WHITE NOISE AS AN INTERVENTION FOR CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)

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This project is dedicated to my
family for their continued
support for me.

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ABSTRACT

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by Andrew Cook

ADHD medications have harmful side effects and are not effective for some children with the disorder. Behavior modification procedures have strong research support as an alternative treatment option for ADHD and do not have harmful side effects. White noise is one such environmental manipulation that may be an effective treatment for ADHD. White noise has been shown to reduce crying episodes in young children and to improve sleep of hospital patients. Continuous white noise played through headphones was used as a classroom intervention to reduce students' off-task behavior and increase their percentage of attempted and correctly completed items on assignments. Three students on medication for ADHD received 75dB of white noise or no noise on a single-subject reversal design 5 days per week for 7 to 17 weeks. All 3 students showed a reduction in off-task behavior when listening to white noise relative to their respective baselines. During white noise conditions, verbal and passive off-task behavior decreased considerably and motor-off task behavior was eliminated for all students. Mean off-task behavior was never higher during white noise conditions than it was during baseline for any of the children. One student attempted and correctly completed a higher percentage of items, one attempted fewer but correctly completed 100% of items, and one showed almost no difference in items attempted and percent correct when working under white noise compared to baseline. Results from a social validity scale indicated that all 3 boys, their teachers, and 2 of 3 parents rated the intervention as effective, easy to implement, and they all advocated for its use in the future.

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CHAPTER I

INTRODUCTION

According to the *Diagnostic and Statistical Manual of Mental Disoders-4th Edition* (DSM-IV), attention-deficit hyperactivity disorder (ADHD) is characterized by impulsivity, hyperactivity and inattention (American Psychiatric Association, 2000). These symptoms must have manifested in childhood (before age 7), cause impairment of normal functioning in multiple settings, be present for a minimum of 6 months and not be caused by another disorder. To be diagnosed as ADHD, one must meet criteria for 6 of 9 symptoms of inattention or of hyperactivity\impulsivity; if at least 6 criteria are met for both, the individual is diagnosed with ADHD-Combined type. About 8% of children aged 4-17 are diagnosed with ADHD (Center for Disease Control and Prevention [CDC], 2005), many of whom have difficulty with interpersonal relationships and assignment completion (Barkley, 2006). Thus, classroom-based interventions for children with ADHD should address all spectrums of the disorder, incorporate pre and post intervention assessment data and be personalized for the individual (DuPaul, Stoner & O'Reilly, 2002).

Development of ADHD

Research supports several potential biological and environmental factors as potential causes of ADHD. Results from twin studies (Sharp et al., 2003; Sherman, McGue, & Iacono, 1997) yielded higher concordance rates between monozygotic than dizygotic twins for an ADHD diagnosis, suggesting a genetic influence. In addition, dysregulation of catecholamines (epinephrine, norepinephrine and dopamine) is often associated with the ADHD symptoms (Pliszka, McCracken & Maas, 1996). Individuals with ADHD have been shown to demonstrate

dopamine hypoactivity in the prefrontal cortex (Genro, Kieling, Rohde & Hutz, 2010) and have significantly fewer dopamine metabolites in their cerebrospinal fluid relative to controls. Quantities of metabolites show a strong inverse correlation with hyperactivity as measured on behavior rating scales (Castellanos, et al., 1994). Environmental factors contribute to ADHD symptoms as well. Babies born at low birth weight are more likely to be diagnosed with ADHD later in life (Mick, Biederman, Prince, Fischer, & Faraone, 2002), as are fetuses exposed to heavy cigarette smoking (Motlagh et al., 2010) and those exposed to certain non-tricyclic antidepressant medications during their mother's pregnancy (Figueroa, 2010). It is safe to assume that ADHD is not due to biology or environment alone. Two common interventions used to treat behaviors associated with ADHD include medication and the use of behavior modification.

ADHD Medications

The majority of children diagnosed with ADHD are treated with prescription medication (CDC, 2005); particularly stimulants such as methylphenidate and mixed-salt amphetamines, yielding mixed results. Stimulant medications have considerable evidence-based support for the treatment of impulsivity, inattention and hyperactivity (Faraone & Buitelaar, 2010) and may also enhance certain skills required to perform well in school (McInnes, Bedard, Hogg-Johnson & Tannock, 2007). However, typical side effects of these drugs include decreased appetite, sleep problems and anxiety. Less frequently occurring side effects are the development of tics, cardiovascular problems and other psychiatric conditions (National Institute of Mental Health [NIMH], 2008). Despite the effectiveness of medication for some individuals, some report experiencing a large number of negative effects associated with stimulant use (Thorell &

Dahlstram, 2009). Long-term effects of stimulant use on humans are unknown, but in one clinical trial, methylphenidate administered to rats during preadolescence produced depressive symptoms that endured into adulthood (Carlezon, Mague & Andersen, 2003).

In addition to negative side effects, as many as 25% of children with ADHD may fail to display normal classroom functioning despite taking stimulants (Dupaul & Rapport, 1993). The American Academy of Pediatrics' new treatment guidelines for ADHD recommend that physicians consider behavioral techniques as the initial treatment for young children and that stimulants be prescribed only if behavioral treatments do not significantly improve symptoms (Dooren, 2011).

Behavior Modifications

Behavior modification procedures involve adjusting aspects of the environment to address ADHD symptoms. These procedures have demonstrated effectiveness in treating symptoms of ADHD in children. The methods involved often require little training and can be implemented by teachers or parents. A meta-analysis of 174 studies judging the effect of behavior modification procedures for children with ADHD revealed strong evidence for their efficacy, with average effect sizes ranging from .83 in group studies to 3.78 in single-subject designs (Fabiano et al., 2009). A variety of behavioral procedures have been employed. For example, use of self-monitoring of study skills and homework performance by students with ADHD has proven effective in increasing rates of homework completion and academic achievement (Meyer & Kelley, 2007). Students with ADHD given access to a calm environment such as a park for a short period of time have demonstrated significantly better concentration in class immediately afterward than they did after being in a distracting environment for the same

amount of time (Taylor & Kuo, 2009). Using physical activity as a reward for attention compliance can also enhance attention in children with ADHD for the duration of a class period (Azrin, Vinas & Ehle, 2007). Such studies indicate that behavioral modification techniques can effectively improve symptoms of ADHD. Continued investigation of behavioral interventions that are easy to implement and have few adverse effects is important.

White Noise

Recent research has demonstrated that another type of environmental manipulation, white-noise, may enhance certain cognitive functions in children with ADHD (Soderlund, Sikstrom & Smart, 2007) and decrease attention problems (Soderlund, Sikstrom, Loeftesnes & Sonuga-Barke, 2010). The study by Soderlund, et al. (2007) evaluated the effect of white noise on recall performance of 14 students with ADHD (7 of whom were medicated and 7 who were not). Seven additional students without ADHD served as controls. Two attention-focused tasks, a self-performed (SPT) and verbal task (VT), were used in the presence and in the absence of white noise. During SPT tasks, the children were presented with commands such as 'roll the ball' and asked to perform the task, whereas during VT tasks they were presented with the same type of commands and given no instructions for action. Students with ADHD as a combined group correctly recalled a significantly higher mean proportion of items on the SPT task with white-noise (.52) than without (.47). Controls recalled a significantly lower mean proportion of items on the VT task while listening to white-noise (.35) than they did in the no-noise condition (.42). Students with ADHD did not perform significantly different on the VT task during either condition, nor did controls on the SPT task. Perhaps most promising is the similarity in recall performance for students with ADHD during the white-noise condition and controls during the

no noise condition for the SPT task (mean of .52 for both) and the VT task (mean of .41 for ADHD students vs. mean of .42 for controls). These results suggest that white noise may enhance particular cognitive skills for students with ADHD (those on medication and those not) to levels comparable to that of other non-ADHD students, at least on certain tasks.

Soderlund et al. (2007) attributed the results of the study to stochastic resonance (the phenomenon that an ideal noise level may optimize cognitive performance) and the Moderate Brain Arousal (MBA) model (Sikstrom & Soderlund, 2007). The MBA model states that dopamine level determines the amount of noise necessary to reach an ideal noise level and that those with low dopamine levels may require more external stimulation than normal students to compensate for their lower neural activity (Sikstrom & Soderlund, 2007). The authors hypothesized that students with ADHD would benefit from listening to white noise because the stimulation would help them reach this optimal level. They also hypothesized that non-ADHD control participants would not benefit because white noise would provide more noise than the moderate level required for their ideal performance (Soderlund et al., 2007). Considering that individuals with ADHD often have significantly lower dopamine levels (Pliszka et al., 1996; Genro et al., 2010; Castellanos et al., 1994), and demonstrate hypoarousal in neural functioning based on Electroencephalographic (EEG) and Electrodermal Activity (EDA) measures (Lazzaro et al., 1999) relative to the normal population, Soderlund et al.'s (2007) hypotheses were supported by the ADHD students' enhanced performance on the SPT task and the non-ADHD controls' somewhat depressed performance while listening to white noise.

The effects of white noise on sentence recall were also investigated for children with and without attention problems (Soderlund et al., 2010). Students were presented with eight lists of

verb-noun sentences and asked to recall as many as possible both in the presence and in the absence of white noise. Each list contained 12 sentences and took approximately 1 minute and 40 seconds to present. The total proportion of correctly recalled sentences was used as the dependent measure. A significant interaction (p = .003) was found between noise (white-noise vs. no-noise) and group (inattentive vs. attentive). Inattentive children showed a significant improvement in the mean proportion of sentences recalled when listening to white noise compared to no noise (.39 vs. .44), whereas attentive children performed significantly less well (.46 vs. .41) during the white noise condition (Soderlund et al., 2010). The results of this study support the previous findings by Soderlund et al. (2007). However, the inattentive students were deemed so by their teacher and had not been diagnosed with ADHD. The research on the effects of white noise and cognitive performance for children with ADHD is limited, but the positive results found in these studies suggest this approach may have potential for helping students with ADHD in the classroom.

Although stimulant medications provide benefit for some students with ADHD (Faraone & Buitelaar, 2010; McInnes et al., 2007), they do not sufficiently help everyone taking them (Dupaul & Rapport, 1993). Also, these medications can cause unfavorable side effects (NIMH, 2008). Behavior modification strategies that alter the environment and reinforce positive behaviors have demonstrated efficacy for students with ADHD in the classroom (Fabiano et al., 2009; Meyer & Kelley, 2007; Taylor & Kuo, 2009; Azrin et al., 2007), and are important to consider prior to prescribing medication (Nooren, 2011). For some students, both a behavioral procedure and medication may be necessary. White noise is a behavioral technique that may improve cognitive functioning for medicated and non-medicated students with ADHD

(Soderlund et al., 2007; Soderlund et al., 2010), and potentially improve educational outcomes for these students.

Purpose of Study

Using a single-subject reversal design, the present study examined the effect of white noise on off-task behavior and percentage of items attempted and correctly completed on individual assignments for three students on medication for ADHD. The hypotheses were that white noise would (a) reduce off-task behavior, (b) increase the percentage of items attempted and (c) increase the percentage of attempted items completed correctly.

CHAPTER II

METHOD

Participants and Settings

Three Caucasian, male students in a rural public elementary school who had been previously diagnosed with ADHD were included in the study. All of the boys were diagnosed as ADHD by a physician, prescribed stimulant medication and were struggling academically. Nine-year-olds Edgar and Kareem were third-graders who each took 7.5mg Adderall once before school and Cecil (8-years-old), a second-grader, was prescribed 30mg Vyvanse to be taken once before school. Kareem spent part of his day in a special education classroom and Cecil was provided academic accommodations via a 504 plan; Edgar did not receive any additional documented academic support. Edgar and Kareem shared a general education classroom and teacher and sat in close proximity to one another.

Experimental Design

An ABCAC design was used for all 3 participants. During baseline (A) no headphones and no white noise were used, in condition B students wore headphones that played no sound and during intervention (C) the boys wore headphones that played white noise. Changes in conditions occurred for each student when off-task behavior data were consistent for at least three consecutive observation sessions. The experiment began for each student when assent forms were returned and ended on the final day of school. The entire experiment lasted 17 weeks for Edgar, 16 weeks for Kareem and 8 weeks for Cecil. A 1-month follow up was

planned for each student, but the need to establish consistency for off-task behavior data limited the time left in the school year to do so.

Instrumentation

Rating Scale

Each of the boys' teachers rated their behavior using the *Attention Deficit Disorders Evaluation Scale-Third Edition* (ADDES-3; McCarney & Arthaud, 2004) school version. Teachers rated each student as either 0 (not developmentally appropriate for the student's age) or on a frequency scale from 1 (not observed) to 5 (occurring one to several times per hour).

The ADDES-3 was normed on a sample of 3,903 students aged 4 through 18, with slightly more males than females. Standardization groups differed by gender and some gender-specific age groups have fewer than 100 students in the norm sample. The authors reported that the standardization sample closely matched the 2000 U.S. Census in terms of race, geographic region and parent occupation with the exception of an overrepresentation of blacks (24.64% in sample versus 12.14% in nation) and an underrepresentation of individuals from the western U.S. (9.69% in sample versus 22.40% in nation).

Overall internal consistency was strong, yielding a correlation of .99. Test-retest reliability was assessed with 855 students with a 30-day retest interval. The results indicated strong stability with a .92 correlation for the Inattentive subscale and .88 for the Hyperactive\Impulsive scale.

In terms of content validity, items for the ADDES-3 were designed by diagnosticians and educators based on observed inattentive, hyperactive and impulsive behaviors and are consistent with those on the DSM-IV.

The ADDES-3 was compared with the *ADD-H Comprehensive Teachers Rating Scale-Second Edition* (ACTeRS; Ullmann, Sleator, & Sprague, 2000) and the *Conners' Teacher Rating Scale-Revised: Long Form* (CTRS-R:L) (Conners, 2000) to evaluate concurrent validity. Correlations with the ACTeRS were .80 for inattention and .78 for hyperactive\compulsive. For the CTRS-R:L, the majority of correlations were in the high .80's.

Criterion-related validity was investigated with 78 randomly selected students. Those previously diagnosed with ADHD who were currently receiving school services for the condition had an average standard score of 6 for both ADDES-3 subscales. Those without ADHD averaged a standard score of 10 on both subscales.

Checklists

A 9-item checklist (Appendix F) was developed for the study and given to both teachers to ensure the proper implementation of the procedure. The checklist provided the teacher with the steps to be completed before the experiment began (e.g., complete ADDES-3 and provide script to class), as it was being implemented (e.g., white noise study form, placement of generator and headset and instructions for one-on-one attention) and after it was completed (e.g., complete the social validity scale).

Equipment

Brookstone Tranquil Moments Junior™ white noise generators were used during the study. The volume of the generators was initially calibrated by the university's audiology department and recalibrated throughout the study by the examiner via use of a portable decibel reader (Tenma® Sound Level Meter, model 72-935). The white noise was delivered to the ears of each student through Sony® MDR-E818LP Fontopia headphones.

Social Validity

A 4-item social validity scale addressing effectiveness, ease of implementation and possible future use of white noise in the classroom was developed for this study (Appendix E) using a 5-point Likert-type scale. A 1 denoted strong disagreement and a 5 denoted strong agreement in response to positive statements about the intervention. Each item on the scale was rated independently by the three boys, their teachers, and their parents.

Procedure

A permission form and a consent form (Appendix B) were signed by the school principal for approval to conduct the study. The principal then recommended teachers she felt would be suitable to aid in the study and provided each of them with a permission form (Appendix B) to sign if they were willing to participate. The teachers who returned forms then identified students in the classroom with ADHD who were disruptive or struggling academically. The researcher provided each teacher a packet containing a parent consent form (Appendix B) the teacher mailed to the parent of the student along with a stamped return envelope. In all, six packets were mailed. Each student whose parents returned the consent forms was given a student assent form

(Appendix B), which was read to them by their teacher and signed by the student if he or she was willing to participate. Although six student assent forms were returned, only three were returned in time to complete the intervention prior to the end of the school year. Thus, three students served as participants. After receiving each signed student assent form, the teacher was provided with the 9-item teacher checklist and the experiment began for the student. ADDES-3 rating scales were completed by teachers 3-4 weeks after student assent forms were returned. Teachers then identified a period of time during which students would be completing assignments independently every day of the week. The experiment took place at this time 5 days per week. Edgar and Kareem were observed in their classroom simultaneously at 8 AM and Cecil was observed at 8:15 AM in his classroom.

Prior to beginning the study, the teacher read a script prepared by the examiner to all students in the classroom. This was done in an effort to explain the purpose of the project and to reduce any stigma for the participant by allowing everyone in the class the opportunity to listen to the white noise through the headphones (Appendix C for script).

A white noise generator was placed under each student's desk by his teacher 5 days per week during the predetermined time for the duration of the study. Each student was required to wear his headphones during conditions B and C until he finished his assignment(s) or for a maximum of 30 minutes. During conditions A and B the generator was turned off. During intervention (condition C), teachers turned the volume dial on the generator to a point marked on the side of the generator. This point corresponded to 75 decibels (dB) as measured from the headphones by the University's Audiology Department. The National Institute on Deafness and Other Communication Disorders (2008) reported that sounds at and below 75 dB are not likely to

cause hearing damage, even after continuous exposure. Students were instructed not to adjust the volume on the generators and decibel levels were verified on all units a minimum of twice per week by the researcher with the portable decibel reader to ensure reliability. The researcher informed teachers when each student changed conditions. During all conditions of the study, teachers were asked to conduct classroom activities in their usual manner.

Off-task behavior was defined as talking to another student or the teacher about something unrelated to the assignment (verbal off-task), standing or walking while not attending to the task (motor off-task) or looking at something other than the assignment or teacher while she was speaking (passive off-task). Behaviors were recorded on a Classroom Observation Record (COR; Appendix A) as either academically engaged (any behavior not off-task) or as one of the three types of off-task behavior (motor, verbal or passive). Off-task behavior was recorded by the researcher for each of the boys on average 2-3 days per week, due to the researcher's university class schedule which prevented him from being able to collect data on certain days of the week.

Data for off-task behavior were recorded using a momentary time-sampling (MTS) procedure with 15-second intervals. After 15 minutes of recording or when each student completed their independent assignment(s) the session ended. A minimum of 9 minutes were required from a session for the data to be included in the study. Any time a student received one-on-one assistance from the teacher or another adult was excluded from the observation data. Four of Kareem's sessions were excluded because of time constraints due to his exit for special education support in another classroom at 8:15 A.M. One of Edgar's sessions was excluded

because of the duration of his one-on-one support. All of Cecil's sessions were included in the study.

Interobserver agreement was examined for off-task behavior for all participants during 20% of the observation sessions by having an observer trained in the use of MTS simultaneously and independently code behavior. Agreement was calculated by dividing the number of intervals in agreement by the total number of intervals observed and multiplying by 100%. Overall agreement ranged from 86% to 100% with a mean of 93%.

Teachers collected the assignments completed by each student during the predetermined time 5 days per week in a folder and recorded (a) the date, (b) the percentage of total items attempted and (c) the percentage of attempted items answered correctly on each assignment. Assignments that could not be quantified were excluded from the study. The percentage of items attempted and percentage correct were verified by the researcher for each assignment. Discrepancies were brought to the attention of the teacher who determined the correct score.

Each student and his teacher completed a white noise study form (Appendix D) 5 days per week during the predetermined time to ensure treatment integrity. The form included (a) the date and subject of the assignment(s) each student worked on, (b) whether or not headphones were worn, and (c) if worn, whether the headphones were playing white noise. Data provided on the form were examined weekly by the researcher to ensure each student was in the appropriate condition when the researcher was not present. No inconsistencies were found.

Upon completion of the study, social validity scales were completed independently by the boys, their parents and their teachers. Teachers were asked to complete the teacher form and, if

needed, aid the student in completing the student form in privacy. The scales were mailed to parents with a stamped return envelope.

CHAPTER III

RESULTS

Results from the teachers' ratings of each student on the ADDES-3 are illustrated in Table 1. The overall ADDES-3 quotient is a measure of each student's overall ADHD characteristics and ability to be successful in the classroom compared to his peers; the average quotient range is 85 to 115 and the standard error of measure (SEM) is 4. The Inattentive and Hyperactive-Impulsive subscales have an average standard score range of 7 to 13 and an SEM of 1. Low scores are considered problematic on the ADDES-3. The Inattentive scale gauges the student's ability to sustain attention and follow directions, whereas the Hyperactive-Impulsive scale assesses impulse control and response to environmental stimuli. All three students were on medication for ADHD and these ratings reflect their behavior when on medication. Edgar was rated as average in all areas, Kareem's behavior was rated as having serious concerns in all areas, and Cecil was rated as average overall and on the Hyperactive-Impulsive scale with a low average score on the Inattentive scale.

Table 1. *ADDES-3 Quotients and Standard Scores (SS)*

Student	Quotient	Inattentive SS	Hyperactive-Impulsive SS
Edgar	101	11	10
Kareem	76	4	6
Cecil	92	7	10

Figure 1 depicts the percentage of intervals Edgar was off-task during baseline (A; no headphones, no white noise), headphones-only condition (B; headphones with no white noise) and intervention (headphones with white noise). During baseline conditions (A1 +A2), Edgar was off task for a mean of 26.7% of intervals compared to 4.1% during intervention (C1+C2).

Use of headphones alone did not reduce his off-task behavior (mean of 35.7%). The final observation for Edgar (session 26) reflects his off-task behavior while listening to white noise when he was not on medication. Edgar's mother elected not to medicate him on the last day of school, resulting in a change in condition. Although Edgar was off-task more than he had previously been while listening to white noise, he was still off-task less than he was during most baseline observation sessions when he was on medication.

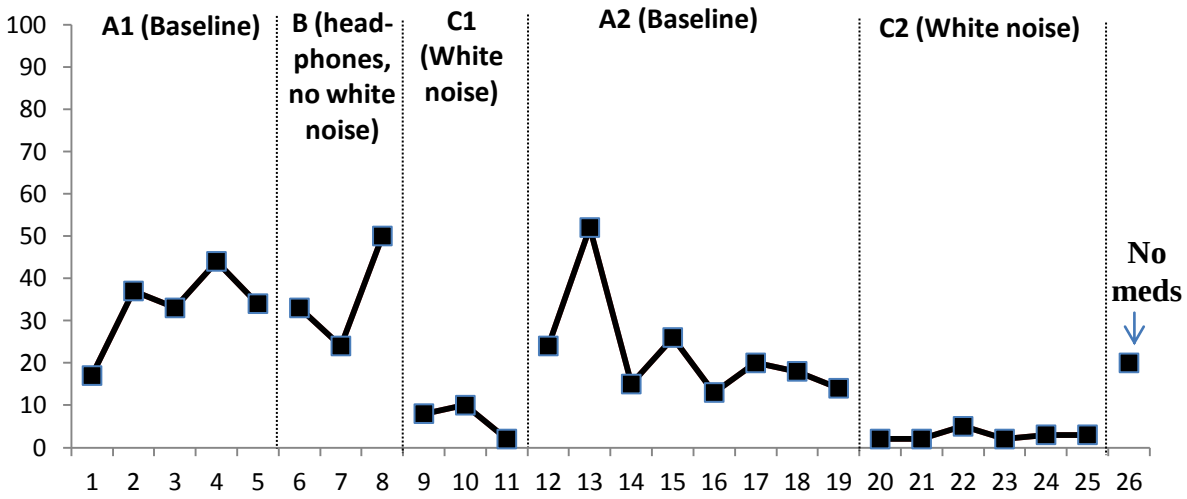

Figure 1. *Percentage of Intervals Off-task for Edgar*

The percentage of intervals off-task for Kareem during conditions A, B and C are shown in Figure 2. Kareem was off-task a mean of 52.3% of intervals during baseline (A1+A2) and 57% during condition B, but during intervention (C1+C2), his off-task behavior decreased to 22.3%. The final observation (session 21) was taken during the last day of school when Edgar was not medicated and he consequently conversed with Kareem for an extended period.

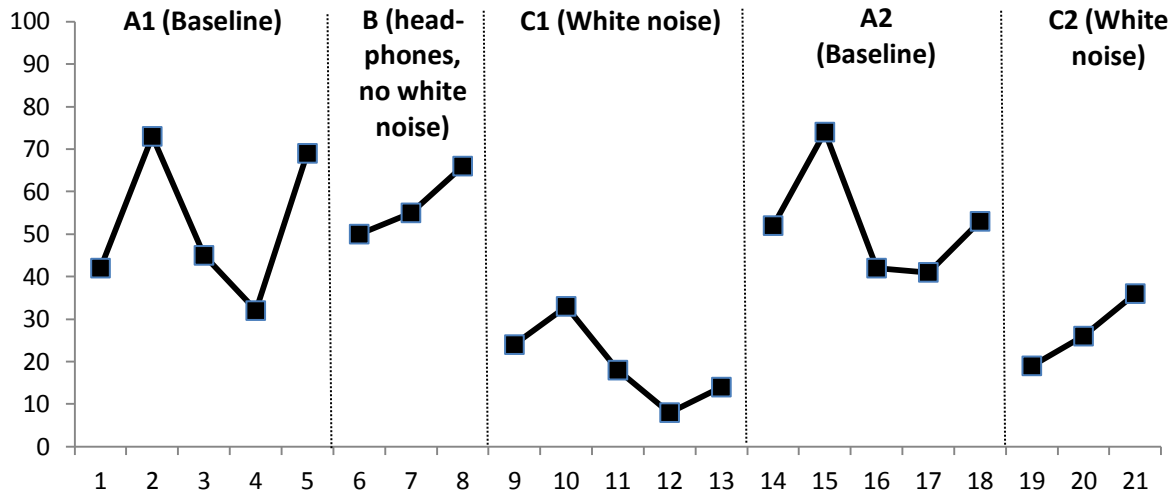

Figure 2. *Percentage of Intervals Off-task for Kareem*

Figure 3 shows the percentage of intervals off-task for Cecil during the three conditions. Cecil was off-task for a mean of 34.3% of intervals during baseline (A1+A2) and only 8% during intervention (C1+C2). Headphones alone did not result in a decrease in his off-task behavior; he was off-task a mean of 36% of intervals during condition B. The final data point for Cecil (session 19) was on the final day of school.

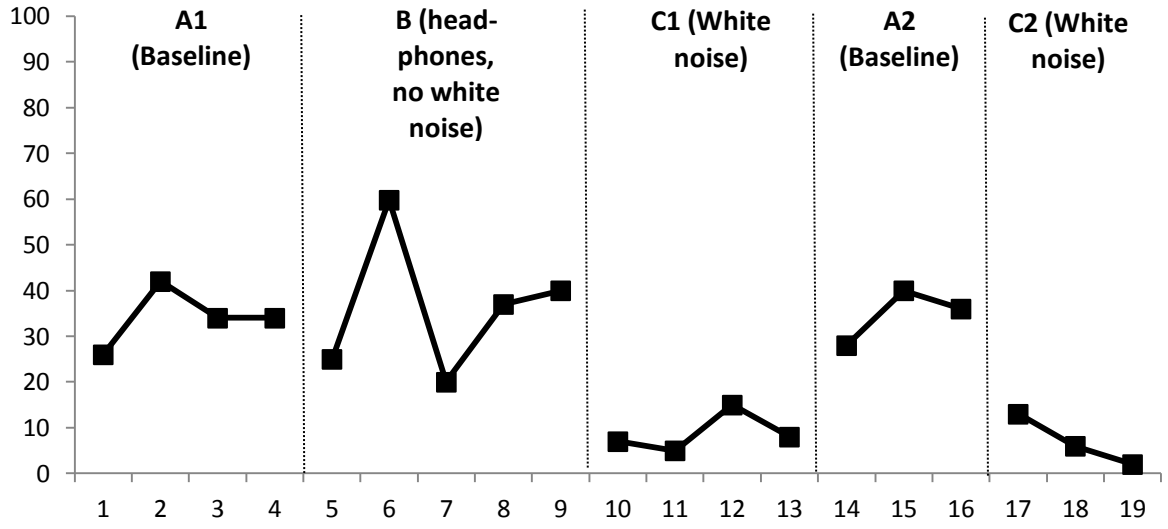

Figure 3. *Percentage of Intervals Off-task for Cecil*

Off-task behavior was examined in terms of type of off-task behavior for each student for each condition (i.e., the two baseline conditions, the headphones only condition, and the two headphones and white-noise conditions). Results are displayed in Table 2. Passive off-task behavior occurred most often for all three boys in all conditions. The results demonstrate that the three types of off-task behavior occurred less frequently for all students when they were listening to white noise (C1+C2). Both verbal and passive off-task behavior were considerably reduced during white noise phases relative to baseline for all three boys. Motor off-task behavior was observed in 0% of intervals during white-noise phases for all of the boys.

Table 2. *Mean Percentage of Intervals for Each Type of Off-task Behavior for Each Student*.

Student	Behavior	Condition	Mean % of intervals off-task
Edgar	Verbal	A1+A2	6.8%
		B	0.7%
		C1+C2	0.2%
	Motor	A1+A2	2.4%
		B	3.7%
		C1+C2	0%
	Passive	A1+A2	17.5%
		B	31.3%
		C1+C2	3.9%
Kareem	Verbal	A1+A2	7.2%
		B	6.1%
		C1+C2	2.0%
	Motor	A1+A2	3.3%
		B	1.1%
		C1+C2	0%
	Passive	A1+A2	41.8%
		B	50.1%
		C1+C2	20.3%
Cecil	Verbal	A1+A2	4.4%
		B	2.8%
		C1+C2	0.7%
	Motor	A1+A2	1.7%
		B	2.0%
		C1+C2	0%
	Passive	A1+A2	28.2%
		B	31.5%
		C1+C2	7.3%

Table 3 displays the mean percentage of items attempted and the percentage correct on assignments during each condition for each student. Edgar attempted nearly all items on his assignments throughout baseline and intervention and correctly completed about a similar percentage of items during all phases. Kareem attempted a smaller percentage of items during phase B and intervention than during baseline, but he answered all items correctly when listening

to white noise, thus his accuracy improved considerably from baseline. Cecil attempted and correctly completed a higher mean percentage of items when listening to white-noise than he did during baseline.

Table 3. *Mean Percentage of Items Attempted and the Percentage Correct on Assignments for Each Student and Condition*

Student	Condition	Mean % Attempted	Mean % Correct
Edgar	A1+A2	98%	67.1%
	B	100%	67%
	C1+C2	100%	65.5%
Kareem	A1+A2	87.5%	83.8%
	B	53.30%	91.7%
	C1+C2	50%	100%
Cecil	A1+A2	86.7%	73.6%
	B	99%	62.5%
	C1+C2	100%	85.7%

The mean response to four positive statements on the social validity scale regarding the desire to use white noise in the future, its effectiveness and its ease of implementation appear in Table 4. The statements were evaluated by each of the boys, their teacher and a parent. Each statement was rated on a scale of 1 to 5; a 1 indicated strong disagreement and a 5 denoted strong agreement. All three boys rated the intervention positively as did their teachers. Edgar and Kareem's parents also agreed with the statements regarding the intervention. Cecil's parent rated the intervention somewhat poorly despite her son's positive results for off-task behavior, assignment completion and assignment accuracy.

Table 4. *Mean Rating (1-5 scale) on the Social Validity Scale by Student and Rater*.

	Rater		
Student	Self	Teacher	Parent
Edgar	5	5	4.75
Kareem	5	4.25	4.5
Cecil	5	4.5	1.75

CHAPTER IV

DISCUSSION

Teacher ratings on the ADDES-3 describe the students' behavior while on medication for ADHD. Kareem's teacher felt his behaviors characteristic of ADHD were quite problematic, however, Edgar and Cecil's behaviors were rated in the normal range. Edgar and Cecil may have benefitted from medication whereas Kareem did not. Despite the average ratings for the Cecil and Edgar, all three boys were reported by their teachers to have been struggling academically prior to implementation of the study, they were diagnosed as ADHD by a physician, and they displayed a considerable amount of off-task behavior.

Results from the study indicate that all 3 students displayed off-task behavior less frequently while listening to white noise compared to baseline and headphones-only conditions when working independently. These data suggest that white noise can reduce off-task behavior for students with ADHD who are on stimulant medication. This benefit is not provided by simply wearing headphones as off-task behavior only decreased when white noise was used. These results support those from previous studies (Soderlund et al., 2007; Soderlund et al., 2010), which indicated that children with attention difficulties demonstrate marked improvement on tasks related to attention while listening to white noise. Thus, this intervention may be particularly helpful for students with ADHD who are on medication, and who display attention problems and struggle with their academic work.

Data from the last day of school for Edgar suggest that stimulant medication may have helped to reduce his off-task behavior because its removal led to an increase in off-task behavior. However, white noise may still have helped reduce off-task behavior in this instance because

levels were still lower than most baseline data points and the headphones-only observation sessions. Edgar's increase in off-task behavior directed toward Kareem probably contributed to Kareem's increase in off-task behavior that day. The amount of off-task behavior for both boys that day was still lower than most data points during baseline and the headphones-only conditions. The excitement of the last day of school also may have been a contributing factor to an increase in off-task behavior for these two students. However, Cecil's off-task behavior on the last day of school was his lowest data point, providing evidence for the effectiveness of white noise despite any excitement regarding the last day of school.

All three boys demonstrated a reduction in passive, verbal and motor off-task behavior while listening to white noise compared to baseline. A considerable decrease in passive off-task behavior was evident for all boys. Not surprisingly, verbal and motor off-task behaviors were nearly extinguished during white-noise phases. Getting up, walking around and talking to others is more difficult when wearing headphones and when distractions are diminished by the white noise. These two types of off-task behavior are disruptive to the teacher and to other students. Thus they are likely to be behaviors a teacher would most likely to want addressed first. White-noise may not only be beneficial to the student receiving the intervention, but also to the teacher and other students in the classroom.

Although white noise effectively reduced off-task behavior for all three boys, its effect on the percentage of items attempted and correctly completed was mixed. Cecil showed considerable improvement in items attempted and items correctly completed while listening to white noise relative to baseline, indicating that the intervention helped him do more work with better accuracy. Kareem was more accurate during intervention, correctly completing every item

he attempted, but he attempted a lower percentage of items than in baseline. Perhaps he concentrated better on the tasks which may have taken more time. Edgar attempted more items but was slightly less accurate during intervention compared to baseline. This decrease in accuracy may have been due to the increased difficulty of the subject matter near the end of the year. Cecil and Kareem's accuracy may not have been affected by increased assignment difficultly because both received additional academic support in the school and Edgar did not. The results between the three boys indicate that white-noise can provide academic benefit for some but its impact on academic work warrants further research.

In addition to the promising results on the boys' off-task behavior, Cecil on assignment effort and accuracy, and Kareem's accuracy results from the social validity scale show high satisfaction from all the boys, their teachers and two of three parents. All the boys strongly felt that white noise improved their ability to stay on-task and complete their work. They also indicated that they would like to continue to use it in the future. The process of putting on headphones and listening to white noise became part of their normal routine for the boys and their classmates did not appear distracted by the procedure. During the return to baseline, all of the boys questioned why they were no longer wearing the headphones and when they would wear them again. Cecil commented after the first day with white noise, "I think I can finally do my work now".

The boys' teachers were strong advocates for future use of white noise for students in their classrooms and agreed that the intervention was successful in terms of decreasing off-task behavior and enhancing item completion and accuracy on assignments. The one exception was Kareem's teacher who felt neutral with regard to its effectiveness in improving Kareem's

assignment completion. Both teachers spoke favorably about the simplicity of implementation of the intervention and were impressed by the immediate effectiveness of white noise in reducing off-task behavior. Edgar and Kareem's parents were both very pleased with the progress their children made and expressed the desire to use white noise in the future by rating all four items a 4 or 5. Edgar's parent asked the researcher if Edgar could continue using the white noise generator the following school year. Despite the improvements Cecil made while listening to white noise, ratings from his parent suggested displeasure with the intervention. A letter was sent to the parent asking for an explanation of the negative ratings, but no response was received.

White noise may be an important treatment option for ADHD for several reasons. Students with ADHD showed an immediate and sustained decrease in off-task behavior when listening to white noise, even those already on medication. Because of the number of individuals who experience no benefit (Dupaul & Rapport, 1993) or multiple negative effects (Thorell & Dahlstram, 2009) from ADHD medications, alternative treatment options are needed. Similar to other behavioral interventions that have demonstrated effectiveness in improving behaviors associated with ADHD (Fabiano, et al., 2009; Azrin, et al., 2007; Baijal & Gupta, 2008), white noise can be implemented in the classroom or at home and it does not produce the harmful side effects associated with stimulant medications for some students. Further, white-noise has the advantage of requiring little teacher time and effort.

The limitations of the current study are its generalizability to other populations of students and the need for greater control of variables related to assignment completion and accuracy, both of which can be addressed with future research. Although results from Soderlund et al. (2007) showed that children with ADHD who were not taking medication improved on

attention and verbal tasks while listening to white noise, the effect on assignment completion and accuracy and classroom behavior was not investigated for these students. Their study was also conducted in a laboratory setting, which may limit its external validity. The current study incorporated only young Caucasian males and used a constant decibel level of white noise. Carryover effects of white noise into other settings (i.e., group lecture, lunchroom) were not examined either. Perhaps most importantly, follow-up could not be conducted because of time constraints, thus limiting evidence of the long-term effectiveness of white noise. Future research investigating behavior and academic competence for students with ADHD who are not on medication as well as those of various races\ethnicities, genders and cognitive ability levels will be important. Further investigation of different decibel levels of white noise would provide greater insight into the effectiveness of white noise for students with ADHD as well. For subsequent studies, evaluation of how subject matter and students' perceived difficulty of each assignment influence effort and accuracy under conditions of white noise would be beneficial.

APPENDICES

APPENDIX A

CLASSROOM OBSERVATION RECORD

Student: **Observer:**

Age: **Class size:**

Grade: **Class type:**

Subject: **Current Phase (A,B,C):**

Time start: **Time stop:**

Total time:

Description of observation techniques:
Momentary time-sampling: 15 seconds

Behavior codes and definitions (to be individualized for each student):

VO= Verbal off-task:

MO= Motor off-task:

PO= Passive off-task:

AE = Academic engagement:

COR Data Recording

Time	Behavior	Time	Behavior	Time	Behavior	Time	Behavior
:15		7:45		:15		7:45	
:30		8:00		:30		8:00	
:45		8:15		:45		8:15	
1:00		8:30		1:00		8:30	
1:15		8:45		1:15		8:45	
1:30		9:00		1:30		9:00	
1:45		9:15		1:45		9:15	
2:00		9:30		2:00		9:30	
2:15		9:45		2:15		9:45	
2:30		10:00		2:30		10:00	
2:45		10:15		2:45		10:15	
3:00		10:30		3:00		10:30	
3:15		10:45		3:15		10:45	
3:30		11:00		3:30		11:00	
3:45		11:15		3:45		11:15	
4:00		11:30		4:00		11:30	
4:15		11:45		4:15		11:45	
4:30		12:00		4:30		12:00	
4:45		12:15		4:45		12:15	
5:00		12:30		5:00		12:30	
5:15		12:45		5:15		12:45	
5:30		13:00		5:30		13:00	
5:45		13:15		5:45		13:15	
6:00		13:30		6:00		13:30	
6:15		13:45		6:15		13:45	
6:30		14:00		6:30		14:00	
6:45		14:15		6:45		14:15	
7:00		14:30		7:00		14:30	
7:15		14:45		7:15		14:45	
7:30		15:00		7:30		15:00	

VO: _____ /60 = % **MO: _____ /60 = %**

PO: _____ /60 = % **AE: _____ /60 = %**

APPENDIX B

PERMISSION FORMS

CMU
CENTRAL MICHIGAN UNIVERSITY

Dear Principal,

I am contacting you for approval to implement a study in your school. I am looking for students aged 8-12 with ADHD to participate in a behavioral /academic intervention for my thesis project. I would greatly appreciate your opinion on recommendations for teachers that may be suitable to help in the study.

I am investigating alternatives to medication for children with ADHD in the classroom, including white noise. White noise is a continuous sound that covers the entire spectrum of human hearing, somewhat like the static between radio stations. Research has shown that white noise may be beneficial for reducing off-task behavior for kids with ADHD. This sound may make it easier for some children to focus on the task at hand, lower arousal level and avoid distractions in the classroom.

I will be supplying the children with headphones connected to white noise generators that play the white noise while they are working on instructional activities, not during lecture time. The procedure should not be a distraction to teachers or other students and in fact may well benefit both.

If you have any questions or concerns, or would like more information, please contact me or Tim.

Thank you!

Email: cook2ar@cmich.edu
Phone: 616-502-2359

Andrew Cook

CMU
CENTRAL MICHIGAN UNIVERSITY

Dear Teachers,

For anyone who does not know who I am, my name is Andrew Cook and I am a practicum student in school psychology at Central Michigan University working under Tim Klifman at your school. I am contacting you because Mrs. Weaver recommended you as someone familiar with children with ADHD in the school. I am currently looking for children with ADHD between the ages of 8-12 to participate in a behavioral/academic intervention.

For my thesis, I am investigating an alternative to medication for children with ADHD in the classroom, which is the use of white noise. White noise is a continuous sound that covers the entire spectrum of human hearing, like the static between radio stations. Research has shown that white noise may be beneficial for reducing off-task behavior for students with ADHD. This sound may make it easier for some children to focus on the task at hand, lower arousal level and avoid distractions in the classroom.

I will be supplying the children with headphones that play the white noise while they are working on activities, not during lecture time. The procedure should not be a distraction to you or other teachers or students and in fact may well benefit both. I am looking for the most disruptive and misbehaving students with ADHD you have in your classroom. Any potential students should also be obtaining below average grades in at least one subject area. Participants can be on medication as long as they are still displaying behavior problems and/or having difficulty completing assignments.

If you have any questions or concerns, please contact me or Tim. If you know of any children, let me know and I will get you a consent form to send home to their parents.

Thank you!

Email: cook2ar@cmich.edu
Phone: 616-502-2359

Andrew Cook

CMU
CENTRAL MICHIGAN UNIVERSITY

School Principal Consent Form

Study Title: White noise as a classroom intervention for children with ADHD.

Research Investigators' Names and Departments:

Andrew Cook – Graduate Researcher
email: cook2ar@cmich.edu **phone:** 616-502-2359

Sharon Bradley-Johnson – School Psychology Professor at Central Michigan University **email:** johns1sb@cmich.edu **phone:** 989-774-6480

Introductory Statement

This study is designed to investigate the effects of white noise in the classroom for students with ADHD. White noise is a continuous sound that incorporates the entire spectrum of human hearing.

What is the purpose of this study? The purpose of the study is to help students stay on task and complete their assignments more efficiently. I will be evaluating white noise as an invention for ADHD and the results will provide information regarding the effectiveness of this intervention for ADHD.

What will students do in this study? Each student in the study will work on assignments as they normally would and will not be removed from the classroom. They will be asked to wear headphones that will sometimes be playing white noise. This will occur only once a day during a time when the teacher indicates each student has the most difficulty staying on task.

How long will it take each student to do this? Each student will wear the headphones for no more than 30 minutes at a time. The study may go on for several weeks, possibly even a few months, with each child participating every day.

Are there any risks of participating in the study? No, because the volume will be adjusted to prevent any damage to hearing and each student will be instructed not to change settings on the white noise generator.

What are the benefits of participating in the study? If the procedure is effective, students in the study may display off-task behaviors less frequently when the white noise is playing and may complete assignments more efficiently.

Will anyone know what each student does or says in this study (Confidentiality)? Information regarding students will only be viewed by me. Each student will have a number associated with their data and information about each will be kept separately from the coding system. I will be the only one able to match the data to the identity of the student.

Will students receive any compensation for participation? No.

Is there a different way for students to receive this compensation or the benefits of this study? There is no compensation for participating in the study.

Who can I contact for information about this study?

Andrew Cook – Graduate Researcher
email: cook2ar@cmich.edu **phone:** 616-502-2359

Sharon Bradley-Johnson – School Psychology Professor at Central Michigan University **email:** johns1sb@cmich.edu **phone:** 989-774-6480

You are free to refuse to allow students to participate in this research project or to withdraw your consent and discontinue your student's participation in the project at any time without penalty. Your participation will not negatively affect your student's or your relationship with the school involved in this research project.

If you are not satisfied with the manner in which this study is being conducted, you may report (anonymously if you so choose) any complaints to the Institutional Review Board by calling 989-774-6777, or addressing a letter to the Institutional Review Board, 251 Foust Hall Central Michigan University, Mt. Pleasant, MI 48859.

My signature below indicates that all my questions have been answered. I agree to allow my child participate in the project as described above.

_____ _____
Signature of Parent/Guardian Date Signed

_____
Name of Child/Ward

A copy of this form has been given to me. _____ Parent/Guardian Initials

CMU
CENTRAL MICHIGAN UNIVERSITY

Parent/Guardian Consent Form

Study Title: White noise as a classroom intervention for children with ADHD.

Research Investigators' Names and Departments:

Andrew Cook – Graduate Researcher
email: cook2ar@cmich.edu **phone:** 616-502-2359

Sharon Bradley-Johnson – School Psychology Professor at Central Michigan University **email:** johns1sb@cmich.edu **phone:** 989-774-6480

Introductory Statement

This study is designed to investigate the effects of white noise in the classroom for students with ADHD. White noise is a continuous sound that incorporates the entire spectrum of human hearing.

What is the purpose of this study? The purpose of the study is to help your child stay on task and complete her or his assignments more efficiently. I will be evaluating white noise as an invention for ADHD and the results will provide information regarding the effectiveness of this intervention for ADHD.

What will my child/ward do in this study? Your son or daughter will work on assignments as they normally would and will not be removed from the classroom. They will be asked to wear headphones that will sometimes be playing the white noise. This will occur only once a day during a time where the teacher indicates your child has the most difficulty.

How long will it take my child/ward to do this? Your child will not have to wear the headphones for more than 30 minutes at a time. The study may go on for several weeks, possibly even a few months, with your child participating everyday.

Are there any risks of participating in the study? No, because the volume will be adjusted to prevent any damage to hearing and your child will be instructed not to change settings on the white noise generator.

What are the benefits of participating in the study? If the procedure is effective, your son or daughter may display off-task behaviors less frequently when the white noise is playing and may complete assignments more efficiently.

Will anyone know what my child/ward does or says in this study (Confidentiality)? Information regarding your child will only be viewed by me. Each child will have a number associated with their data and information about your child will be kept separately from the coding system. I will be the only one able to match the data to the identity of the child.

Will my child/ward receive any compensation for participation? No.

Is there a different way for my child/ward to receive this compensation or the benefits of this study? There is no compensation for participating in the study.

Who can I contact for information about this study?

Andrew Cook – Graduate Researcher **email:** cook2ar@cmich.edu **phone:** 616-502-2359

Sharon Bradley-Johnson – School Psychology Professor at Central Michigan University **email:** johns1sb@cmich.edu **phone:** 989-774-6480

You are free to refuse to allow your child/ward to participate in this research project or to withdraw your consent and discontinue your child/ward's participation in the project at any time without penalty. Your participation will not negatively affect your child/ward's or your relationship with the school involved in this research project.

If you are not satisfied with the manner in which this study is being conducted, you may report (anonymously if you so choose) any complaints to the Institutional Review Board by calling 989-774-6777, or addressing a letter to the Institutional Review Board, 251 Foust Hall Central Michigan University, Mt. Pleasant, MI 48859.

My signature below indicates that all my questions have been answered. I agree to allow my child participate in the project as described above.

_____ _____

Signature of Parent/Guardian Date Signed

_____

Name of Child/Ward

A copy of this form has been given to me. _____ Parent/Guardian Initials

CMU
CENTRAL MICHIGAN UNIVERSITY

Child Assent Form for
Minors Aged 7–12

Study Title: White noise as a classroom intervention for children with ADHD.

Research Investigators' Names and Departments:

Andrew Cook – Graduate Researcher
email: cook2ar@cmich.edu **phone:** 616-502-2359

Sharon Bradley-Johnson – School Psychology Professor at Central Michigan University **email:** johns1sb@cmich.edu **phone:** 989-774-6480

What is this research about?

We would like you to help a research study that uses a special sound played through headphones to help you focus better in class. You can ask a question at any time and you can say no anytime you want to. Your parents or legal guardian said that it is OK for you to be in this study, but we want to let you choose if you want to do this.

What will happen to me in this research? – The sound in the headphones may help you block out distractions in the classroom. You will do your work as usual and sometimes you will wear headphones that may or may not be playing the special sound. The sound is a new idea and there is no guarantee it will help you study better.

How long will it take me to be in your research? You will not have to wear the headphones for more than 30 minutes a day. The study will last for a few weeks to a few months.

Can anything bad happen to me? The volume will be adjusted to prevent any damage to hearing.

Can anything good happen to me? You may find that you have an easier time studying and completing your work when the headphones are playing the sound. You are also helping us understand if the sound helps and if it does, it may be used with other children with ADHD.

Do I have other choices? You may choose not to do this.

Will anyone know I am in the research? Only your classmates and teacher will know you are trying to help us with our study and how you are doing.

Will I be paid? No**.**

Who can I talk to about the research? You may talk to your teacher, Andrew or Sharon about the study.

What if I do not want to do this? You do not have to be in this research study. You can say no at any time. No one will be upset with you if you stop.

SIGNATURE CLAUSE

Do you want to be in the study?

☐ *Yes, I want to be in the study* ☐ *No, I do not want to be in the study*

_____
Name of Child (Print)

_____ _____
Signature of Child Date

_____ _____
Signature of Person Explaining Assent Date

A copy of this form has been given to me _____ Participant's Initials

APPENDIX C

CLASSROOM SCRIPT

To be read by teacher

<Student name(s)> has volunteered to wear headphones connected to a special machine for a short time each day in this classroom. The headphones may or may not be playing a special sound. I ask that no one touches the headphones or the machine connected to it because they are very expensive. Only I will be allowed to turn the system on and off. <**Student name(s)>** will be wearing the headphones on and off for the next several months to help him\her in the classroom. Mr. Cook will be coming into the classroom a few times a week to observe us during this time and answer any questions <**Student name(s)>** may have.

APPENDIX D

WHITE NOISE STUDY FORM

Student Name: Teacher Name:

Date	Assignment	Headphones? (Y or N)	Teacher Check	Noise on? (Y or N)	Teacher Check

APPENDIX E

SOCIAL VALIDITY MEASURES

Teacher

Please rate the following comments on a scale of 1 to 5

1 = strongly disagree
2 = disagree
3 =neutral
4 = agree
5 = strongly agree

	strongly disagree	disagree	neutral	agree	strongly agree
Q1: I felt the white noise had a positive benefit the students…					
a) On-task behavior	1	2	3	4	5
b) Assignment completion	1	2	3	4	5
Q2: I felt that the study was easy to implement	1	2	3	4	5
Q3: I would support the school allowing children with ADHD to use white noise generators in the classroom	1	2	3	4	5

Social Validity Measure: Parent

Please rate the following comments on a scale of 1 to 5

1 = strongly disagree
2 = disagree
3 =neutral
4 = agree
5 = strongly agree

	strongly disagree	disagree	neutral	agree	strongly agree
Q1: I felt the white noise had a positive benefit on my child's ability to…					
a) Stay on task	1	2	3	4	5
b) Complete his or her assignments	1	2	3	4	5
Q2: I felt that having my child wear the white noise headphone in class did not interfere with his or her ability to learn	1	2	3	4	5
Q3: I would approve allowing my child to continue to use the white noise in the classroom	1	2	3	4	5

Social Validity Measure: Student

Please rate the following comments on a scale of 1 to 5

1 = strongly disagree
2 = disagree
3 =neutral
4 = agree
5 = strongly agree

	strongly disagree	disagree	neutral	agree	strongly agree
Q1: I felt the white noise helped me					
a) Stay on task	1	2	3	4	5
b) Complete my assignments	1	2	3	4	5
Q2: I felt that wearing the white noise headphone in class was easy and did not interfere with my ability to learn	1	2	3	4	5
Q3: I would like to continue to Use white noise in the classroom	1	2	3	4	5

APPENDIX F

9-ITEM TEACHER CHECKLIST

- **<u>Before they wear the headsets playing white noise</u>**
    - **1- Complete ADDES-3 rating scale**
        - I will help you understand the directions
    - **2- Script provided to the classroom**
        - Let other kids hear the noise
        - Reduce stigmatization

- **<u>During designated time – 5 days a week</u>**
    - **1-Collect assignment(s) they worked on in folder after graded**
    - **2-Student self-monitoring sheet -double checked by you**
        - Student writes assignment they are working on, whether or not they are wearing the headset and listening to the noise
    - **3-Place white noise generator under desk for duration of the assignment(s)**
    - **4-Help student put on headset** – during headset phase only. You will be instructed by me when this begins
    - **5-Only provide the student one-on-one attention when he asks for it**
    - **6-Conduct classroom as you normally would**
        - **i**.e. discipline, classroom rules

- **<u>When the study is completed</u>**
    - **1-Complete social validity scale**
        - Yourself, student and student's parent

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