JOURNAL OF
EMERGING INVESTIGATORS

Article

Exploring a possible link between ADHD and inattentional blindness

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SUMMARY

Attention Deficit Hyperactivity Disorder (ADHD) is characterized by impulsivity, hyperactivity, and inattention. These symptoms of inattention led us to wonder about a connection between ADHD and the phenomenon of inattentional blindness. We attempted to replicate a previous study done on this subject, and based on the results of that study, we hypothesized that people with ADHD would display more inattentional blindness in perceptually simple tasks and less inattentional blindness in perceptually complex tasks. Our results indicate that there is no significant correlation between ADHD and inattentional blindness in either type of task. This finding goes against our initial hypothesis and the conclusions from the only prior study on this topic. People with ADHD may not have the advantage of reduced inattentional blindness.

INTRODUCTION

For people without visual impairment, it would seem that object perception is an easy task. However, there is evidence that not all information we "see" is actually perceived. If an object is not the primary focus of attention, it could come into one's field of view without one being aware of and perceiving it. This phenomenon is known as inattentional blindness, and the phrase was first coined by Mack and Rock who described it as a failure to notice salient and foveated stimuli due to attention being engaged elsewhere (1).

Inattentional blindness is believed to be quite common and occur particularly when one is selectively focusing attention, but there have been few studies looking at inattentional blindness in individuals with Attention Deficit Hyperactivity Disorder (ADHD). Those with ADHD have difficulty focusing and selectively attending, and thus may be less prone to inattentional blindness compared to those without ADHD. Two studies have examined whether there is a difference in inattentional blindness in people diagnosed with autism, another disorder that is associated with attention dysfunction (2-3). In these studies, ability to detect change outside the focus of attention was assessed using tasks that involved static images: the Cross Detection Task and the Flicker Task. In the Cross Detection Task, participants are instructed to focus on a cross to determine which line is longer, while other shapes are flashed within the participants' fields of view. During the Flicker Task, presentation of an original image quickly alternates with a slightly manipulated image, with a blank screen inserted in between. The participant must actively seek to find the part of the image that is manipulated, or changed, during that brief blank screen. Researchers in both studies concluded that adults and children with autism have reduced rates of inattentional blindness, or that they perceive more information that is outside the focus of attention, compared to a control group (2-3).

To the best of our knowledge, only one study has examined the link between ADHD and inattentional blindness (4). These researchers found that participants with ADHD showed less inattentional blindness compared to neurotypical controls during the dynamic, and perceptually complex Monkey Business Illusion Task (5). Specifically, participants watched a short video of two teams passing several basketballs, which is the focus of the participants' attention, while a gorilla passes through the scene. The gorilla went largely unnoticed by those who were focused on the basketball passes, but those with ADHD were more likely to notice the gorilla than neurotypical control participants. These researchers also reported that those with ADHD showed greater inattentional blindness than control participants during a static, less perceptually complex task (the MOXO-Continuous Performance Task). Concentration on a dynamic, perceptually complex stimulus requires executive attention. Therefore, those with ADHD may find this difficult, as their attention wanders, which discourages inattentional blindness. In less perceptually complex tasks involving relatively static images, it may be easier for those with ADHD to focus attention, leading to levels of inattentional blindness comparable to controls. The major aim of our study was to replicate these previous results, emphasizing differences in inattentional blindness due to perceptual complexity.

The task-dependent distinctions in inattentional blindness for people with ADHD are theoretically supported by the hunter versus farmer hypothesis, which states that certain features of ADHD, such as impulsiveness, hyperactivity, and transient concentration, were once helpful in a hunter-gatherer society, but have become less useful in a farming society that heavily rewards intense focus on one task at a time (6-7). The perceptual load theory also hypothesizes that people with ADHD will have higher rates of distractibility in

tasks with a low perceptual load, but will have normal rates of distractibility in tasks with a high perceptual load (8-9). This was demonstrated in a recent study where participants with ADHD performed similarly to the non-ADHD participants in high load tasks (9). Thus, this model predicts that the participants with ADHD show more inattentional blindness in perceptually simple tasks, but will show similar rates of inattentional blindness in complex tasks compared to controls.

In the current study, we examined whether there is a link between ADHD and inattentional blindness by attempting to replicate the only other inattentional blindness experiments completed with participants diagnosed with ADHD (4). Specifically, we investigated whether inattentional blindness differs between those with and without ADHD symptomology during a perceptually simple task with static images and a more dynamic, perceptually complex task. We hypothesized that participants with ADHD would display more inattentional blindness than neurotypical control participants on the perceptually simple task, meaning they would be less likely to notice changes outside of the focus of attention, but less inattentional blindness than neurotypical control participants on the perceptually complex task, thus reporting greater perception of objects outside of attentional focus. Our hypotheses were based on the hunter versus farmer theory and the perceptual load theory detailed above. Overall, we failed to replicate prior work, and we did not find support for our hypotheses.

RESULTS

The Monkey Business Illusion Task

To test our hypothesis that participants with ADHD would display less inattentional blindness than neurotypical control participants in a complex task, participants watched the video titled “The Monkey Business Illusion” (5). This dynamic video involves a scene where two teams – one wearing black shirts and the other wearing white shirts – pass basketballs back and forth while the players move around a room. Participants are asked to count the number of passes made by one team. During the scene, three distracting things occur: (1) a person in a gorilla suit walks through, stops in the middle of the room, beats on their chest and exits; (2) the curtain hanging in the background changes color from red to gold; and (3) one of the players leaves the scene. Participants were asked to report how many passes the team wearing white made, as well as whether they saw these three distracting changes occur.

We found that 51 of 86 (59.3%) participants reported seeing the gorilla in the video. We also found that 12 of 97 (12.4%) participants reported seeing the background curtain change color and 27 of 97 (27.8%) noticed the player leaving the scene. Participants who had previously seen this exact video were excluded from analyses.

Participants were given an inattentional blindness score of 0 – 3 based on how many of the three unexpected events they reported seeing: the gorilla, the curtain changing color, and the player leaving the game. Higher scores indicate the participant reported seeing more of these changes and thus showed lower inattentional blindness. After excluding the participants who had already seen the gorilla video, we examined whether this inattentional blindness score differed for those who had ADHD symptoms (based on a score of 5 or higher on the ADHD Symptom Checklist). An independent t-test indicated that the difference in inattentional blindness scores between participants with ADHD symptoms (M = 1.97, SD = 0.73) and without ADHD symptoms (M = 2.07, SD = 0.69) was not statistically significant ($t(82) = 0.51$, $p = .05$) (**Figure 1A**). Furthermore, inattentional blindness scores and ADHD scores were entered into a correlation analysis as continuous variables (r = -0.01, p = 0.93), but again this relationship was not statistically significant. In contrast to our hypothesis that those with ADHD symptoms would show less inattentional blindness than neurotypical control participants in a complex task, the results suggest that participants with and without ADHD display equivalent levels of inattentional blindness in a dynamic, perceptually complex task.

The Cross Task

To test our hypothesis that participants with ADHD symptoms would display more inattentional blindness than neurotypical control participants in a simple, less cognitively demanding task, each participant completed the “Cross Task”. In this task, for six trials, a static cross shapeis briefly presented on the screen, and participants are instructed to report which line of the cross is longer, horizontal or vertical. On the sixth (critical) trial, a shape flashes in one quadrant of the cross, and participants are asked whether they saw the shape, what shape it was, and where it flashed on the screen.

We found that 44 of 98 (44.9%) participants noticed the surprise shape flashed in the cross on the sixth trial. Of those participants who noticed the shape, 11 (25%) reported a square, 10 (22.7%) a circle, 9 (20.5%) a triangle, 5 (11.4%) a rectangle, 1 (2.3%) a pentagon, 1 (2.3%) a diamond, 1 (2.3%) a cross, 1 (2.3%) reported it as “round”, 1 (2.3%) a shape of an angle, 1 (2.3%) a star, and 3 (6.8%) were not sure. Of those

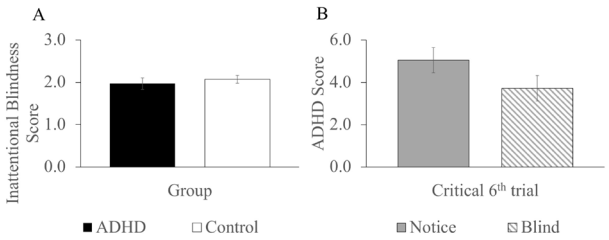

Figure 1. Outcomes of the Perceptually Complex and Perceptually Simple Task of Inattentional Blindness. (A) Average Inattentional Blindness scores (range 0 - 3) on the perceptually complex Monkey Business Illusion for participants with symptoms of ADHD (n = 36) and neurotypical control participants (n = 62). **(B)** Average ADHD Symptom Checklist scores for those who noticed the shape on the critical sixth trial of the Cross Task (Noticed; n = 44) and those who did not (Blind; n =54). Error bars = standard error of the mean.

participants who saw the shape, 14 (31.8%) reported it in the top left quadrant, 14 (31.8%) in the bottom left quadrant, 13 (29.5%) in the top right quadrant, and 3 (6.8%) in the bottom right quadrant.

An independent *t*-test indicated the ADHD symptom scores for participants who reported they noticed the shape (M = 5.05, SD = 3.97) and those who did not (M = 3.72, SD = 4.41) was not statistically different ($t(96) = 1.54$, $p = 0.13$) (**Figure 1B**). This suggests that those who reported the shape did not score higher on the ADHD symptom checklist than those who were "blind" and did not notice the shape. Furthermore, whether the critical shape on the sixth trial was noticed did not significantly differ between those in the ADHD group (M = 0.56, SD = 0.50) and those in the control group (M = 0.39, SD = 0.49) ($t(96) = 1.62$, $p = 0.11$). In contrast to our hypothesis, that participants with ADHD would display more inattentional blindness than neurotypical participants on a simple, less cognitively demanding task, the results indicate no significant differences between the two groups.

DISCUSSION

The main goal of our study was to compare inattentional blindness between adults with ADHD symptomology and a control group without ADHD. Specifically, we wanted to test the hypotheses that participants with ADHD symptomology would display more inattentional blindness on a perceptually simple task, but less inattentional blindness on a dynamic and perceptually complex task. These hypotheses were based on theories of ADHD and findings from the only other empirical investigation into differences in inattentional blindness between these two groups. We aimed to replicate this prior experiment using an online sample of MTurk workers (4).

Generally, we did not find support for these hypotheses, as the attention abilities did not differ between the two groups of participants in either the perceptually simple or complex task. Instead, we found that adults with and without ADHD symptomology performed similarly on both the Monkey Business Illusion and Cross Tasks. Participants across both groups noticed the unexpected events at the same rate, including the gorilla walking through the scene, the player leaving the scene, the curtain changing color, and the shape flashed in the critical sixth trial of the Cross Task.

Like the previous study on inattentional blindness and ADHD, we utilized the "Monkey Business Illusion" Task for our dynamic and perceptually complex task (4). However, we did not have access to the proprietary MOXO-continuous performance task used in the previous study, and instead opted to use the low perceptual load Cross Task that contains static images flashed briefly on the screen. The Cross Task has been utilized by other researchers examining inattentional blindness in participants with autism (2). We did not counterbalance the order of these tasks, and future research would benefit from randomizing the order to reduce the possibility that the Monkey Business Illusion Task influenced performance on the Cross Task. The other major difference between the current experiment and that of Grossman *et al*. is that those researchers tested a group of participants who had an ADHD diagnosis (4). In the current study, we utilized an online sample of MTurk workers that were not specifically recruited for an ADHD diagnosis. Instead, participants completed an ADHD questionnaire, and based on scores on that questionnaire were grouped as having ADHD symptoms or not. These differences in our methodology and paradigm may be partly responsible for the lack of differences between our two groups on inattentional blindness and the contrast of our results with those of previous experiments that examined inattentional blindness in participants with ADHD (4).

There are several other limitations that may account for why we did not replicate the prior findings in the literature. First, this was an online sample, and there may be characteristics about this online sample that differ from in-person samples. For example, individuals participating online may engage less with the task and be distracted by other things (e.g., television or outside noise), which would be less likely if they were physically present in a laboratory with a researcher explaining instructions and ensuring they complete the task diligently. Second, as noted, we did not specifically recruit participants who had an ADHD diagnosis but, for logistical reasons, chose to have all participants complete the ADHD symptom scale, and we classified participants into the two groups based on their scores. The number of participants who scored above the cutoff threshold and were included in our ADHD sample is much higher (~36%) than one would expect in a community sample (~4%) (10). It is possible that even though some participants scored high on this questionnaire, they would not meet the requirements for an ADHD diagnosis if assessed by a clinician. Furthermore, the ADHD group sample size was much smaller than the control group and may have lacked enough power to detect differences between the two groups.

In conclusion, the participants we classified as showing ADHD symptoms did not have different inattentional scores than neurotypical control participants on either the perceptually simple Cross Task or perceptually complex Monkey Business Illusion Task. We did not reach the same conclusions as prior studies that we were seeking to replicate (2–4). Inattentional blindness has significant implications for the real world, such as noticing changes in the environment while driving. It is possible that ADHD may provide an advantage and reduce inattentional blindness under some conditions, but specific details about our methodology could potentially account for our null findings. This is an important research area, and future studies should try to fill this large gap in the literature by examining differences between those with attentional dysfunction and those without.

METHODS

Participants

The study was approved by the Southern Methodist University Institutional Review Board, and all participants

gave informed consent. A total of 99 Amazon Mechanical Turk (MTurk; www.mturk.com) workers recruited through Cloud Research/Turk Prime (11) were compensated $4 for approximately 20 minutes of study participation. One participant was excluded from all analyses based on specific responses which suggested they were most likely a "bot" created to answer surveys, leaving a final sample of 98 participants. An additional nine participants failed an "attention check" where they were instructed to type "Silver" in a text box, but answered incorrectly because they did not carefully read the instructions. These nine participants were not excluded from any analyses since inattentiveness is ultimately what we were measuring in this study. There were 11 participants (5 with ADHD symptoms) who had seen a similar video so they were excluded from the Monkey Business Illusion analysis regarding whether they "saw the gorilla", but included in all other analyses. One additional participant had seen the exact video shown in the experiment, so they were excluded from all analyses regarding the Monkey Business Illusion.

The sample was on average 29 years old (SD = 4.0), had 15.14 years of education (SD = 1.89), and included 69 males and 29 female participants. All participants received an ADHD score based on the Adult ADHD Self-Report Scale (ASRS-v1.1) Symptom Checklist ranging from 0–18 (12)the World Health Organization (WHO. The average ADHD score was 4.32 (SD = 4.25). If the participants scored 5 or above on this measure they were considered to have symptoms of ADHD. Four participants (4.1%) self-reported they had been diagnosed with a learning disorder (e.g. ADHD, dyslexia), of which 3 were included in the 36 (36.7%) who were classified as showing ADHD symptoms by our measure. Additional demographic information including race, ethnicity, sex, education, and employment status was tabulated (**Table 1**).

Materials and questionnaires

The Monkey Business Illusion Task was completed first, and is considered dynamic and perceptually complex (5). Participants watched this video with the title edited out to eliminate any information about the stimuli. The scene consists of two teams of three people passing several basketballs back and forth, one team is wearing white and the other team is wearing black t-shirts. The participant is asked to count the number of passes made by the team wearing white. During the passing of basketballs, three unexpected events occur in the scene: (1) a person in a gorilla costume walks into the middle of the screen, beats on his chest for a few seconds, and then exits the scene; (2) the curtain in the background changes color from red to gold; (3) one player wearing a black t-shirt leaves the scene entirely. The video ends as soon as the players stop passing the basketballs and participants are then asked a series of questions about the unexpected events (see procedure section below).

For the second and perceptually simple task with static stimuli, we employed the Cross Task utilized in prior work (1). Participants are presented six trials where a cross appears briefly on the screen (110 ms), followed by a crosshatch mask (2000 ms). Participants indicate via button press which line of the cross is longer, the horizontal or the vertical line. Participants are given five regular trials and then on the sixth (critical) trial, a shape (circle, square, triangle, or star) briefly appears unexpectedly in one of the four quadrants of the cross. The participant is then asked to respond about whether they saw the shape, which shape they saw, and which quadrant it appeared in.

Lastly, participants completed three questionnaires: (1) the Shipley Institute of Living Vocabulary Test which asks participants to select the correct synonym among 4 choices for 40 target words (13); (2) the Behavioral Inhibition/Behavioral Approach Scales (BIS/BAS) which is a 24-item self-report questionnaire designed to measure the complementary

Table 1. Characteristics of the sample by ADHD group.

Characteristic	ADHD symptoms (n = 36)		non-ADHD (n = 62)	
ADHD score	9.1 (SD = 3.16)		1.5 (SD = 1.43)	
Race	Caucasian	66.7%	Caucasian	66.1%
	Black	16.7%	Black	14.5%
	Asian or Pacific Islander	11.1%	Asian or Pacific Islander	12.9%
	American Indian or Alaskan Native	5.6%	American Indian or Alaskan Native	1.6%
	"Other"	0%	"Other"	4.8%
Sex	Male	72.2%	Male	69.4%
	Female	27.8%	Female	30.6%
Ethnicity	Hispanic	16.7%	Hispanic	6.5%
	Not Hispanic	83.3%	Not Hispanic	93.5%
Education	High School	25.0%	High School	27.4%
	College	58.3%	College	66.1%
	Graduate Training	16.7%	Graduate Training	6.5%
Employment	Employed Full-Time	75.0%	Employed Full-Time	59.7%
	Employed Part-Time	11.1%	Employed Part-Time	14.5%
	Student	8.3%	Student	4.8%
	Not Employed	13.9%	Not Employed	24.2%
IB Score	1.96 (SD = 0.73)		2.07 (SD = 0.69)	
Cross Task		20.0%		24.0%

Note: ADHD = Attention Deficit Hyperactivity Disorder; IB Score = Inattentional Blindness.

motivational systems (14); (3) the Adult ADHD Self-Report Scale is a brief ADHD symptom checklist to determine the number of participants in our sample that met criteria for ADHD symptomatology. A score of 5 or above on this measure indicates symptoms of ADHD, but not a clinical diagnosis (12) the World Health Organization (WHO. All participants also provided demographic and general health information.

Procedure

Participants completed the experiment online via Qualtrics (www.qualtrics.com), and it was distributed to MTurk workers via CloudResearch/TurkPrime (11). After providing informed consent, participants watched the Monkey Business Illusion video and then were asked a series of questions: (1) how many times the people in white t-shirts passed the basketball, with the correct answer being 16, and (2) what was the color of the other team's shirt, which was black. These first two questions served as manipulation checks to ensure that participants were paying attention to the video. The next questions probed whether participants noticed the three unexpected events in a yes-or-no format. The last question asked whether they had seen this video before, with four options to choose from: (a) "No, I have never seen it", (b) "I haven't seen it, but I have heard about it", (c) "I've seen a similar video", or (d) "Yes, I've seen this exact video". The Monkey Business Illusion task was followed by the Cross Task detailed above.

After the two tasks, participants completed the Shipley Vocabulary Test that included an additional question to assess engagement and attention that required participants to select the word "GOWN" from the choices, rather than the synonym of the target word. Participants then completed the BIS/BAS, the Adult ADHD Self Report Scale, and responded to demographic and general health questions. The Shipley and BIS/BAS scores are not reported in this paper. The final question was a second attention check, which required that participants type the word "SILVER" into a text box after reading several lines of instructions.

Received: August 11, 2020
Accepted: December 16, 2020
Published: December 21, 2020

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