2019

Can Fidgeting Help Students Maintain Attention? How Restricting Movement And Varying Cognitive Load Relate To Attention On Reading Comprehension Task

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A Thesis

Presented to

The Faculty of the Department of Experimental Psychology

Indiana State University

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

by

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May, 2019

Abstract

In an attempt to understand the implications that fidgeting may have upon student academic performance in the classroom, the relationship between fidgeting behaviors, sustained attention, and hyperactivity was examined. Twenty-eight fifth grade students were asked either to move as normal or have their movement restricted during a reading task. They were also asked to remember either one or five digits while engaging in a reading task in order to vary the cognitive load placed upon each participant during with the task. Teachers were asked to complete a hyperactivity rating scale for each participant to determine their typical levels of hyperactivity in the classroom. It was hypothesized that there would be main effects of cognitive load and movement restriction on reading comprehension and instances of participant fidgeting. It was also hypothesized that there would be a correlation between reported hyperactivity and instances of fidgeting. Ultimately, none of the hypotheses were supported. Implications, such as the social stigma of fidgeting and expected classroom behavior, limitations, such as measuring and coding difficulties, and possible avenues for future research, including examining groups with and without ADHD diagnoses, are discussed.

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Can Fidgeting Help Students Maintain Attention? How Restricting Movement and Varying Cognitive Load Relate to Attention on Reading Comprehension Task

Primary school is the beginning of the road in the long journey of an individual's education. While curricula and student expectations may change over the years, certain aspects of school seem to persist throughout time. One characteristic that appears to be permanent in many classrooms is that students are expected to sit still in order to pay attention during lessons throughout the school day. While remaining still during lengthy or monotonous tasks may be adequate for some students, others may experience the unconscious desire to fidget while doing schoolwork. Although fidgeting behaviors exist around us all on a daily basis, there is a surprising dearth of psychological research on the subject, and it seems as if every study reaches a unique, different conclusion as to the reason behind why people fidget and what situations may provoke the behavior. This mysterious habit is defined as, "uneasiness or restlessness as shown by nervous movements" (Merriam-Webster, 2018). While this dictionary entry does indeed provide a definition, it remains vague and limited in scope. The murkiness associated with this definition is mirrored by the scientific literature on the subject in which even researchers have trouble reaching a consensus about how to properly define fidgeting. While it is difficult enough to come up with a proper, all-encompassing definition, understanding *why* people fidget may be even harder to understand.

Whether it is referred to as fidgeting or fiddling, there are countless explanations as to why people fidget, and some appear to be favored more than others within the psychological community. Psychologists as far back as the 19th century have noticed that there seems to be a link between the capacity to pay attention and extraneous body movements (Ribot, 1890). In a particularly early explanation of fidgeting, Francis Galton discussed observations he made of students during a lecture (Galton, 1885). He claimed that fidgeting occurred in parallel with diminished attentional engagement. As students sat in lectures, he noticed that they became increasingly fidgety as a function of time and material covered. Occasionally, he noted, something in the lecture would occur that caused the audience to become mentally aroused. When this happened, he witnessed an important observation: the fidgeting behaviors in the audience greatly decreased in terms of both duration and severity. Although this is a relatively casual anecdote about fidgeting behaviors, it is fairly consistent with modern theories, which predominantly argue that fidgeting and inattention are intricately related. While early understandings of fidgeting behaviors, such as what Galton believed, were purely circumstantial and observational, there is a recent newfound interest on the topic from a research standpoint.

Currently, there exist two schools of thought about fidgeting habits. One group argues that an individual will fidget as they become less engaged with a given task and that fidgeting would divert attention away from the primary task. In other words, people who subscribe to this belief of fidgeting would say that individuals become distracted by their own fidgeting behaviors, taking important resources away from other areas of cognition. According to this viewpoint, fidgeting would be seen as detrimental towards one's attentional capacity; as fidgeting increases, an individual's attention would likely decrease. It seems as if this was, and perhaps still is, the popular opinion in the educational system. For example, one researcher asked 24 high school teachers what they desired when they told their students to pay attention (Carson, Shih, & Langer, 2001). Roughly 97 percent of the teachers responded by saying that they wanted their students to sit still and that this would represent them attending to the lesson. Clearly, these teachers would argue that fidgeting is harmful for maintaining one's attention.

On the other end of the spectrum, and in direct contrast with what was discussed above, is the belief that fidgeting may help to alleviate some of the difficulties of paying attention to a task. Simply, individuals that support this claim believe that engaging in fidgeting behaviors helps keep one's focus on a primary task by introducing an external stimuli that serves to offset inattention or boredom resulting from disengagement with a task (Zentall, 1975). It is important to consider, however, that the two sides of this theoretical coin both assume the same foundation: fidgeting occurs alongside inattention. They merely differ on how fidgeting affects individuals following the onset on the behavior. For example, proponents of this belief would argue that fidgeting initially shows itself occurring as one's attention is fading, but that that inattention should be relatively short lived as fidgeting continues because of the arousing aspect associated with the action.

As stated, the most prevalent and widespread theory seems to be that fidgeting occurs in tandem with the onset of inattention (Farley, Risko, & Kingstone, 2013), with researchers on either side arguing about its benefits or detriments towards cognition. While fidgeting may not necessarily be *caused* by inattention or vice-versa, researchers believe that they are correlated and that fidgeting can act as a cue to others that an individual is entering a state of inattention. Simply put, when an individual spends an extended amount of time on an under-stimulating task or is generally in an under aroused state, he or she may unknowingly begin to fidget as a means of increasing physical arousal; in other words, it is believed that dips in mental focus are paralleled by increases in bodily mannerisms. While fidgeting may initially occur because an individual's attention towards a task is waning, many researchers (Zentall, 1975 and Kercood, Grskovic, Lee, & Emmert, 2007) think that it happens as the body's natural way of increasing physical arousal, which would, in turn, rouse the individual to an increased attentional state, making it a useful tool to those who may need to maintain long term focus on a task. Although it may sound as if the presence of fidgeting indicates that an individual has lost focus, it could actually be the opposite case; while fidgeting is indeed likely to occur in individuals who are beginning to experience inattention towards a task, that same act should have the subsequent benefit of helping the person to experience greater long-term focus following the onset of the act through increased physical arousal. Because much of our structured time is spent constrained to a chair or desk, as is the case in most school and many work environments, fidgeting may be especially useful for increasing physical arousal when it is difficult or impossible to get up and walk around.

Wilson (2002) argues that the body plays a very important role in mediating cognition and that bodily movements may help facilitate greater cognitive regulation. Fidgeting can be an effective tool for warding off inattention in the classroom by increasing arousal (Wilson & Korn, 2007) or introducing a change in task (Ariga & Lleras, 2011), both of which have been suggested to help individuals maintain their attention on a long or unstimulating task. One can view the action of fidgeting as a sort of mental jump start initiated by a physical motion that interacts with attentional systems in order to sustain or optimize attention. Indeed, students who engaged in fidgeting behaviors during schoolwork experienced benefits at both the micro level of movement (Kercood & Banda, 2012), which could be characterized as small hand movements like tapping fingers or clicking a pen, and at the macro level of movement (Mahar et al., 2006), which could include full arm stretches or leg tapping; this suggests that movement, or lack thereof, may be an important factor when considering how people enter a state of inattention. It may be beneficial for educators to not only tolerate but, in fact, encourage fidgeting behaviors in students who derive benefits from them rather than reprimanding those students for physical movement throughout lessons.

Hand and body movements have been shown to be linked to other areas of cognition in addition to attention. Pine, Bird, and Kirk (2007) investigated children's hand movements and their lexical retrieval abilities. Researchers randomly assigned children into two groups; the experimental group had their gestures restricted by placing their hands in mittens fastened to their desks with Velcro, while the control group was allowed to gesture as usual. They found that the children were able to correctly assign a label to more pictures when allowed to gesture compared to when their gestures were restricted. Additionally, children were able to resolve a "tip-of-the-tongue state" more often when allowed to gesture with their hands. These results suggest that gesturing is an important aspect of utilizing language and information recall. Children who had their hand movements restricted had a harder time processing and utilizing different language skills, demonstrating a potential link between hand movements and their ability to think quickly and accurately. Because many teachers often tell students to remain as still as possible while speaking or giving a verbal presentation, these findings have important implications in the classroom in terms of giving students the best possible chance to utilize their language comprehension skills to their fullest abilities. To date, this is one of the few studies that examined the results of restricting hand movements on task performance. There have been even fewer studies, if any, that have actively restricted children's hands in an attempt to examine how fidgeting may impact constructs such as attentional control and information recall.

Optimal Stimulation Theory

A theory that may shed light on the complex nature of fidgeting behaviors is the Optimal Stimulation Theory. This pro-fidget theory proposes that when an individual experiences a level of stimulation below their typical, desired level, they will unknowingly seek external means of stimulation to achieve their optimal, homeostatic level, which better allows them to focus on the task at hand (Zentall, 1975). Tasks that could be classified as under-stimulating would include monotonous or unchallenging tasks, such as completing overly simple math problems (Greenop & Kann, 2007 and Kercood et al., 2007) listening to something considered boring (Andrade, 2009) or reading mundane passages. As the theory's name suggests, activities that increase arousal may attenuate some of the negative effects associated with under-arousal, such as decreased sustained or focused attention. The type of external stimulation that an individual may seek can range from bodily movements (Carriere, Seli, & Smilek, 2013), which could include extremity manipulation or hair-twirling, to object manipulation (Kercood & Grskovic, 2010), such as clicking a pen or playing with articles of clothing, to visual and auditory stimuli (Greenop & Kann, 2007), which could include listening to music. Extraneous stimulation, in the form of physical movement or perceptual stimulation, has been demonstrated to provide benefits towards maintaining attention on a long task. Additionally, if given the option, individuals are more likely to select a form of extra stimulation that has been previously associated with greater instances of on-track behavior (Emmert, Kercood, & Grskovic, 2009). This suggests that individuals may be either unconsciously or overtly aware of their improved on-task behavior with added stimulation.

To provide an example of the Optimal Stimulation Theory in action, a researcher conducted a study to see if supplementing a low-stimulation task with an unrelated, high-stimulating task would improve on-task performance (Andrade, 2009). She had participants listen to a pre-recorded phone call under two conditions. The control group listened to the call and wrote down key information pertaining to the call on a notepad, which could be considered analogous to students taking notes during a lesson, while the experimental group listened to the call while shading in printed images, which would be similar to students doodling during a lesson. The results would likely be shocking to many people: the experimental group recalled more information on a surprise memory test when compared to the control group, suggesting that completing this extraneous and stimulating, yet unrelated, task actually aided in concentration and memory retention. This method of increasing external stimulation is thought to be useful both for students with and without attentional problems and students with an inherent propensity to fidget; this has important implications for classroom procedures involving taking notes and completing exams. These interesting results provide credibility to the Optimal Stimulation Theory by showing that individuals who supplemented their mundane task with an extraneous, engaging activity were able to better process the information than those who attempted to actively attend to the information.

Individuals, when subjected to an under stimulating situation, are expected to fidget in different ways depending on their environment and movement options. For example, when not constrained to a seat, people may be more likely to stand up and walk around when their attention begins to lapse. When restricted to a seated position, people may further fidget in different ways; for example, certain people may engage in object manipulation while others may touch their mouth or face. When an additional restriction is placed on hands, one may experience more instances of “leg jiggling”, bouncing, or squirming in their seat. Researchers wanted to know if children derived varying attentional benefits from varying types of physical movement (Kercood & Banda, 2012). Children with and without attentional problems participated in three conditions. In the baseline condition, participants listened to a story read aloud through a speaker and were provided with no stimulation during the task. In the other two conditions, participants completed a similar listening task but were given either a pencil and paper to doodle with or an exercise ball to sit on during the task, both of which provided more stimulation than the baseline. Results indicate that participants overall completed a recall quiz faster and with a higher accuracy during the experimental conditions compared to the baseline condition. Specifically, participants completed the task faster in the doodling condition, but overall accuracy was higher in the exercise ball condition. It is additionally worth noting that participants with attentional problems received marginally more benefit from the intervention conditions. While it is true that participants overall performed better in the doodling and exercise ball conditions, those with attentional problems experienced a slightly higher boost in accuracy than those without attentional problems. These results suggest that both gross and fine motor movements may help any individual to maintain focus on a task that is not particularly engaging, such as listening to an unstimulating recording. Giving students the opportunity to engage in physical movements, within the realm of possibility in a classroom setting, may be beneficial to them when they feel under stimulated.

While the Optimal Stimulation Theory traditionally explains fidgeting behavior as a result of hyperactivity associated with ADHD, to be discussed in subsequent sections, some research shows that extra stimulation can help both children with hyperactivity as a result from ADHD and typically developing children (Greenop & Kann, 2007). In this study, researchers wanted to determine if introducing an extra stimulus to children during an unchallenging math task would help or hinder their performance. They chose to use an auditory stimulus so that the extra stimulus would not compete for resources from the primarily visual modality associated with completing arithmetic. The researchers hypothesized that children with ADHD would perform at an overall lower level on a math task than typically developing children in the condition with no extra stimulation, but that the scores of the children with ADHD would improve in the condition with the extra stimulation. While this hypothesis was indeed supported, they also found that the mean accuracy score of math problems completed was higher for both groups in the extra stimulation condition than in the condition with no extra stimulation.

These aggregated results of many of the aforementioned studies provide some evidence that Zentall's (1975) Optimal Stimulation Theory may apply to all children and not merely those with an ADHD diagnosis. Overall, participants in all the above studies experienced an increased performance in the forms of higher rates on recall quizzes and higher accuracy on a math task in the conditions with the extra stimulation compared to the conditions with no added stimulation. Students who were not able to supplement their stimulation during these monotonous tasks performed at lower levels than children who received extra outside stimulation.

Trait hyperactivity

An important aspect to keep in mind when discussing constructs such as attention, especially in young children, is that of hyperactivity. In and outside of the classroom, hyperactivity has important implications on how a child will behave. For example, Holborow and Berry (1986) found that among a sample of children, 26.5 percent of children who were labeled as hyperactive experienced learning difficulty, whereas only 5.2 percent of the non-hyperactive children experienced learning difficulties. Additionally, Zentall (1993) found that reading comprehension, math performance, and both sustained and selective attention were adversely affected by a child's observed hyperactivity levels. Zentall (1993) theorizes that decreased performance in these areas may not result solely from hyperactivity, but rather that it may be caused by the mental effort made by a child in an attempt to sit still. Socially, students are expected to sit relatively still during lessons in order to pay attention to the primary task of the lesson and avoid attending to extraneous, distracting stimuli that would result in diminished focus. However, the mere thought of having to sit still may be enough to distract students with a higher propensity towards hyperactivity. Rather than attending to a given lesson, hyperactive students may be putting greater effort towards monitoring and controlling their bodily activity. By allowing these students to move freely, they may have an easier time allocating their cognitive resources towards the important subject materials.

Although it would be interesting to include, an ADHD diagnosis is not a variable in the current study. That being said, one of the most common symptoms of ADHD includes hyperactivity (Feldman & Reiff, 2014), which will be a construct of interest here as this behavioral component is important in understanding one's tendency towards fidgeting. It is also important to note just how prevalent this disorder is; in the U.S., ADHD is among the highest diagnosed neurodevelopmental disorders in children and adolescents and continues to increase (Pastor & Reuben, 2008). By accruing more knowledge on fidgeting behaviors and how they relate to symptoms of ADHD, such as inattention and hyperactivity, it could have important implications for classroom behavioral expectations. Because there are few existing studies that examine restraining hand movements in children, it is hard to determine how students with higher trait hyperactivity will react to the intervention. Hyperactive students may have a hard time remaining still even if they are asked to refrain as much as possible from moving.

While an argument can be made that fidgeting provides some level of benefit to any type of individual, some studies propose that children with higher trait hyperactivity may benefit from it more than those with lower levels of hyperactivity (Hartanto, Krafft, Iosif, & Schweitzer, 2016). Hartanto et al. (2016) wanted to understand how frequency, duration of, and intensity of physical movements interacted with how well typically developing children and children with

ADHD performed on a flanker paradigm task. Participants wore activity monitors to quantitatively measure how much motor activity they engaged in during the task. Results indicated that more rigorous movement significantly boosted performance in the group with ADHD, but not in the typically developing group. This suggests that children with more hyperactive tendencies may benefit from the ability to move during a complex task more than individuals without the high propensity for hyperactivity. Additionally, children with ADHD fidgeted more frequently during their correct trials than during their incorrect trials. The results of this study suggest that restless behaviors associated with hyperactivity may function as a means to regulate attention and increase alertness. Alternatively, the students with hyperactivity may have been better able to focus on the task while moving because they were not simultaneously asked to remain still. However, it should be noted that other studies (Greenop & Kann, 2007 and Kercood & Banda, 2012) have found benefits from movement in samples of children with and without ADHD, suggesting that movement while completing a task has the possibility of helping individuals with different needs. Once again, while an ADHD diagnosis is not a variable in the current study, it may prove useful to understand a participant's typical level of hyperactivity in a classroom setting to understand how manipulations of movement restriction and task load affect their fidgeting behaviors.

Cognitive load and working memory

Another important concept to consider when broaching the subject of attention is that of cognitive load and how it impacts one's working memory. Specifically, cognitive load refers to how much mental effort is being spent as a function of one's working memory (Daneman & Merikle, 1996). Simply put, the more that a task requires of an individual's working memory, the higher the cognitive load associated with that task. It has been suggested that by increasing the cognitive load associated with completing a reading task, the perceived difficulty of the task should similarly increase because of the increased demands for working memory (Carretti, Borella, Cornoldi, & De Beni, 2009). As an example, Ariga and Lleras (2011) found that by asking participants to maintain a series of digits in their memory during a vigilance task, their performance on the primary task was lower than participants who were not asked to remember digits during the primary task. These results indicate that when an individual's working memory is taxed more heavily, their performance on accompanying tasks should likely be diminished.

It is to be expected that as task difficulty increases, the time it takes to complete the task should proportionally increase and performance on the task should decrease. To assess this prediction, researchers asked participants to complete an attention network task (ANT) under two conditions with varying cognitive load (Najmi, Amir, Frosio, & Ayers, 2014). Participants were asked to complete the ANT while counting backwards from 100 by ones or by threes in the low load and high load conditions, respectively. They found a significant main effect of cognitive load for both the speed and accuracy associated with completing the task that required more working memory. The task that involved a low cognitive load was completed significantly faster and with significantly greater accuracy than the high load condition. Based on these results, researchers argue that tasks with greater cognitive load tax working memory more than tasks with low cognitive load. This discrepancy would account for diminished performance of participants in conditions of high versus low load.

Fidgeting that occurs alongside waning attention is expected to occur when an individual must endure an unstimulating or easy task when compared to a more engaging task that requires greater mental facilities; prior examples would argue that this sort of fidgeting occurs in order to keep an individual mentally engaged in the task. In a laboratory or classroom setting, individuals typically have two tasks to attend to: completing a manifest or primary task, which could include listening to a lesson or completing an exam, and focusing on sitting relatively still, which could be considered a secondary task. Certain researchers, such as Farley et al. (2013) might argue that if an individual is presented with a secondary task that requires some level of mental control, such as consciously attempting to sit still, it would follow that during periods of inattention, performance should be diminished in both the primary and secondary tasks. This is because when an individual is in a state of inattention, they will have fewer mental capacities, or executive-control resources, to devote to the tasks. Greater cognitive resources will be spent considering the two tasks rather than just the one. It is therefore theorized that when individuals are presented with a primary task and secondary task that requires executive control, they should experience decreased task performance, measured in the current study as decreased recall and increased extraneous body movements. For example, if an individual was asked to sit as still as possible during a task, it is expected that their performance should be lesser compared to an individual without the same constraint because of it requiring greater working memory demands.

An additional important aspect of working memory is that it may help shield essential mental processes from diminished attention. The amount of working memory that a task requires can play a role in how susceptible an individual may become to losing focus on said task. While this is a topic of some contention, many researchers (Forster & Lavie, 2009 and Berti & Schröger, 2003) have found that for tasks with a low load, attention loss will be greater than tasks with a high load. It is believed that for tasks with a low cognitive load, individuals will lose attention more easily than individuals completing a task with a high load. These results suggest that for tasks that require more cognitive resources, people are able to focus attention more efficiently and can effectively resist losing attention as compared to tasks that may not require as many cognitive resources. By manipulating load, it would be interesting to observe how it may affect one's ability to sustain attention; this could be accomplished by observing fidgeting behaviors.

In a study designed to determine the effect of load on on-task behavior, researchers manipulated the load of a task by changing distraction letters that would accompany target letters on a screen (Forster & Lavie, 2009). Participants were asked to complete a letter search task in which they were to look out for target letters mixed in with distractor, or non-target letters. In the low load condition, all of the non-target letters were lower-cased Os, and in the high load condition, the non-target letters were various mixed letters. During this task, participants were given thought probes after each trial that inquired as to what they were thinking about during the trial. While participants in the high load condition experienced significantly longer reaction times and had an overall greater percentage of errors, they also had significantly more task related thoughts than the participants in the low load condition, indicating that they were using more of their cognitive resources to consider the task. These findings suggest that participants were overall more engaged on the task in the high load condition and were better able to maintain their focus than participants in the less demanding low load conditions. The performance of participants in the high load condition was, on the whole, weaker than those in the low load condition, but they were able to attend to the task better. Consistent with the Optimal Stimulation Theory, it would be expected that participants in the high load condition, because they were more mentally engaged with the task, would experiences fewer instances of fidgeting behaviors.

Other researchers similarly contend that increased working memory demands will help an individual to stay engaged in a task. Berti and Schröger (2003) designed a study to determine if task load would affect how well participants were able to maintain focus on a primary task. Participants in both the high and low load conditions were asked to distinguish between short and long auditory tones and to designate their length by pressing a button that corresponded with its respective tone length. In the low load condition, participants simply indicated if the tone was short or long. In the high load condition, however, participants were asked to indicate whether the *previous* auditory tone was short or long in duration. By having participants indicate if the preceding tone was short or long, it required more cognitive effort because they had to attend to the current tone and try to remember the one from before. Attempting to remember the prior tone while attending to the current one essentially became two discrete tasks, as compared to the individuals who only had to attend to one task. As expected, and concurrent with the results of Ariga and Lleras (2011), participants performed at a significantly lower level in the high load condition compared to the low load condition, with around 83 and 95 percent correct in each condition, respectively. Additionally, participants had shorter response times in the low load condition relative to the high load condition. Of most interest here, and also consistent with the aforementioned results of Forster and Lavie (2009), was that participants were ultimately more likely to maintain attention in the high load condition. The researchers assessed attention levels by measuring event related brain activity. When a novel stimulus occurred, e.g. a changing tone, researchers were able to tell how aroused participants became by the deviant sound. Participants in the high load condition showed reduced amplitudes of certain brain potentials, specifically P3a and reorienting negativity, suggesting that when the tone changed, they noticed it less than participants in the low load condition, who were more likely to become distracted by the changing tone. The researchers argue that this occurs because the participants in the high load condition, relative to the low load condition, had more cognitive resources wrapped up in the primary task as they attempted to remember the previous tone and the tone that they were currently hearing. Participants in the low load condition, who simply had to indicate when the current tone changed, were more observant of external stimuli, suggesting they would be more likely to lose attention when the tone changed.

Cognitive load may also factor into how much an individual may fidget during a task. It would be expected that as the load of a task decreases, incidental body movements should increase (Di Nocera et al., 2013). This prediction would be consistent with what Zentall (1975) would argue because a task that requires less working memory would inherently be less stimulating to an individual. According to the Optimal Stimulation Theory, completing a task that is under stimulating should result in higher instances of fidgeting behavior in order to increase stimulation to an ideal level. These predictions were corroborated in a study that was designed to manipulate the load of a task in order to observe the effect on an individual's on-task behaviors (Di Nocera et al., 2013). Researchers measured individuals' incidental motor activity using capacitive sensors in their seats that measured body movement across conditions with varying difficulty in the form of increased or decreased cognitive load. Using a modified version of the game Tetris, the researchers manipulated how quickly the tiles would fall down the screen; the tiles falling slowly (125 ms per row) or quickly (80 ms per row) would decrease or increase the load, making the task easier or more difficult, respectively. In the task with a lower cognitive load, participants had significantly higher instances of extraneous movements than participants in the high load condition. These results suggest that the increase in restlessness was due to the lower mental workload associated with the less mentally demanding task. Interestingly, the researcher theorized that the results could additionally be attributed to the fact that participants in the low load condition were also more salient of their discomfort because they were not as engaged in the task as participants in the high load task. Inversely, participants were more focused on the primary task during the high load condition and were therefore not as aware of their bodily discomfort, which resulted in fewer instances of fidgeting.

Current Study

By examining the aforementioned constructs, the current study sought to better understand how children's fidgeting behaviors and the cognitive load associated with a task were related. Specifically, children in fifth grade were the target participants in the current study. Students, especially younger students, were crucial to investigate since fidgeting may have an impact in a classroom setting because of its expected relationship with attentional capacity and potential to regulate attention. Additionally, a number of previously mentioned studies (Carson et al., 2001, Emmert et al., 2009, Greenop & Kann, 2007, Hartanto et al., 2016, Kercood & Banda, 2012, Kercood & Grskovic, 2010, Kercood et al., 2007, and Mahar et al., 2006) primarily studied children aged roughly 10 years old, with the majority of participants being in fifth grade. A similar population of students was chosen in order to provide context to the results of the current study. Additionally, children were the population of interest because they are more likely to demonstrate greater fidgeting behaviors than adults; that is, as an individual's age increases, their overall energy expenditure, and therefore fidgeting, is expected to decline (Carriere et al., 2013).

Past studies (Frick-Horbury & Guttentag, 1998 and Pine et al., 2007) have indeed used restricted hand movement as a variable in their respective designs. However, the prior mentioned studies both restricted movement to understand how it affected one's ability to utilize their lexical retrieval abilities and had little to do with attentional capacity. The current study used restricted hand movements as a manipulation to help understand how fidgeting is related to attention. In an attempt to limit movement in participants, the ability to fidget was manipulated in a slightly different fashion to Pine et al. (2007). While they used mittens fastened to a table to limit participants' movement, in the current study, participants were simply asked to sit on their hands during the reading portions of the task. This method of manipulating movement was chosen for three reasons. First, it used no extra resources compared to providing mittens and Velcro for a classroom of participants. Secondly, it was thought that sitting on hands was perhaps less novel to students and would ultimately be more natural to them compared to having their hands fastened to a desk in mittens, which was thought to reduce the possibility that they became distracted by the manipulation. Finally, and most importantly, is the fact that this form of movement manipulation allowed for participants to inadvertently remove their hands from underneath their bottoms if the urge to fidget became too strong. While participants were reminded in this situation to keep their hands underneath them, these slip ups were still coded as instances of fidgeting and were thought to provide useful information about the utility and perceived function that fidgeting serves and in which situations it may be most useful.

A number of previously mentioned studies have manipulated the cognitive load associated with a task in order to examine various outcomes on task performance, but few have examined fidgeting behaviors as a function of task load, and none have examined how restricting hand movements and varying cognitive load would affect reading recall. Previous studies have manipulated task load in various ways. Forster and Lavie (2009) manipulated the load of the task by asking participants to search for a target letter amongst distractors. This type of manipulation would be near impossible to implement while completing a reading task as the manipulation would use the same modality as the primary task. Other studies simply increased the load by making the task more difficult (Di Nocera et al., 2013). Theoretically, this could be accomplished in a reading task by providing alternative, more difficult reading passages or by applying a shorter time limit to the task. However, these sorts of manipulations have the potential to impact reading comprehension above and beyond the participants' ability to attend mentally to the task. The current study utilized a different approach, most similar to how Berti and Schröger (2003) manipulated cognitive load. Depending on group assignment for cognitive load, participants were asked to remember one digit or five digits throughout the reading portions of the task for the low and high load conditions, respectively. Orsini et al. (1987) found that children aged 10 years old were able to recall, on average, roughly five digits, which is why it was selected as the number of digits for the high load condition in the current study. Upon receiving the recall quiz, participants were also asked to report the digit(s) in serial order. It was expected that participants in the high load condition would need to use greater working memory resources in order to remember the digits compared to the participants in the low load condition.

While there are numerous different ways to add load to a task, this method of load manipulation was selected for a few reasons. First, it was believed that providing participants with digits prior to the reading task would result in fewer instances of participants either attempting to cheat or from focusing too heavily on one aspect of the task. If digits were instead, for instance, embedded within the reading passage, participants may finish the reading and spend their last few moments with the materials trying to memorize the sequence, only to write it mere moments later. This could have potentially led to a ceiling effect for digit recall with little room for variance. Additionally, if digits were placed within the reading passage, participants may have focused too much on the digits during the task and not enough on the reading passage, which could potentially lead to a floor effect for comprehension scores. If participants focused too heavily on the digits, it would be expected that reading comprehension scores may have aggregated towards the lower possible scores, which would again limit the possibility for greater variance between comprehension scores.

An additional construct of interest in the current study is that of trait hyperactivity. As explained earlier, a proper ADHD diagnosis was not considered in the current study. This omission occurred because it was thought that there may have been too few participants with an ADHD diagnosis, which would have resulted in a sample size that would be too small to provide meaningful results. However, it is relatively easy to assess a child's typical levels of hyperactivity as compared to acquiring a proper ADHD diagnosis. By using the School version of the ADHD Rating Scale-5 (DuPaul, Power, Anastopoulos, & Reid, 2016), which is designed to assess an individual's inattention and hyperactivity levels, teachers were able to indicate each participant's typical level of hyperactive behaviors in class. While this scale can be completed by both educators and parents, only educators were asked to fill out the scale because the classroom is the environment of interest in the current study.

The current study utilized a 2 (restricted movement versus non-restricted movement) x2 (high cognitive load versus low cognitive load) between subjects design and focused on children's fidgeting behaviors in a classroom setting. Participants were asked to complete four blocks of reading tasks followed by four multiple choice reading comprehension quizzes. Prior to participation, teachers were asked to complete the School version of the ADHD Rating Scale-5 (DuPaul et al., 2016). The performance of participants was measured in the form of correct responses on the reading comprehension quizzes and total instances of fidgeting.

Hypotheses

H1: In the event that no interaction occurs, it is hypothesized that there will be a main effect of cognitive load on reading comprehension so that participants in the high load condition will receive overall lower scores on the reading comprehension quiz than those in the low load condition. This is simply because the task will be more cognitively demanding and the participants should have more difficulty completing it accurately (Ariga and Lleras, 2011, Najmi et al., 2014).

H2: Additionally in the absence of an interaction, it is hypothesized that there will be a main effect of cognitive load on fidgeting behavior so that participants assigned to the low load condition will overall demonstrate a higher amount of fidgeting behavior than those in the high load condition. Consistent with the Optimal Stimulation Theory (Andrade, 2009, Kercood & Banda, 2012, and Zentall, 1975), it is expected that this will occur because of the relatively low stimulation associated with the task compared to the high load task.

H3: In the absence of an interaction, it is hypothesized that there will be a main effect of restricting movement on reading comprehension so that participants assigned to the non-restricted movement condition will have overall higher reading comprehension scores than those in the restricted movement condition. Consistent with what Farley et al. (2013) might argue, this is likely to occur because the non-restricted movement condition will be less demanding than the restricted movement condition. Participants in the restricted movement condition may have to contribute more mental effort in an attempt to self-regulate their own movements.

H4: Consistent with the findings of Feldman and Reiff (2014), it is hypothesized that there will be an effect for hyperactivity such that individuals who show greater levels of hyperactivity will overall demonstrate greater amounts of fidgeting compared to individuals who show lower levels of hyperactivity.

H5: Although the availability to engage in fidgeting is expected to be beneficial across all conditions, it is hypothesized that participants who show greater levels of hyperactivity, as assessed by their educators, relative to participants who show lower levels of hyperactivity, will receive higher reading comprehension scores when allowed to fidget compared to when their movement is restricted.

H6: It is hypothesized that there will be an interaction effect for task load and movement restriction on reading comprehension. Participant reading comprehension should be relatively similar and relatively low in the high load condition regardless of their movement-restriction condition. This is because under high load, fidgeting is not expected to be as meaningful of a manipulation because under high task load, the desire to seek outside stimulation will be lessened. Therefore, movement restriction is not expected to distract (i.e. decrease reading comprehension performance) participants. However, movement restriction is expected to become a more meaningful variable for influencing reading comprehension for students placed in the low load condition because they may be seeking extra, outside stimulation in the form of fidgeting. Participants in the non-restricted movement condition are expected to score much higher on reading comprehension than participants in the restricted movement condition under low load because they will be able to achieve increased stimulation in the form of fidgeting, which should help them focus on the task better (Zentall, 1975) and will not be distracted by attempting to suppress their urge to fidget.

H7: It is hypothesized that there will be an interaction effect for task load and movement restriction on instances of fidgeting behaviors. Participants' instances of fidgeting are expected to be relatively similar and relatively low when they are assigned to the high-load condition, regardless of their condition for movement-restriction, because they should be highly stimulated, which should, in theory, negate their need to seek out extra stimulation in the form of fidgeting (Zentall, 1975). However, when participants are assigned to the low-load condition, movement restriction is expected to become a more meaningful variable that affects instances of fidgeting. It is expected that participants in the non-restricted movement condition will fidget much more than participants in the restricted movement condition when low task load is placed upon them because they will have the ability to fidget more with their hands. Both groups should theoretically be seeking out extra stimulation, but participants in the restricted-movement condition will not be able to fidget as much because of that restriction.

Method

Participants

Twenty-eight fifth grade students were recruited from two elementary schools in Midwestern towns in the United States. The participants were asked to indicate their age and gender prior to beginning testing. The age of the participants ranged from 10 to 12 years old (M=10.68, SD=.67). Of the twenty-eight participants, 10 (35.7%) were males and 18 (60.7%) were female. Although participants were not asked to indicate their race on the demographics questionnaire, it appeared that the sample was representative, in terms of race, of elementary schools in the area. For the 2017-2018 school year, fifth grade students in the school district were 81.4% white, 5.6% Hispanic, 1.3% Asian, 4.6% black/African American, and 7.1% multiracial.

Originally, 13 elementary schools were contacted. Of those 13 contacted schools, only two (15%) allowed for data collection. And of those two schools, which had a total of 83 fifth grade students, only 28 (34%) students returned informed consent forms. Of the 28 participants, 6 were assigned to group 1 (non-restricted movement, low cognitive load), 7 were assigned to group 2 (restricted movement, high cognitive load), 8 were assigned to group 3 (non-restricted movement, high cognitive load), and 7 were assigned to group 4 (restricted movement, low cognitive load). The group assignment process is detailed in the procedure section below.

Materials

Reading Passages. Participants were issued four separate reading passages to complete. The passages were acquired from an archive that provides grade-specific reading passages with accompanying reading comprehension quizzes (Fountas & Pinnell, 2010). The content of the passages was varied so as to introduce novel material to participants in an attempt to limit their existing background knowledge on any given subject. This was done so that certain participants would not have an unfair advantage over others if they were familiar with some of the content in the passages. Additionally, each reading passage fit neatly on two sheets of paper. This was done intentionally so that students would not have to physically touch the reading passage to flip pages. Each passage was expected to take four to five minutes to complete. See Appendix A for an example of a reading passage used.

Reading Comprehension Quiz. Participants were given a reading comprehension quiz following each reading passage. The quizzes were designed to ask participants about material that was covered in the passage. To avoid ambiguous or subjective responses, the questions were exclusively multiple choice. While the previously mentioned reading passages provided recall quizzes along with each passage, they typically only included two multiple choice questions. To introduce greater possibility for variance in responses, each provided quiz was supplemented with an additional three questions so that each recall quiz consisted of five total multiple choice questions. Participants were instructed to circle their chosen response for each item. See Appendix B for an example of a reading comprehension quiz used.

Digit Recall. Located at the top of each recall quiz, participants were asked to write the sequence of numbers, in serial order, that they were asked to maintain in memory throughout each reading period. Participants assigned to the high cognitive load condition wrote their provided sequence of five digits in serial order and participants assigned to the low cognitive load condition wrote their provided single digit within the provided space. For each reading period, different series of digit(s) were given to participants.

School version of the ADHD Rating Scale-5. Prior to data collection, teachers were asked to complete a short form that inquires about students' typical levels of hyperactivity and impulsivity. The School version of the ADHD Rating Scale-5 (DuPaul et al., 2016) is a 29-item questionnaire that addresses a variety of behaviors that are associated with hyperactivity and inattention. As instructed on the form, teachers read each item, which consist of common problems a student might experience in the classroom, and, using a four point Likert scale, indicated how frequently that behavior has been a problem over the past six months or since the school year started. Responses to each problem behavior could range from a zero, which indicates that the behavior has never or rarely been an issue, to a three, which indicates that the behavior is very often an issue. The form is broken into two sections: one section addresses behaviors related to inattention and the other section addresses behaviors related to hyperactivity and impulsivity. Because hyperactivity is the true construct of interest in the current study, only that portion of the measure was given to teachers; the inattention section of the scale was not provided to teachers to complete. Some examples of behaviors from the hyperactivity section included "Fidgets with or taps hands or feet or squirms in seat" and "Leaves seat in situations where it is inappropriate".

The scale has desirable psychometric properties and has widespread use for research purposes. Overall, the scale has high internal consistency; the scale yielded an alpha coefficient of .95 for the Hyperactivity-Impulsivity portion (DuPaul et al., 2016). For the current study, the scale yielded an alpha coefficient of .59 for the hyperactivity portion of the scale. Test-retest reliability was also adequate. Teacher ratings, occurring six weeks apart, yielded a Pearson product-moment correlation coefficient of .90 for the Hyperactivity-Impulsivity portion. The scale also shows adequate relationships with other criterion measures that assess hyperactivity. Finally, the scale shows desirable discriminant validity. Statistically significant differences in mean ratings between groups with ADHD and control groups were found for teacher

Hyperactivity-Impulsivity ratings ($F(2, 87) = 23.57$, $p < .0001$). See Appendix C for the full form.

Demographic questionnaire. Participants were given a brief, two-item questionnaire that inquired about their gender and age. See Appendix D for the full demographic questionnaire.

Camera Placement. Prior to data collection, cameras were placed strategically in the room in which participants were tested. The cameras were placed on tripods roughly 6 feet in front of participants in groups of three or four at eye level so that each student was within view from both the waist up and the waist down. This placement allowed for recorded observation of fidgeting behaviors above the desk associated with the upper-body movements and fidgeting behaviors below the desk associated with lower-body movements. Camera placement was completed prior to data collection while there were no participants present in order to avoid distraction before testing. However, students were made aware of the fact that they were being recorded.

Behavioral Coding. Participants were filmed from the time that assent forms were collected until they finished their final reading comprehension quiz. Participants were filmed in order to record their fidgeting behaviors for later analysis. The PI and three undergraduate student coders were responsible for coding the behaviors found in the recordings. Coding was broken down into two different categories of behaviors. First, upper-body movements consisted of five different behaviors that were commonly seen amongst participants. Second, lower-body movements also consisted of five different commonly observed behaviors that students were showing. Additionally, exclusion criteria were given to coders for behaviors that would not be considered fidgeting (e.g. wiping at nose, tracing along reading passage with finger, etc.). Additionally, some behaviors were excluded because of their short duration; for example, if a participant was to re-position himself in the chair (and the movement's duration was less than three seconds), that behavior was not considered to be fidgeting.

Video recordings were broken down by reading passage and, even further, by each minute. Behaviors were recorded on a table that consisted of upper-body fidgets and lower-body fidgets for each minute of each reading passage. Coders were instructed to record each instance of fidgeting. For each instance, the starting time and ending time were recorded. Additionally, each instance received a label for specific types of upper-body and lower-body fidgets, respectively. Total scores were tallied up for each reading passage and a final score was calculated across all reading passages to signify a participant's total amount of fidgeting during testing. See Appendix E for a list of fidgeting behaviors, including exclusion criteria.

Interrater reliability was strong, (r=.76, p <.01). For five out of the twenty-eight participant scores (~18%), there were discrepancies between coders. After bringing in a third coder to resolve those discrepancies, interrater reliability became stronger (r=.93, p<.01).

Procedure

Participants from both elementary schools were assigned to one of four experimental groups prior to testing. At one of the schools, the two fifth grade classrooms were divided by academic aptitude. To reduce any potential confounds and to ensure roughly equal testing group sizes, the entire pool of prospective participants from that school was randomly assigned to one of two groups rather than randomly assigning classrooms to conditions. At the other school, the pool of prospective participants was similarly randomly assigned to groups to ensure roughly equal numbers of participants in both testing groups; the two fifth grade classrooms returned informed consent forms disproportionately. In other words, informed consent form return rates varied by class.

The PI entered the testing room 15 minutes prior to data collection to prepare the cameras and set up the projector. At one of the schools, the PI was provided with a specific testing room. Participants were taken to this testing room by a school-provided chaperone according to their randomly assigned groups. At the other school, one of the fifth grade classrooms was used for testing. In this case, students who were not participating in the study were taken to the other fifth grade classroom. At both schools, once the first testing group was finished, those participants exited the room and the new testing group was brought in afterwards.

Prospective participants, whose parents had given the PI informed consent, entered the testing room. Prior to implementing any testing conditions, including beginning video recording, assent was obtained from the students. Once assent was obtained from all willing participants, video recording began. Participants were then given instructions about their respective movement conditions. Students in the restricted movement condition were asked to sit on top of their hands any time that they had reading materials in front of them. Participants in the non-restricted movement condition were not given any special instructions regarding their movement.

The PI distributed a folder to each participant that contained a demographic questionnaire, four reading passages and four reading comprehension quizzes. The PI then instructed the participants to remove and complete the first sheet from the envelope, which contained the demographic questionnaire.

Prior to beginning reading the first passage, the PI explained the digit memorization procedure. Depending on cognitive load group assignment, participants were asked to attempt to remember either one digit or five digits if they were in the low load or high load condition, respectively. Digit(s) were presented to students visually using the projectors found in the testing rooms. Digits were projected in very large, bold font onto a screen roughly eight feet in front of participants. Participants were given 15 seconds prior to each reading period to attempt to memorize the digit or sequence of digits. Following the 15 seconds, the digits were removed from the screen. The participants were then instructed to begin reading.

After five minutes elapsed, the PI instructed participants to slide the reading passage underneath their folders in order to keep it out of sight during the quiz. Participants in the restricted movement condition were told that they could move freely during times that they are completing quizzes. Participants were then asked to remove the next two sheets, the first recall quiz, from the folder. The participants took three minutes to complete the recall quiz. Additionally, they were reminded to write the digit(s) in serial order that they were asked to remember during the prior reading period.

Once three minutes had elapsed, students were asked to place their completed quiz underneath their folders. Directly after this, the PI asked the participants to remove the next reading passage from their folders. This process was repeated until the fourth and final reading comprehension quiz was completed. At this point, video recording ceased. After the completed testing materials had been collected by the PI, participants were asked to choose a prize out of a box as an incentive for their participation. Participants were then released from testing. At this point, testing was complete.

Results

Descriptive statistics were run for each of the dependent measures. In terms of a participant's total instances of fidgeting, the range of possible scores was from 0, which signified no instances of fidgeting while reading, to 2,400, which would signify fidgeting every second, with both the upper- and lower-body, for the entire duration of reading across the four passages. Instances of participant fidgeting was measured in total seconds spent fidgeting and reported values combined the total number of seconds a participant spent fidgeting for both their upper- and lower-body across each minute of each reading passage. Observed scores ranged from 106 to 1,096 (*M*=509.86, *SD*=267.64). Participants spent an average of eight minutes and thirty seconds fidgeting across the possible forty minutes of testing (twenty possible minutes for upper-body fidgeting and twenty possible minutes for lower-body fidgeting). There was not a significant difference in instances of fidgeting between upper-body fidgets (*M*=231.39, *SD*=238.16) and lower-body fidgets (*M*=278.46, *SD*=233.26), $t(27)=.642$, $p=.526$, $d=.20$.

Possible reading comprehension scores ranged from 0, which signified zero correct answers on recall quizzes, to 20, which signified all correct answers on recall quizzes. Observed scores ranged from 6 to 16 (*M*=10.75, *SD*=3.10).

Possible hyperactivity scores for participants could range from 0, which signified that a participant was not hyperactive at all, as per the measure, to 27, which signified that a participant was considered extremely hyperactive by their teacher. Actual scores ranged from 0 to 6. Of the 28 participants, 16 received a hyperactivity score of 0 (57.1%), 2 received a score of 1 (7.1%), 4 received a score of 2 (14.3%), 3 received a score of 3 (10.7%), and 1 received a score of 4, 5 and 6 each (3.6% each, respectively).

To address hypotheses 1, 3, and 6, a 2 (restricted movement versus non-restricted movement) x 2 (high cognitive load versus low cognitive load) factorial ANOVA was conducted to analyze the effect of movement restriction and cognitive load on participant reading comprehension scores. There was not a significant main effect of cognitive load on reading comprehension at the $p<.05$ level for the two cognitive load conditions, $F(1, 26)=1.15$, $p=0.293$, $d=.41$, indicating no significant difference between participants assigned to the low cognitive load condition (*M*=10.08, *SD*=2.78) and participants assigned to the high cognitive load condition (*M*=11.33, *SD*=3.33) in terms of reading comprehension. Similarly, there was not a significant main effect of movement restriction on reading comprehension at the $p<.05$ level for the two movement restriction conditions, $F(1, 26)=0.18$, $p=0.678$, $d=.16$, indicating no significant difference between participants assigned to the restricted movement condition (*M*=11, *SD*=3.04) and participants assigned to the non-restricted movement condition (*M*=10.5, *SD*=3.25) in terms of their reading comprehension. The interaction effect was also not significant, $F(1, 24)=1.80$, $p=.192$.

To address hypotheses 2 and 7, a second 2 (restricted movement versus non-restricted movement) x 2 (high cognitive load versus low cognitive load) factorial ANOVA was conducted to analyze the main effect of cognitive load and its relationship to instances of participant fidgeting. There was not a significant main effect of cognitive load on instances of fidgeting behaviors at the $p<.05$ level, $F(1, 26)=3.11$, $p=.09$, $d=.66$, indicating no significant difference between participants assigned to the low cognitive load condition (*M*=602.08, *SD*=288.42) and participants assigned to the high cognitive load condition (*M*=429.93, *SD*=228.25). The interaction effect between cognitive load and movement restriction on instances of fidgeting was not significant, $F(1,24)=.36$, $p=.556$.

To address hypothesis 4, a Pearson correlation was conducted in order to examine the relationship between reported hyperactivity and instances of fidgeting. Results of the Pearson correlation indicated that there was not a significant association between the reported hyperactivity of a participant and their demonstrated instances of fidgeting, $r(26) = .22$, $p = .271$.

To address hypothesis 5, a multiple regression analysis was conducted to determine if reported hyperactivity and a participant’s ability to fidget while reading significantly predicted reading comprehension scores. The results of the regression indicated that the two predictors explained roughly 2% of the variance, R^2=.02, $F(2, 27)$=.27, p=.765. It was found that a participant's reported levels of hyperactivity did not significantly predict reading comprehension scores (ß=.22, p=.549), nor did a participant's ability to fidget while reading (ß=.34, p=.783). However, there was a small effect size present, which may have helped the regression reach significance given a greater number of participants.

Exploratory analysis showed a trend that participants, on average, tended show more fidgeting behaviors as a function of time spent in the study. Although none of the differences were significant, $F(3, 108)$=.87, p=.457, the possible trend shows that participants showed more fidgeting behaviors during the fourth reading passage (M=140.39, SD=87.42) than during the third reading passage (M=138.54, SD=99.00) than during the second reading passage (M=126.07, SD=92.68) than during the first reading passage (M=104.86, SD=90.86). A trend analysis was conducted to determine if participants really did show more fidgeting behaviors as a function of time spent on the task. It was determined that there was no significant trend present, $F(2, 108)$=.15, p=.858.

Another exploratory analysis was conducted in order to determine if there was a difference in terms of participant instances of fidgeting between the restricted and non-restricted movement group. While participants assigned to the non-restricted movement condition showed slightly higher patterns of fidgeting behaviors (M=565.29, SD=285.54) than those assigned to the restricted movement condition (M=454.43, SD=246.21); $t(26)$=1.1, p=.966, d=.42, this difference was not statistically significant.

Discussion

The purpose of the current study was to examine the relationship between cognitive load, movement restriction, and hyperactivity to see how they affected student reading comprehension and instances of fidgeting behaviors. None of the seven original proposed hypotheses were supported. According to the parameters of the current study, there was not a significant relationship between movement restriction, cognitive load, and reported hyperactivity that would affect either reading comprehension or instances of fidgeting behaviors. Originally, these variables were chosen because there were studies in the existing body of literature that suggested that restricting one's movement (Farley et al., 2013), manipulating the amount of cognitive load they are subjected to during a task (Ariga & Lleras, 2011; Najmi et al., 2014), or how much hyperactivity they typically demonstrate (Pastor & Reuben, 2008) may affect their performance on a task. These effects were not found in the current study, and this may be for a number of reasons.

A possible reason these effects were not observed may be that the manipulation for cognitive load was not strong enough for participants to experience a difference in terms of their reading comprehension performance. While the there was a significant difference in correct recall of digit(s) between participants in the low-cognitive load group (M=8, SD=0.00) and the participants in the high-cognitive load group (M=5.73, SD=1.79); $t(26)$=4.55, $p < .0001$, d=1.80, this difference did not coincide with significant differences in regards to the reading comprehension scores between those assigned to the low-load condition. So while the manipulation for cognitive load was salient, with participants in the low-load condition recalling the digit they were shown prior to each reading passage with 100% accuracy and the participants in the high-load condition recalling the digits they were shown prior to each reading passage with 72% accuracy, this apparently did not influence their ability to recall information they learned in the reading passage. Perhaps the questions in the recall quizzes were too easy and the ability for a participant to recall the information was not influenced by the amount of cognitive load they were put under. With more difficult questions on the recall quizzes, more variability may have been observed.

Another possible reason for the lack of relationship between the independent variables and the dependent variables was because the manipulation for movement restriction was not strong enough. While participants assigned to the non-restricted movement condition showed slightly higher trends of fidgeting behaviors than those assigned to the restricted movement condition, this difference was not statistically significant. Ideally, individuals who were asked to refrain from moving while completing the reading portions of the task would have sat much more still than what was actually observed. The decision to restrict participants' hands, rather than their entire body, was chosen carefully. It was thought that the ability for participants in the restricted movement condition to be able to fidget using their lower body while completing the reading portion of the task would provide an interesting insight into the function that fidgeting may serve. By allowing them to fidget *somewhat* during reading, it was thought that there may be marked differences in fidgeting using the hands and fidgeting using larger-body movements, as would be seen in the lower-half of the body. However, it appears that by allowing participants in the restricted movement condition to fidget using the lower-half of their body, the manipulation for movement restriction was not as powerful as it could have been had the participants in the restricted-movement condition been told to remain completely still while reading. Although there was not a significant difference in terms of participant fidgeting between the two movement-restriction groups, the data hints at a possible trend that may become significant given more stringent movement-restriction manipulations.

Finally, participant hyperactivity may not have acted as a significant predictor of reading comprehension scores and this may be due to the fact that the measure for hyperactivity that was used in the study was not properly suited to the situation. As stated earlier, the School Version of the ADHD Rating Scale-5 (DuPaul et al., 2016) was used in an attempt to understand each participant's standard, baseline levels of hyperactivity in the classroom, as assessed by their teachers. While this measure certainly has strong psychometric properties, it is typically used with children who have received an ADHD diagnosis. Because of this, children without ADHD, who likely show overall lower patterns of hyperactivity compared to children with ADHD, will expectedly score closer to the low end of this measure. Ultimately, there was very little variability in hyperactivity ratings given to participants, which did not give this predictor much power in regards to its effect on reading comprehension scores and instances of fidgeting. By utilizing a more general hyperactivity measure and not one that was designed to assess ADHD related behaviors, there may have been more observed variance in hyperactivity scores.

Through exploratory analyses, it was found that participants showed a trend of fidgeting more as a function of time, as is consistent with various other studies (Carson et al., 2001; Carriere et al., 2013; Galton, 1885). This possible trend should be investigated more in future research because it may suggests that the longer an individual spends working on a task, the more likely are to fidget. This possible trend could be attributed to a few reasons. Firstly, and as Farley et al. (2013) suggested, people simply become bored the longer they spend on a task. As their attention begins to wane, they may attempt to introduce greater amounts of stimulation, something that fidgeting is likely to accomplish (Zentall, 1975). While it is impossible to comment on whether this trend of increased fidgeting as time spent on a task increased impacted participant reading comprehension scores in the current study, it is still a trend worth noting that has implications for educators. If a teacher notices increases in fidgetiness of his or her students, it may signify a prime opportunity to introduce the class to a new task simply because it may signal the class becoming bored with the current activity.

Implications

This study provides important implications that can contribute towards the discussion revolving around fidgeting. It would appear as if this great variability involved with fidgeting boils down to individual factors and preferences. A person's age (Carriere et al, 2013), their engagement with a task (Di Nocera et al., 2013), and their typical level of hyperactivity (Pastor & Reuben, 2008), among other factors, such as their level of physical discomfort (Farley et al., 2013) or the degree to which they are distracted (Forster & Lavie, 2009), may contribute to why there is so much variability in the results of studies examining fidgeting behaviors. Indeed, all of these factors do not exist in a vacuum; there is likely a lot of intersectionality that is at play that determines not only the frequency and severity of one's fidgeting, but the function of those behaviors as well. Just examining one of these factors is likely not sufficient for predicting one's propensity towards fidgeting and a more comprehensive pattern of one's behaviors may be understood by examining multiple different fidgeting factors together.

As for implications from the findings of the current study, it would appear as if there are many individual differences that exist between people in terms of their tendency to fidget in any given situation. Some people may feel compelled to fidget when they are very stressed, some people may feel compelled to fidget when they are under-stimulated, and some people may feel compelled to fidget when they feel socially uncomfortable. It would seem as if allowing those who feel the urge to fidget in any given situation could only be beneficial towards them, whether those benefits come from allowing for sustained attention or reducing discomfort. One real issue when discussing fidgeting seems to be in others' attempts to reduce or refocus a person's fidgety behaviors away from what occurs to them naturally. By attempting to manipulate one's behaviors away from what feels right, they may become more overwhelmed simply by the thought of suppressing those behaviors, which could result in diminished performance in whatever task they were working on. Future research needs to be conducted regarding the limitation of one's movement during a task that requires sustained attention.

Limitations

There were a few different limitations that were present in the current study. Firstly, and as mentioned earlier, the sample size of the current study was relatively small (*n*=28). A larger sample size would have allowed for larger testing groups, which may have facilitated a bit more variance within the groups. To reach a moderate effect size and a desirable power level, the design required 60 participants, or 15 participants per condition. However, with only roughly seven participants per condition, the statistical power was limited to .51, essentially meaning that there was a 50/50 chance of finding an effect. Additionally, some of the hypotheses, such as hypothesis 2, which had a medium effect size, may have been supported had there been a larger sample size. With only 28 participants available, however, there was simply not enough power to bring certain analyses to significance.

A second limitation with the current study is that it was unfeasible to acquire formal ADHD diagnoses for participants. It should be noted that many of the studies (Greeop & Kann, 2007; Hartanto et al., 2016; Zentall, 1993) that the current study was inspired by involved examining both participants with and without ADHD, not simply examining the hyperactivity of students on a spectrum, as was done in the current study. It was thought that using a continuous scale to measure hyperactivity, rather than a dichotomous categorical measure of the presence or absence of ADHD, would encourage more variance in participants' hyperactivity. Yet, it would still have been beneficial to know which, if any, of the participants had an ADHD diagnosis to compare their instances of fidgeting to participants without ADHD. Additionally, it would have been fascinating to examine the effects of various stimulant medications prescribed to children with ADHD and how they influence fidgeting behaviors. However, acquiring this information was similarly unfeasible given the time constraints of the current study.

Another limitation is that participants were given very low hyperactivity scores across the board. As per the hyperactivity measure that was used, the maximum possible score a participant could receive was 27. However, in reality, the maximum observed hyperactivity score was only six, with the average score being only 1.21. Because of this relatively low level of variance amongst participants in terms of hyperactivity, the relationships between reported hyperactivity and the dependent variables of reading comprehension ($r(26)=.14$, $p=.494$) and instances of fidgeting ($r(26)=.22$, $p=.271$) were not strong enough to reach significance. Even though it was clear from recorded footage that some participants were much more hyperactive during testing than others, the relationship between hyperactivity and task performance was hard to examine because of this floor effect. Perhaps the students are very docile during a typical school day and merely showed greater levels of hyperactivity during testing because they were in a novel situation. Teachers were asked to report their students' typical levels of hyperactivity as they occurred on a day-to-day basis, so perhaps they were responding accurately. Regardless, it was clear through viewing the video recordings that some of the participants were showing much higher levels of hyperactivity than others, and by using a different measure of hyperactivity, perhaps one that was not designed to assess children with ADHD, these differences may have become more significant.

A final pragmatic limitation in the current study is that a between-subjects design was chosen. This was done for a few reasons. Firstly, it was simply more practical to test using a between-subjects design because it ultimately required much less time that the schools were committing to towards testing. Additionally, the participants may have become more fidgety as testing carried on merely as a function of time rather than as a result of any manipulations. Secondly, a between-subjects design was chosen in order to avoid practice effects. If participants were asked to read through each reading passage twice, once while their movement was restricted and once while it was not, they may have performed better the second time regardless of their movement condition. However, a within-subjects design would have provided each student with a baseline to compare their instances of fidgeting behaviors while allowed to move freely to when their movement was restricted. It was hard to determine whether a participant's level of fidgetiness was due to movement condition manipulation or due to individual differences.

Future Research

This study would have benefitted by addressing some of the aforementioned limitations discussed, and similar future studies could be improved in a few ways. Acquiring a sample of participants diagnosed with ADHD is a possible route to consider for future studies. By recruiting participants with ADHD diagnoses, hyperactivity may have become a more significant predictor of fidgeting behaviors amongst other the variables. Additionally, it would likely prove useful to obtain information about participants' prescriptions for stimulant medications used in the treatment of ADHD; the effects of these medications may influence a child's propensity towards sitting still in the classroom. It would also be interesting to examine the effects of stimulant medications and their interactions with other constructs of interest such as cognitive load. For example, individuals with ADHD prescribed on stimulants may not experience as much attention loss towards under-stimulating tasks as compared to typically developing individuals or even individuals with ADHD who are not medicated, which has the potential to affect how much they fidget during any given task.

It may also prove interesting to conduct a similar study with samples of various age groups. Carriere et al. (2013) found that individuals were less likely to fidget as they grew older, so it may be interesting to see if the frequency and duration of those behaviors differed between grades. A study of similar design could be conducted comparing the fidgeting behaviors of students in elementary school, middle school, high school, and even college. Additionally, the function of those behaviors may change with different age groups as well. For example, younger individuals, like the ones in the current study, may fidget as a means of increasing their cognitive arousal, allowing them to maintain their attention towards a task. Although the association did not quite reach significance, participants in the current study did engage in fewer fidgeting behaviors when assigned to the high cognitive load condition compared to the low cognitive load condition, which is concurrent with other studies (Berti & Schröger, 2003; Di Nocera et al., 2013). Older individuals, on the other hand, may be more likely to fidget when they are anxious or uncomfortable. By examining differences between age groups in terms of fidgeting behaviors, it may be possible to understand the function of those behaviors.

Another possibility for future research could include a similar design, but utilizing different modalities of the reading passage content as a variable instead. For example, the passage could be either read silently by participants, as was done in the current study, or the passage could be read aloud by an instructor to participants. This visual versus auditory modality may play a role in how well individuals can maintain attention during a prolonged task. There may be observable differences in fidgeting behaviors in response to varying modalities as well, and it would prove interesting to investigate why this may happen.

Conclusion

Fidgeting is something that many individuals do on a daily basis, but these behaviors are rarely considered in the existing base of empirical research. Everything from the surprising scarcity of research on the topic, to the often conflicting findings of these studies, to the various functions that fidgeting may serve help to keep this mysterious behavior from being properly understood by the general public. While the results from the current study may not do much to further the evidence that fidgeting is helpful or harmful towards attention, it seems apparent that more research should be done on this topic because of the implications that fidgeting may have on an individual's personal or professional life.

From the existing literature, it seems obvious that fidgeting still exists as a stigmatized behavior, but there are simply too many individual factors at play when discussing the behavior to label it is unfavorable. Future research needs to be conducted to further investigate the human relationship to fidgeting and the possible functions that fidgeting may serve. Because there is such variety between individuals who fidget, implications from studies that investigate these behaviors may impact people ranging from educators to business professionals. Once the relationship between fidgeting and attention becomes more fleshed out, individuals who do derive benefits from the act, whether that be maintaining greater attention to relieving physical or mental discomfort, may feel more compelled to act upon their impulses to fidget or feel less of an urge to inhibit those behaviors in order to save face. For many people, something that comes naturally in a variety of settings, including classrooms, board rooms, or even in their own homes is fidgeting. Clicking a pen, playing with locks of hair, or tapping fingers on a desk may provide individuals inclined to fidget with an opportunity to be more productive, more attentive, more relaxed, and ultimately, more comfortable in their own skin.

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Appendix A

Reading Passage Example

Alternative Energy Sources Wind, Solar, Geothermal, and Hydroelectric Power

There are many reasons to use alternative energy sources. One reason is to reduce pollutants and greenhouse gases. Alternative or renewable energy sources help to reduce the amount of toxins that are a result of traditional energy use. These alternative energy sources help protect against the harmful by-products of energy use and help to preserve many of the natural resources that we currently use as energy sources.

There are many alternative energy sources: wind power, solar power, geothermal power, and hydroelectric power are some examples.

Wind Power. Wind power is the ability to capture the wind in a way to propel the blades of wind turbines. When the blades rotate, this movement is switched into electrical current with the help of an electrical generator. In older windmills, wind energy turned mechanical machinery to do the physical work like crushing grain to make bread or pumping water to get water. Wind towers are built on wind farms, and usually there are several towers built together. In 2005, the worldwide use of wind-powered generators was less than 1% of all of the electricity use combined. There are several advantages of this energy source: there is no pollution, it never runs out, farming and grazing can still take place on the same land as the wind turbines, and wind farms can be built anywhere. One disadvantage is that you need a consistent wind to get enough power. If the wind speed decreases, less electricity is produced. Large wind farms can also have a negative visual effect for people who live nearby.

Solar Power. Solar energy is used for heating, cooking, making electricity, and even taking salt out of saltwater so the water can be drinkable and used for additional purposes that do not need the salt. Solar power uses sunlight that hits the solar thermal panels to convert the sunlight to heat either air or water. Other methods of using solar power include simply opening up blinds or shades and letting the sunlight pass into the room or using some type of mirror to heat water and produce steam. One advantage of solar power is that it is renewable. As long as there is sunlight, you will be able to harness the power from it. There is also no pollution and it can be used efficiently to heat and light things. You can see the benefits of solar energy in heating swimming pools, spas, and water tanks in many cities across the country.

Geothermal Energy. Geothermal means "earth heat". This energy captures the heat energy under the Earth. Hot rocks under the ground help to heat water to produce steam. If holes are dug in this area of the ground, then the steam shoots up and is purified and used to drive turbines, which in turn gives power to electric generators. The advantages of this type of energy is that there are no harmful by-products, it is self-sufficient once the geothermal plant is built, and the plants are generally small so there is no negative visual effect on the area surrounding the plant.

Hydroelectric Energy. The power that comes from the potential energy of water that is dammed up supplies energy to a water turbine and generator. Another example of this energy is to make use of tidal power. Today, electric generators can be powered by hydro power that can run backwards as a motor to pump water for later use. An advantage is that you can control the use of the energy by controlling the water. You can also generate water all the time as there are no outside forces that prevent this from happening. Furthermore, there is no pollution in using this type of energy. In fact, you can reuse the water that is used for hydroelectric power. The disadvantages are that dams are expensive to build and maintain. There also needs to be a powerful enough supply of water in the area to produce energy.

In Conclusion. In your lifetime, there will be more advances made in the field of energy. Your generation will need to value the natural resources that human life needs on this earth. You will need to be part of the ongoing and individual application of alternative energy sources so the Earth stays healthy and our resources stay renewed.

Appendix B

Reading Comprehension Quiz Example

Recall Quiz 1

Please write the number you were asked to remember while you were reading _______________

<u>Multiple Choice Questions:</u> Please circle the answer that you think fits **best** for each question.

1) What are some examples of alternative energy sources?
    a. Wind power
    b. Solar power
    c. Geothermal power
    d. Hydroelectric power
    e. All of the above
2) Which type of power means "earth heat"?
    a. Coal
    b. Minerals
    c. Geothermal
    d. Hydroelectric
3) What is a reason to use alternative energy sources that was **not** mentioned?
    a. They help protect against harmful by-products of traditional energy use
    b. They help to preserve our natural resources
    c. They are cheaper than other forms of energy
    d. They reduce pollutants and greenhouse gasses
    e. They help reduce the amount of toxins caused by traditional energy use

4) What is a disadvantage of hydroelectric energy?

   a. You can only use freshwater to create hydroelectric energy

   b. You cannot control the energy use because you cannot control the water

   c. It is expensive to build dams necessary to use hydroelectric energy

   d. Rain is needed to create hydroelectric energy

5) In 2005, how much of the worldwide energy use was made using wind power?

   a. 5%

   b. 11%

   c. less than 1%

   d. 4%

   e. 1%

Appendix C

School version of the ADHD Rating Scale-5

Attention and Behavior Rating Form, School Version: Child

Student's name:___________________________ Sex: M F Age:______ Grade:_________

Completed by:______________________________

Please select the answer that *best describes this student's behavior over the past 6 months (or since the beginning of the school year).*

How often does the child display this behavior?

1) Fidgets with or taps hands or feet or squirms in seat.

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

2) Leaves seat in situations when remaining seated is expected.

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

3) Runs about or climbs in situations where it is inappropriate.

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

4) Unable to play or engage in leisure activities quietly.

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

5) "On the go", acts as if "driven by a motor".

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

6) Talks excessively.

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

7) Blurts out an answer before a question has been completed.

    0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

8) Has difficulty waiting his or her turn (e.g., while waiting in line).

0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

9) Interrupts or intrudes on others.

0 = Never or Rarely; 1 = Sometimes; 2 = Often; 3 = Very Often

Appendix D

Demographics Questionnaire

Please write in or circle the response that best applies to you.

1) What is your age? ________

2) What is your gender?

    a. Female

    b. Male

    c. Other (Please specify):______________________________

Appendix E

Behavioral Coding Criteria

Behavioral Coding

List of behaviors:

- Upper-body:
  - 1 – "Bobbing" in seat (up and down)
  - 2 – Swaying in seat (left to right)
  - 3 – Playing with or chewing on object (pencil, clothes, hair, etc.)
  - 4 – Tapping fingers, "twiddling" thumbs
  - 5 – Continuous touching or rubbing of body part with hand (hand, arm, leg, chin, etc.). **Do NOT** count hands folded together.
- Lower-body:
  - A – Rocking feet forward/backwards or left/right
  - B – Sporadically moving feet, "wiggling" feet, or "jiggling" leg
  - C – Tapping feet or toes
  - D – Crossing and uncrossing feet or ankles repetitively
  - E – Rubbing one foot with other foot (do not count foot resting on other foot)

What **NOT** to count:

- Repositioning movements (if duration less than 3 seconds)
- Tracing reading passage with fingers and/or pencil
- Moving hair out of face (if duration less than 3 seconds)
- Wiping at nose (if duration less than 3 seconds)
- Scratching at itch (if duration less than 3 seconds)