Sensory Stimulation as an Academic Intervention in High School Students

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S-BEHA-009

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Abstract

Attention-deficit/hyperactivity disorder (ADHD), in particular inattention symptoms, is related to reading and other academic difficulties. Among high school students, ADHD-related inattention symptoms can adversely impact their ability to engage with long reading comprehension passages, which is frequently required of this age group. ADHD also includes difficulties in sensory processing due to the inability to regulate input properly without overloading the brain; this difficulty can lead to impairments in reading. These impairments are caused by the overload of information from sensory sources, thus not allowing proper focus on reading materials. In this context, this pilot study aims to evaluate the effectiveness of a physical sensory intervention on English Language Arts test scores (meant to evaluate reading comprehension) in high school students (ages 14-18; 45% males) using a common fidget device, as well as the influence of ADHD-related inattention symptoms on that relation. Descriptive study results indicate there is a positive relation between the use of the fidget device and increased ELA scores through improved reading comprehension. The SWAN* scores did not have an impact on the ELA scores or time spent using the device. The present study is an initial step in establishing the potential relation between utilizing a fidget device and improving reading comprehension for high school students with possible ADHD related inattention symptoms. Future research is needed to examine this relation, including with larger samples, stronger reading comprehension measures, and participants carefully assessed and/or diagnosed with ADHD.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by symptoms of hyperactivity, impulsivity, and inattention (American Psychiatric Association, 2013). ADHD is one of the most common childhood disorders, affecting approximately 5% of school-aged children (Polanczyk, et al., 2014), and is associated with functional impairments across the lifespan, including within the educational domain (Ek et al., 2011; Miranda et al., 2014). Indeed, adolescents with ADHD are at high-risk of school suspension, as well as lower academic and graduation rates when compared to their peers without ADHD (Barkley, 2004; Arnold et al., 2020; Kuriyan et al., 2013). ADHD-related inattention, in particular, are associated with lower academic achievement (Condo et al., 2022; Breslau et al., 2009; Weiss et al., 2003), including poorer reading outcomes (Frazier et al., 2004). ADHD-related reading problems are highly concerning, as approximately 25% to 40% of children with ADHD present with a co-occurring diagnosis of reading disability (August & Garfinkel, 1990; DuPaul et al., 2013; Semrud-Clikeman et al., 1992). Moreover, reading difficulties occur even among children without formal reading disability diagnoses (Ghelani et al., 2004).

Slipp's (2021) literature review emphasized that executive function plays a major role in reading abilities. Executive function is the cognitive ability to achieve goals. In this review, it was established that executive functioning is a crucial skill for reading comprehension, indicating a need for strategies employed specifically to target executive functioning. Potocki et al., (2017) focused on the consideration of purpose of reading, such as that when reading a narrative, there is less of a demand on executive functioning, therefore potentially being easier

for students (with executive function deficits) to retain information. Recognizing that reading narratives may have less demand on executive functioning and therefore may have improved reading comprehension is important for this study due to their prevalence in educational settings.

A promising intervention for reading difficulties associated with ADHD-related inattention symptoms and executive function impairments are sensory interventions. For example, there is a significant correlation of ADHD symptoms to high levels of sensory processing sensitivity (Panagiotidi, 2018). There has also been continual research and support of the theory that abnormal sensory processing causes people with ADHD to pay more attention to 'subtle' stimuli, which can be interpreted as increased inattentive symptoms (Panagiotidi, 2018). There are both "nonphysical" and "physical" interventions for sensory needs. Nonphysical interventions may include music, which has been shown to be promising in certain cases, such as children with ADHD (Martin-Moratinos et al., 2023). For example, passive music therapy has been shown to improve reading comprehension, as well as inattention symptoms (Martin-Moratinos et al., 2023). Physical intervention for sensory problems has also been found to mitigate symptoms of ADHD (Nejati, 2021). In a study by Nejati (2021), children with ADHD received a balance-based intervention where they were asked to answer different cognitive questions as they attempted to maintain a given body position. It was found that this intervention was effective in improving working memory, cognitive flexibility, and ameliorating symptoms of inattention and hyperactivity. The interaction between a physical and cognitive task helped relieve ADHD symptoms, hypothesized to be through the necessitated processing and using of different sensory input.

This can imply that other interventions that involve using a task that requires sensory processing and performing a cognitive task at the same time may be helpful in alleviating inattention symptoms.

Based on the aforementioned literature, it is logical to predict that there will be a positive relationship between time spent using a fidget toy, and higher reading comprehension scores. This may suggest that use of a fidget device will counteract inattention symptoms, thus resulting in a higher test score.

Methods

Participants consisted of adolescents in grades 9-12 (ages 14-18) with varying levels of inattention symptoms. A parental consent form was provided to each student. Students gave assent to participate on this form as well. One questionnaire will be administered before the testing takes place. It will be for parent-rated inattention symptoms. This will help determine the severity of the students' inattentive symptoms. Items for the inattention questionnaire were drawn from The SWAN* Rating Scale for ADHD (Swanson, 2001). Each student was given one English Language Arts passage-analysis, the August 2019 NYS English Regents Exam. Students will be provided with a box of fidget toys to choose from and a timer/stopwatch for the test administration to time the student's use of the fidget toy. This testing will be conducted in a traditional classroom environment.

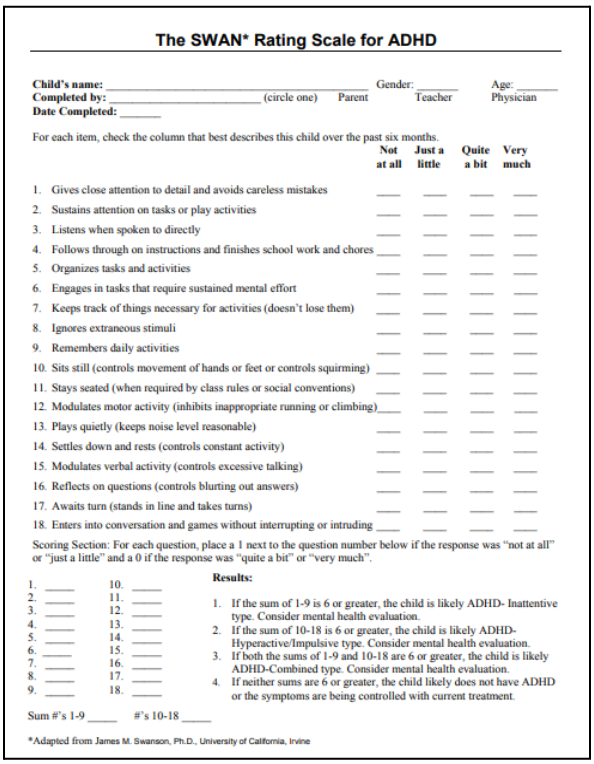
Those who assented to participate received an invitation to come to a controlled setting (a closed classroom with adult supervision) to answer questions about their symptoms and sensory input processing, derived from The SWAN* Rating Scale for ADHD (Swanson, 2001). The SWAN* rating scale also included age, gender, and grade for demographic

information on the student.

Students were given a 9 multiple choice question section of the August 2019 NYS English Regents Exam. This test was selected with the help of qualified ELA teachers. Testing was administered in the same way to each student regardless of grade level or symptom severity. Students were allowed to familiarize themselves with the fidget device before starting the test. The data was collected from each test per student, including the time spent per student using the fidget toy. An observer sat with the student while they completed the test. The test started on the observer's cue. Time spent using the fidget toy was recorded with a stopwatch by the observer, beginning when the student touches it, and ending when they remove contact. To maintain confidentiality, students were given a numerical ID on their test papers (reading packet and SWAN* scale) upon arrival. Upon completion, students were given a paper to hand to their English teacher so they were provided extra credit as a reward for participating in this experiment. Results were graded based on the answer key to the Regents Exam (August 2019 NYS Regents Exam; Picture 1). The time spent using the fidget toy was compared to the score the student receives on their test, and that relationship was compared throughout the data set.

The effect of the toy on the score will be measured by comparing the scores of students who spent less time using the toy to students who spent more time using the toy. If there is a relationship between the time spent using the toy and the scores students receive on the test, then it will be discovered with this variable.

Materials:



The SWAN* Rating Scale for ADHD

Child's name: _____ Gender: _____ Age: _____
Completed by: _____ (circle one) Parent Teacher Physician
Date Completed: _____

For each item, check the column that best describes this child over the past six months.

	Not at all	Just a little	Quite a bit	Very much
1. Gives close attention to detail and avoids careless mistakes	____	____	____	____
2. Sustains attention on tasks or play activities	____	____	____	____
3. Listens when spoken to directly	____	____	____	____
4. Follows through on instructions and finishes school work and chores	____	____	____	____
5. Organizes tasks and activities	____	____	____	____
6. Engages in tasks that require sustained mental effort	____	____	____	____
7. Keeps track of things necessary for activities (doesn't lose them)	____	____	____	____
8. Ignores extraneous stimuli	____	____	____	____
9. Remembers daily activities	____	____	____	____
10. Sits still (controls movement of hands or feet or controls squirming)	____	____	____	____
11. Stays seated (when required by class rules or social conventions)	____	____	____	____
12. Modulates motor activity (inhibits inappropriate running or climbing)	____	____	____	____
13. Plays quietly (keeps noise level reasonable)	____	____	____	____
14. Settles down and rests (controls constant activity)	____	____	____	____
15. Modulates verbal activity (controls excessive talking)	____	____	____	____
16. Reflects on questions (controls blurting out answers)	____	____	____	____
17. Awaits turn (stands in line and takes turns)	____	____	____	____
18. Enters into conversation and games without interrupting or intruding	____	____	____	____

Scoring Section: For each question, place a 1 next to the question number below if the response was "not at all" or "just a little" and a 0 if the response was "quite a bit" or "very much".

1. _____ 10. _____
2. _____ 11. _____
3. _____ 12. _____
4. _____ 13. _____
5. _____ 14. _____
6. _____ 15. _____
7. _____ 16. _____
8. _____ 17. _____
9. _____ 18. _____

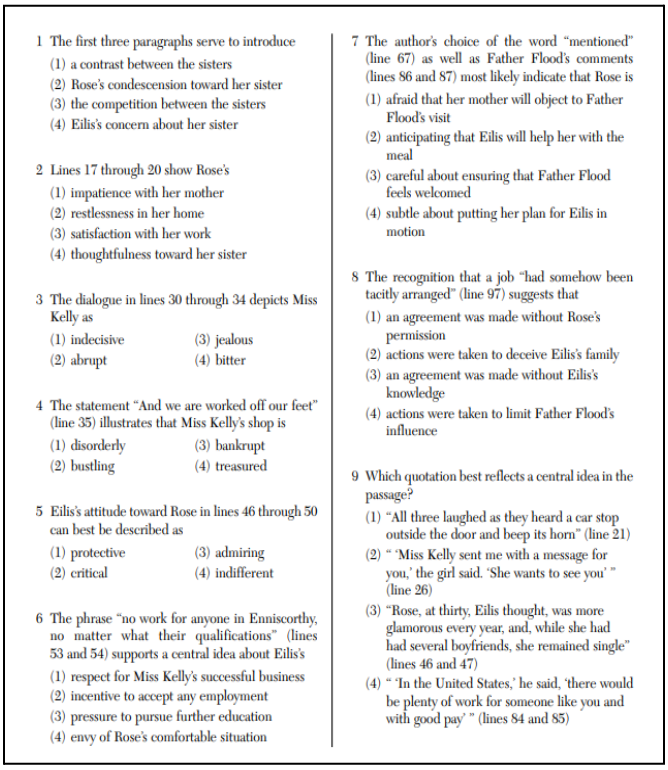
Sum #'s 1-9 _____ #'s 10-18 _____

Results:

1. If the sum of 1-9 is 6 or greater, the child is likely ADHD- Inattentive type. Consider mental health evaluation.
2. If the sum of 10-18 is 6 or greater, the child is likely ADHD-Hyperactive/Impulsive type. Consider mental health evaluation.
3. If both the sums of 1-9 and 10-18 are 6 or greater, the child is likely ADHD-Combined type. Consider mental health evaluation.
4. If neither sums are 6 or greater, the child likely does not have ADHD or the symptoms are being controlled with current treatment.

*Adapted from James M. Swanson, Ph.D., University of California, Irvine

Picture 1, NYS August 2019 English Regents Exam, Section A



1 The first three paragraphs serve to introduce
(1) a contrast between the sisters
(2) Rose's condescension toward her sister
(3) the competition between the sisters
(4) Eilis's concern about her sister

2 Lines 17 through 20 show Rose's
(1) impatience with her mother
(2) restlessness in her home
(3) satisfaction with her work
(4) thoughtfulness toward her sister

3 The dialogue in lines 30 through 34 depicts Miss Kelly as
(1) indecisive (3) jealous
(2) abrupt (4) bitter

4 The statement "And we are worked off our feet" (line 35) illustrates that Miss Kelly's shop is
(1) disorderly (3) bankrupt
(2) bustling (4) treasured

5 Eilis's attitude toward Rose in lines 46 through 50 can best be described as
(1) protective (3) admiring
(2) critical (4) indifferent

6 The phrase "no work for anyone in Enniscorthy, no matter what their qualifications" (lines 53 and 54) supports a central idea about Eilis's
(1) respect for Miss Kelly's successful business
(2) incentive to accept any employment
(3) pressure to pursue further education
(4) envy of Rose's comfortable situation

7 The author's choice of the word "mentioned" (line 67) as well as Father Flood's comments (lines 86 and 87) most likely indicate that Rose is
(1) afraid that her mother will object to Father Flood's visit
(2) anticipating that Eilis will help her with the meal
(3) careful about ensuring that Father Flood feels welcomed
(4) subtle about putting her plan for Eilis in motion

8 The recognition that a job "had somehow been tacitly arranged" (line 97) suggests that
(1) an agreement was made without Rose's permission
(2) actions were taken to deceive Eilis's family
(3) an agreement was made without Eilis's knowledge
(4) actions were taken to limit Father Flood's influence

9 Which quotation best reflects a central idea in the passage?
(1) "All three laughed as they heard a car stop outside the door and beep its horn" (line 21)
(2) " 'Miss Kelly sent me with a message for you,' the girl said. 'She wants to see you' " (line 26)
(3) "Rose, at thirty, Eilis thought, was more glamorous every year, and, while she had had several boyfriends, she remained single" (lines 46 and 47)
(4) " 'In the United States,' he said, 'there would be plenty of work for someone like you and with good pay' " (lines 84 and 85)

Picture 2, SWAN* Rating Scale for ADHD (Swan, 2001)

Picture 3, Fidget Device (Ray 2023)

Questions on the NYS ELA regents were all related directly to the content of the passage read beforehand. As an example, question 4 referenced specific lines from the passage. "The statement "And we are worked off our feet" (line 35) illustrates that Miss Kelly's shop is…" The majority of the questions used this same format, unless asking about the overall message/content of the passage. Questions on the SWAN* form (Picture 2) were statements relating to inattention/hyperactivity, where students responded by selecting the column that best described how much they related to that statement. Question 4, "Follows through on instructions and finishes schoolwork and chores" and question 2, "Sustains attention on tasks or play activities" both ask the student to measure their own ability to pay attention. When the students selected how much they related to the statement, they had the options "Not at all", "Just a little", "Quite a bit", and "Very much" to choose from.

There is no traditional control group, since the test will only be administered once to gauge the effects of time spent using the fidget toy on the student's scores.

The environment the study was conducted in was controlled for consistency. This means a quiet classroom with students, desks, and a supervising teacher. The fidget toy will be a control factor as well, since the students will all be given a fidget toy. The length of the test was also a consistent factor, as it always had the same passage-question structure. The test itself was a consistent factor, as ELA teachers in this school use old NYS Regents exams for all grades, therefore it is possible to use this test for all participating grades.

Data Analysis

Results were analyzed using the program Data Classroom, a user-friendly program commonly used in high school or college to help students learn how to work with data and

statistics. Linear regressions, ANOVA, and a post hoc statistical analysis were run using this program.

Results

SWAN scores were collected as a measure of ADHD symptomatology in the participating students. A score labeled “1” describes a child very likely to have Inattentive type ADHD, a score labeled “3” describes a child very likely to have Combined-Type of ADHD, and a score labeled “4” describes a child who does not exhibit enough symptoms in either Inattentive or Hyperactive to potentially meet ADHD diagnosis criteria. In this study, the majority of students scored 4s, with two students scoring 1s, and one student scoring a 3.

Table 1

ELA score (x/9)	Total Time on Test (s)	Cube Total Time (s)	Swan Score	Age	Gender
6*	795.34	441.95	3	15	M
7	686.8	84.63	4	14	F
3	836.63	15.49	4	14	F
4	594.64	19.02	4	15	F
7	725.52	412.27	4	14	M
8	833.46	536.04	4	15	F
6	652.87	1.9	4	16	F
4	1210.55	65.75	4	16	F
5	583.16	17.98	4	16	F
8	648.56	13.54	4	15	F
5	643.48	63.5	4	16	M
6*	681.26	687.6	1	16	M
9*	380.53	144.78	1	17	M
8	583.03	18.85	4	17	M
6	496.17	4.07	4	16	M
7	982.2	530.64	4	18	M
7	980.28	595.54	4	17	F
8	765.37	552.1	4	18	M
8	632.13	215.24	4	17	F
7	686.1	684.84	4	18	F

Highlighted sections show the students who received scores other than 4 on the SWAN ADHD rating scale, which are indicative of possible ADHD

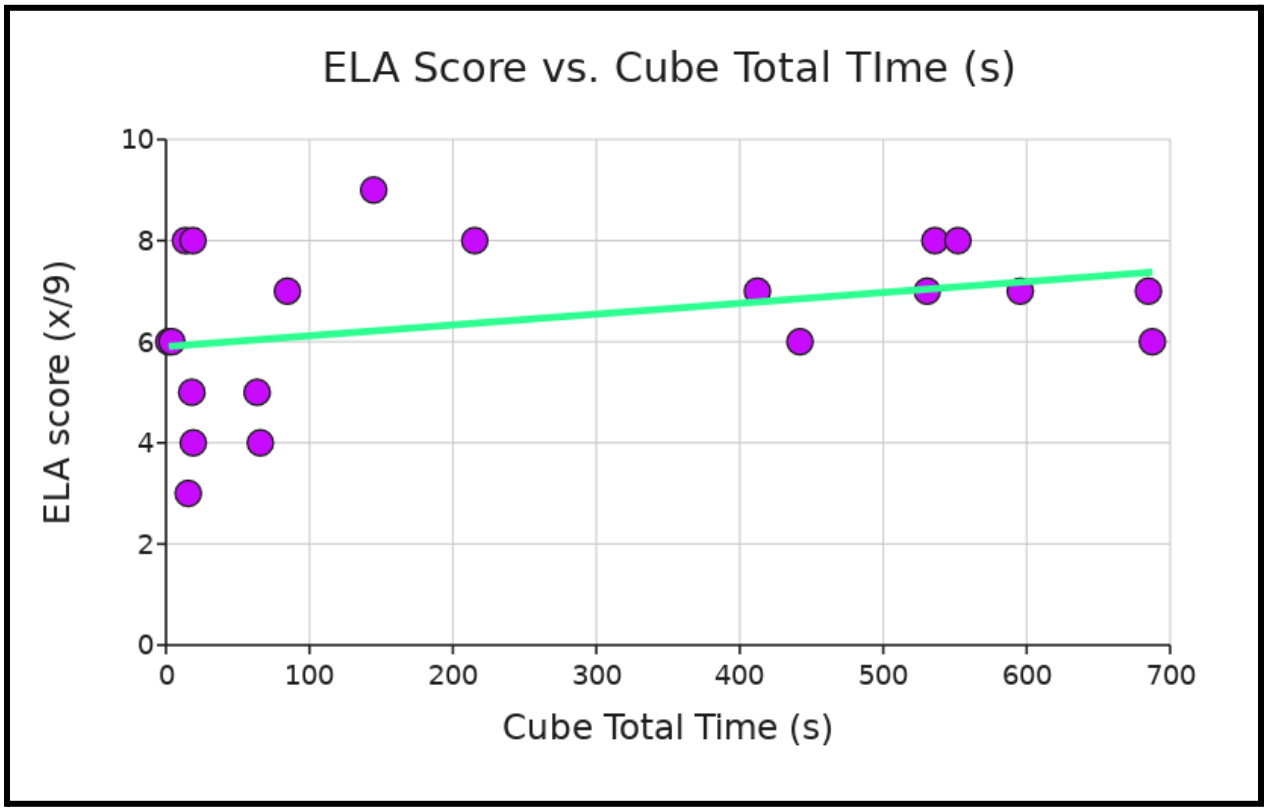


Figure 1, ELA Score vs. Cube Use Time

In the above figure, the comparison between Cube Total Time (s) and ELA Scores is shown. It shows a positive relationship, and upon analysis with Data Classroom, the linear regression showed a p-value of 0.13, with an equation of y = 0.002141x + 5.903. This is an insignificant statistical value. However, the positive r^2 value (0.123) indicates a descriptive relation.

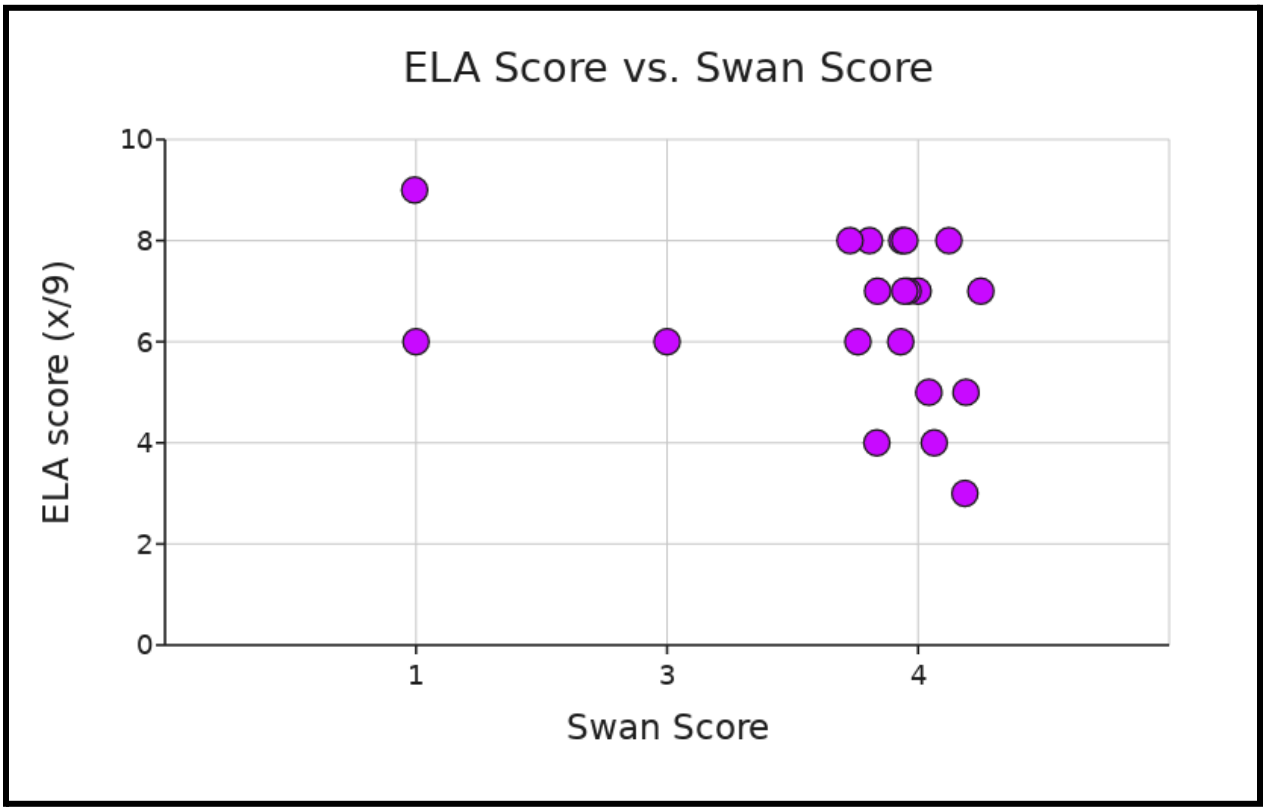


Figure 2, ELA Scores vs SWAN Scores

Figure 2 indicates that students that scored within the ranges of possible ADHD scored just around the average (or above) ELA score of 6.45. The ANOVA that was run gave a p-value of 0.63.

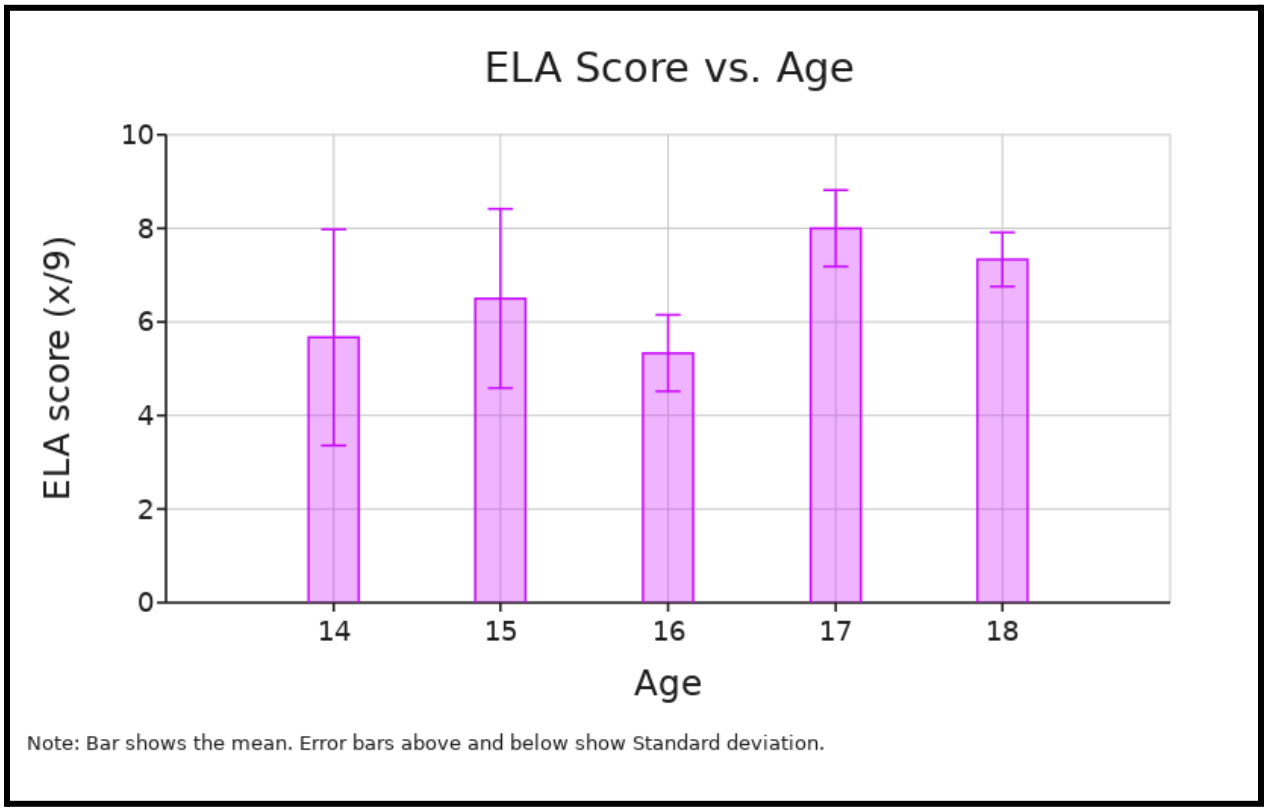


Figure 3, ELA Score vs. Age of Participants

Figure 3 shows that some of the variations in test scores could be due to age, as it appears that the majority of the older students (17-18) have the highest test scores. There are some outliers in the younger groups, such as higher or lower scores on the average age group. An ANOVA was run, and revealed a p-value of 0.06. Between specific age groups in a post-hoc test, it was revealed that 17-16 had significant differences *(*p= 0.05). This demonstrated a difference in age groups and test scores.

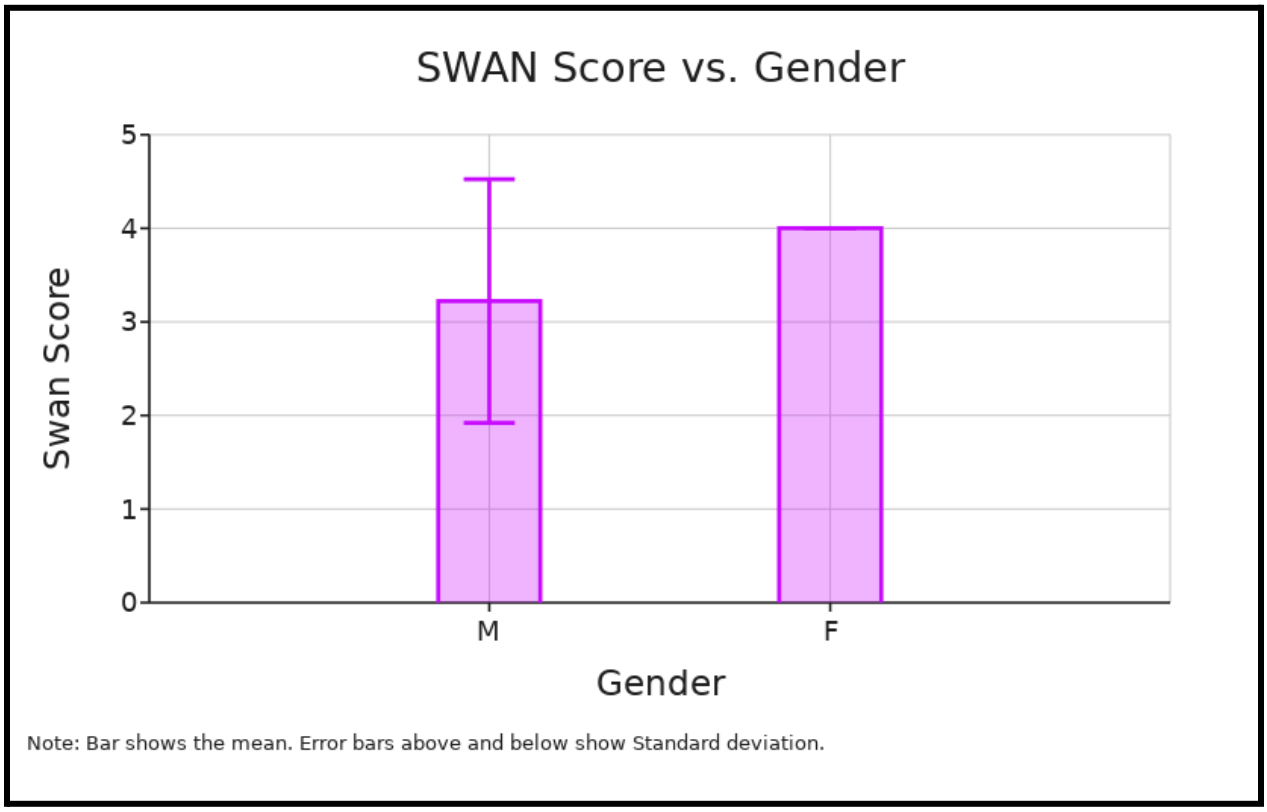


Figure 4 **Gender was self reported by students, M for male, F for female.*

Figure 4 demonstrates the results of a t-test comparing SWAN Scores and gender of the students. The p-value was 0.11, indicating a possible descriptive relationship between gender and Swan Scores. The males had the Swan Scores indicative of ADHD, while none of the females measured at levels indicative of ADHD.

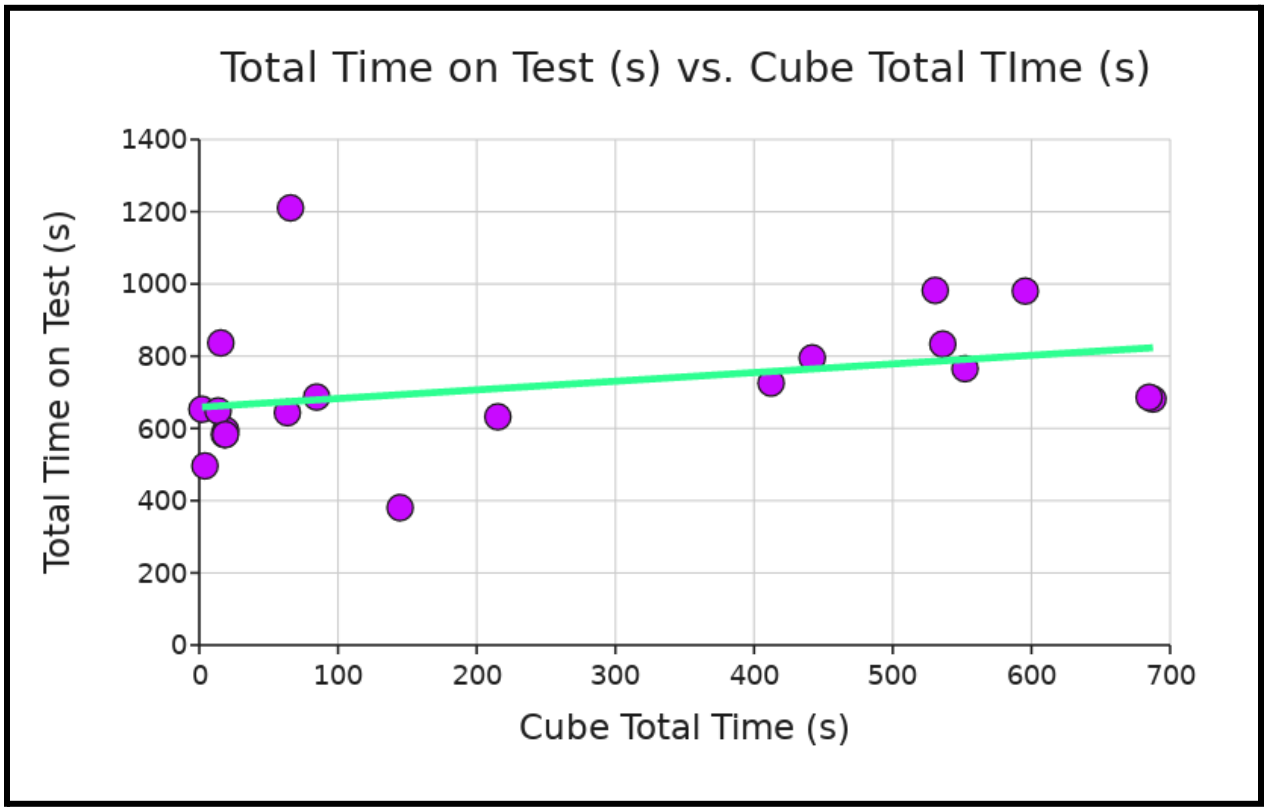


Figure 5

This linear regression of time spent on test vs time spent using the toy had a p-value of 0.14, indicating a possible relationship. The linear regression equation was y = 0.2394x + 658.8, with an r^2 value of 0.115. If there is a relationship between these two variables, then it is possible to say that the more time spent on the test, the more the students will use the toy.

Discussion

Given the overlap between ADHD inattention symptoms and reading comprehension difficulties, it is crucial to find accessible and functional interventions in the classroom. Physical interventions, such as fidget devices may serve as an important tool in mitigating the academic difficulties associated with ADHD symptoms. The present study sought to determine if this physical and sensory intervention (fidget toy) would mitigate the inattention symptoms

impacting reading comprehension ability. Figure 1 demonstrates that there is a possible positive relationship between the variables. With a p-value of 0.13, (while not significant) it is possible that the relationship, given more samples to analyze, could be significant. On account of the relationship between those variables, it is important to include this as evidence of physical, sensory interventions as a way to improve focus on reading comprehension in high school students. Since the SWAN scores were not included in this specific analysis of Cube Time (s) and ELA Score (x/9), it is also important to note that it is possible that a physical, sensory intervention while reading can improve reading comprehension for students without ADHD.

Figure 2 provides evidence that the relationship between ADHD symptoms and ELA scores was not significant. This implies that either ADHD type may not have an effect on reading comprehension, the intervention was successful, or there was not enough data for the students who measured within the ADHD ranges supplied by the SWAN score questionnaire. In contrast, Figure 3 demonstrates that age may play a factor in the ELA scores. This is likely due to the older students simply having, on average, more experience with this test structure. Though some participants ages 14-15 had higher scores, on average they did not have similar levels in reading comprehension when compared to ages 17-18. Though the test structure is used for all age groups in the school, the older participants have had more exposure and practice with this format.

Figure 4 shows that it was only the male students that met the ADHD criteria presented by the SWAN questionnaire via self-assessment. This could be due to sample size, and not having enough students for females meeting ADHD criteria presented by the SWAN test. It

could also be representative of females having, on average, lower rates of ADHD due to demonstrating symptoms differently (Mowlem, 2019). This would require much more exploration, with a much larger, more varied sample.

Figure 5 demonstrates a possible relationship between time spent on the test and the time spent using the toy. Findings may suggest that if the student spends more time on the test, they may use the toy more, and thus may get a better test score. Additionally, per Figure 1, a longer usage period of the fidget device is correlated with higher ELA test scores. Future studies are required to determine this relationship.

There were several limitations that should be discussed. This study was conducted with a small sample of 20 students. Participants were primarily honor students and there were 5 students per grade level (freshman, sophomore, junior, senior). Limitations in sample size can be attributed to recruitment and class restrictions. Larger sample size, and recruitment of students beyond those in honors classes may have led to more varied and conclusive results. Furthermore, given the sample primarily comprised of honor students, this could lead to elevated reading comprehension scores that make it more difficult to detect the benefits of the fidget toy. Additionally, while the current sample consisted of an even split of male and female students, a larger sample size may have allowed for more reflective differences in ADHD presentations between sexes found in current literature. In Mowlem 2019, it was found that differences in perceptions of ADHD symptoms may have caused underdiagnosis in female vs male children. This study implied that differences in presentation (females presenting with inattentiveness more often) is often overlooked in studies and the real world. It is also worth considering the potential bias of the fidget device's presence. Finally, given that students knew

they were being observed, they may be less inclined to use the fidget toy due to appearing distracted and disengaged. Future studies may benefit from explicitly indicating that the fidget toy is there for the participant to use if it is beneficial.

Conclusion

While the hypothesis was not strongly supported by the data collected, this study demonstrated support for a physical, sensory intervention in an academic setting, for a complex process that ADHD impacts. This pilot study adds to the literature field of ADHD and reading comprehension/ability, as well as support for sensory interventions for ADHD symptomatology. While findings were not statistically significant, they may provide indicative information for much larger studies building upon this idea. Given the accessibility of fidget devices, physical sensory intervention may serve as an important and obtainable intervention for combating the academic difficulties that come with higher levels of ADHD symptoms. This is important to acknowledge when discussing interventions that often require medical professionals. More accessible interventions may allow for more individuals of varying incomes to negate against common academic difficulties. The present study may serve as a foundation for future studies of larger sample size to further determine the effects of fidget devices and ADHD symptoms on reading comprehension scores.

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