain biased toward the masculine hyperactive stereotype of ADHD expression, likely adversely affecting rates of ADHD diagnoses in women and girls (Bruchmuller et al., 2012).



The current study does not account for comorbidities in children diagnosed with ADHD, such as oppositional defiant disorder (ODD), anxiety, depression, and behavioral conditions. Future research should examine the effects of background music on children who have comorbid disorders with ADHD. It would be beneficial to study how differences in reaction to low-level background music in children with only ADHD and children with ADHD and other disorders may impact scores on the working memory tasks.

The current study does not examine the benefits or disadvantages of more than one level of noise or of types of music other than classical. Most past research has focused primarily on the negative aspects of noise (Söderlund et al., 2010). Future research should consider the effects of differing music and music at different volume levels on children with ADHD, children with ADHD and other conditions, and neurotypical children.

SIGNIFICANCE OF PROPOSED RESEARCH

As ADHD and other forms of neurodivergence become increasingly recognized, researched, and diagnosed, it is necessary to develop environmental tools and methodology to help accommodate a range of **neurodiverse** learning needs and styles in the primary and secondary school system. This study intends to determine whether the auditory mechanism of classical background music aids the EF performance of students with ADHD diagnoses in working memory tasks. This research has the potential to reduce the stress placed on students with ADHD in the classroom environment and improve their likelihood of academic success.

IT IS NECESSARY TO DEVELOP ENVIRONMENTAL TOOLS AND METHODOLOGY TO HELP ACCOMMODATE A RANGE OF NEURODIVERSE LEARNING NEEDS AND STYLES.

WORKS CITED

Belleville, S., Rouleau, N., Van der Linden, M., & Collette, F. (2003). Effect of manipulation and irrelevant noise on working memory capacity of patients with Alzheimer's dementia. Neuropsychology, 17, 69-81.

Biederman, J., Monuteaux, M. C., Doyle, A. E., Seidman, L. J., Wilens, T. E., Ferrero, F., Morgan, C. L., Faraone, S. V. (2004). Impact of executive function deficits and attention-deficit/ hyperactivity disorder (ADHD) on academic outcomes in children. Journal of Consulting and Clinical Psychology, 72(5), 757-766. doi. org/10.1037/0022-006X.72.5.757

Bruchmuller, K., Margraf, J., & Schneider, S. (2012). Is ADHD diagnosed in accord with diagnostic criteria? Overdiagnosis and influence of client gender on diagnosis. Journal of Counseling and Clinical Psychology, 80(1), 128-138. doi: 10.1037/a0026582

Bunford, N., Brandt, N. E., Golden, C., Dykstra, J. B., Suhr, J. A., & Owens, J. S. (2014).

Attention-deficit/hyperactivity disorder symptoms mediate the association between deficits in executive functioning and social impairment in children. Journal of Abnormal Child Psychology, 43(1), 133–147. doi: 10.1007/s10802-014-9902-9

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. Science, 333(6045), 959–964. doi: 10.1126/science.1204529

Elosúa, M. R., Olmo, S. D., & Contreras, M. J. (2017). Differences in executive functioning in children with attention deficit and hyperactivity disorder (ADHD). Frontiers in Psychology, 8. doi: 10.3389/fpsyg.2017.00976

Fadus, M. C., Ginsburg, K. R., Sobowale, K., Haliday-Boykins, C. A., Bryant, B. E., Gray, K. M., & Squeglia, L. M. (2019). Unconscious bias and the diagnosis of disruptive behavior disorders and ADHD in African American and Hispanic youth. Academic Psychiatry, 44(1), 95-102. doi:10.1007/s40596-019-01127-6

Fernández-Sotos, A., Fernández-Caballero, A., & Latorre, J. M. (2016). Influence of tempo and rhythmic unit in musical emotion regulation. Frontiers in Computational Neuroscience, 10. doi: 10.3389/fncom.2016.00080

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2013). Adolescents' functional numeracy is predicted by their school entry number system knowledge. PLoS ONE, 8(1), 1–12. doi: 10.1371/journal.pone.0054651

Greenop, K., & Kann, L. (2007). Extra-task stimulation on mathematics performance in children with and without ADHD. South African Journal of Psychology, 37(2), 330-344. doi.org/10.1177/008124630703700208

Harvard University, Center on the developing child. (n.d.). InBrief: Executive function.

Retrieved April 26, 2020, from https://developingchild.harvard.edu/resources/inbrief-executive-function/

Huizinga, M., Dolan, C. V., & Molen, M. W. V. D. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. Neuropsychologia, 44(11),

2017–2036. doi: 10.1016/j.neuropsychologia.2006.01.010

Kumar, R., & Gleason, M. M. (2019). Pediatric attention-deficit/hyperactivity disorder in Louisiana: Trends, challenges, and opportunities for enhanced quality of care. Ochsner Journal, 19(4), 357-368. doi: 10.31486/toj.18.0103

Maloy, M., & Peterson, R. (2014). A meta-analysis of the effectiveness of music interventions for children and adolescents with attention-deficit/hyperactivity disorder. Psychomusicology: Music, Mind, and Brain, 24(4), 328–339. doi: 10.1037/pmu0000083

Martin, A. J., Cumming, T. M., O'Neill, S. C., & Strnadová, I. (2017). Social and emotional competence and at-risk children's well-being: The roles of personal and interpersonal agency for children with ADHD, emotional and behavioral disorder, learning disability, and developmental disability. Social and Emotional Learning in Australia and the Asia-Pacific, 123–145. doi: 10.1007/978-981-10-3394-0_7

Martinussen, R., Hayden, J., Hogg-Johnson, S., & Tannock, R. (2005). A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. Journal of the American Academy of Child & Adolescent Psychiatry, 44(4), 377–384. doi: 10.1097/01.chi.0000153228.72591.73

Mattison, R. E., & Mayes, S. D. (2010). Relationships between learning disability, executive function, and psychopathology in children with ADHD. Journal of Attention Disorders, 16(2), 138–146. doi: 10.1177/1087054710380188

Pickering, S. J. (2006). Assessment of working memory in children. Working Memory and Education, 241–271. doi: 10.1016/b978-012554465-8/50011-9

Schoemaker, K., Bunte, T., Wiebe, S. A., Espy, K. A., Deković, M., & Matthys, W. (2011). Executive function deficits in preschool children with ADHD and DBD. Journal of Child Psychology and Psychiatry, 53(2), 111–119. doi: 10.1111/j.1469-7610.2011.02468.x

Schutte, A. R., Torquati, J. C., & Beattie, H. L. (2016). Impact of urban nature on executive functioning in early and middle childhood. Environment and Behavior, 49(1), 3–30. doi: 10.1177/0013916515603095

Söderlund, G. B., Sikström, S., Loftesnes, J. M., & Sonuga-Barke, E. J. (2010). The effects of background white noise on memory performance in inattentive school children. Behavioral and Brain Functions, 6(1), 55–65. doi: 10.1186/1744-9081-6-55

Uhlig, S., Jansen, E., & Scherder, E. (2016). Study protocol RapMusicTherapy for emotion regulation in a school setting. Psychology of Music, 44(5), 1068–1081. doi: 10.1177/0305735615608696

Zentall, S. S. (1993). Research on the educational implications of attention deficit hyperactivity disorder. Exceptional Children, 60(2), 143-153. doi.org/10.1177/001440299306000208