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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 (Picking, 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
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.

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.
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) x 2 (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 par-
lor. 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 approxi-
mately 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 di-
agnosis 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 diag-
nosed with ADHD than women and girls, with studies demon-
strating 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, primar-
ily presents as “inattention and disorganization,” behaviors that
are more subtle and difficult to recognize than the “disruptive-
ness 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**


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