Executive Functions in University Students with ADHD

– An Experimental Study

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Abstract

ADHD is a neurodevelopmental disorder that often persists into adulthood. Executive functions are relatively consistently reported as a potential underlying factor in ADHD in children, however, it is unclear how and in what ways they persist in adult years. Inhibition has been theorized to be a core deficiency in ADHD. The present study aimed to investigate executive functions and particularly inhibition in students with ADHD. A total of 385 students completed the Conners' Adult ADHD Rating Scale and the Executive Function Index Scale. 49 students then completed an inhibition task (arrow task). Inhibition was measured by calculating a spatial congruency score for reaction time and accuracy. Higher ADHD scores were indicative of lower daily executive functions (measured via questionnaires). No significant differences in cognitive inhibition were found between students with and without ADHD. Further research is needed to understand the examined discrepancy between impaired behaviourally measured executive functions and non-deficient cognitive inhibition in students with ADHD.

Keywords: ADHD, Students, Executive Functions, Inhibition, Arrow Task

Executive Functions in University Students with ADHD– An Experimental Study

Attention deficit hyperactivity disorder (ADHD) was long thought to only be present in childhood. Since the late nineties, ADHD has also been recognized as a disorder across the lifespan and long-term studies show that symptoms of ADHD diagnosed in children persist during adulthood in about 50 to 80 per cent (Lara et al., 2009; Cheung et al., 2015; Van Lieshout et al., 2016). Adults with ADHD frequently experience functional impairments and are at risk for comorbidities (Sobanski et al., 2007). Deficits in executive functions have been consistently reported as a potential underlying factor of ADHD in children, however, the role of executive functions in adult ADHD is still not well understood (Martel et al., 2007).

ADHD is characterized by interfering deficits in attention and/or hyperactivity/impulsivity (American Psychiatric Association, 2022). Three different subtypes of ADHD are differentiated: predominantly inattentive, mixed, and predominately hyperactive/impulsive. A body of neuropsychological research on ADHD demonstrates structural, neural, and neurochemical brain differences in children and adults with ADHD (Hervey et al., 2004; Epstein et al., 1997; Johnson et al., 2001). ADHD is one of the most heritable psychiatric disorders, but current research suggests that many genes probably contribute, and individuals' gene effects are small (Wilens et al., 2004). Several theories of ADHD have been put forward by psychologists and psychiatrists in the last decades (Johnson et al., 2009). However, no theory to this date is able to conclusively explain the link between the behavioural symptoms of ADHD and brain differences. However, a substantial body of research and theories have emerged that investigate deficient executive functions as potential causal agents of ADHD.

Executive Functions

Executive functions, broadly speaking, are "those capacities that enable a person to engage successfully in independent, purposive, self-serving behavior" (Lezak et al., 2004, p. 42). They can be regarded as a higher-order instance that guides lower-order cognitive functions such as perception, language, and action (Alvarez & Emory, 2006). Executive functions can be both studied and examined on a behavioural (e.g., employing self-report measures) and cognitive level (using cognitive tasks). In daily life, executive functions play a major part; enabling us to focus, successfully solve problems, and plan our future (Ferguson et al., 2021). On a cognitive level, executive functions can be conceptually divided into five categories: planning, inhibiting, working memory, fluency and set-shifting (Pennington & Ozonoff, 1996). However, different fields of research employ different definitions of executive functions and there is until this day no agreement about which cognitive functions constitute executive functions (Nigg et al., 2002).

Executive Function Deficits in ADHD

On a behavioural level, several studies employing questionnaires found that adults with ADHD are more likely to have impairments in EF than adults without ADHD. Deficits in EF are estimated to be a cognitive comorbidity deficit in about 30 percent of people with ADHD (Biederman et al., 2006; Biederman et al., 2004). Further, factor analysis of ADHD symptoms in adults has shown that executive impairments and emotional dysfunction may be as central to ADHD as DSM symptoms of adult ADHD (Adler et al., 2017).

On a cognitive level, many studies employing experimental measures of cognitive function, have also shown impairments of executive functions in ADHD. A summary of the evidence of neuropsychological deficits of executive functions in children with ADHD has demonstrated that executive functions are indeed impaired in children with ADHD (Sergeant et al., 2002). Impairments in executive functions unrelated to age, IQ, or sex difference have been also observed in adults with ADHD (Martel et al, 2007). Interestingly, Martel et al. (2007) found that EF deficits were especially related to the inattentive-disorganized symptom area but not to the hyperactive-impulsive domain.

Although both behavioural and cognitive measurements identify individuals with higher levels of functional impairments – the correlation between both measurements is low

(Biederman et al., 2007). It seems that behavioural measures and cognitive measures of EF identify different subgroups of adults with ADHD. Whereas behaviourally measured EF was related to high levels of comorbidity and functional impairments difficulties, cognitive tests of EF identified individuals with lower IQs (Biederman et al., 2008).

Executive Function Theory of ADHD

Global theories of ADHD should account for structural, functional, and phenotypical differences in people with ADHD (Castellanos et al., 2006). Further, theories of ADHD should in some way lead to a better understanding of the disorder, they should apply to the 'real world', be falsifiable, and be fruitful (Barkley, 2004). The executive dysfunction theory fulfils all these criteria and has brought about substantial research. It posits that all symptoms of ADHD are due to impaired functioning of executive control which is caused by functional, structural, and neurochemical abnormalities in the brain (Johnson et al., 2009).

Research on potential causal agents of ADHD commonly focuses on deficits in executive functions. Boonstra et al. (2005) conducted a meta-analysis summarizing the evidence of 13 studies that investigated executive and non-executive functions in adults with ADHD (compared with adults without ADHD) and found that cognitive impairments are probably not restrained to EF deficits. Indeed, in addition to finding medium effect sizes for deficient verbal fluency, set-shifting, and inhibition, they also found medium effect sizes for non-executive cognitive areas such as colour-naming, consistency of response and word reading are deficient in adults with ADHD.

As unified accounts of executive functions are not well-defined, it may thus be more worthwhile to study specific, distinguishable aspects of EF. One aspect that stands out as central to executive function deficits in ADHD could be inhibition.

Inhibition and ADHD

Extensive research substantiates that deficits in inhibition play an essential role in ADHD (Quay, 1997, Schachar et al., 1993, Barkley, 1997; 2010). On a behavioural level, Barkley (2012) proposes the process of inhibition as the most essential deficit in individuals with ADHD. The process of inhibition does not cause the other executive functions but sets the 'stage' so that they can occur. Thus, ADHD is potentially not only a deficit in inhibition but secondarily also a deficit in executive functions and self-regulation caused by inhibition deficits (Barkley, 2012). Or as Barkley (2012) himself puts it: 'The inhibitor deficit in ADHD delays and interrupts the internalization of behaviour that forms the executive functions, and thereby has an adverse impact on the self-regulation they afford to the individual.' Inhibitory problems as measured via cognitive tasks conceptually relate to daily self-regulation. Self-regulation or impulse control is estimated to be governed largely by inhibition (Baumeister, 2014).

On a cognitive level, current literature often differentiates two related but separable processes of inhibition. The first process is the ability to stop or prevent automatic processes (response suppression). The second process is the capacity to shield interruptions of competing responses (interference control). Although terminology differs across different fields of research, this distinction is made by many researchers investigating inhibition (Mullane et al. 2009; Barkley, 1997; Friedman & Miyake, 2004; Nigg, 2000). Evidence of deficient inhibition in adults with ADHD is relatively consistent. One commonly employed task to measure the response suppression aspect of inhibitory deficits is the Stop-Task, which requires participants to respond as quickly as possible to a go-stimulus. The go-stimulus is always presented, but in some trials, an auditory or visual stop signal is presented shortly after the go-signal which requires participants to inhibit their response. A meta-analysis using the Stop Signal Task found impairments of inhibition in both children and adults with ADHD compared to children and adults without ADHD (Senkowski et al., 2022). Further, other studies that have employed the stop-signal task to examine inhibitory deficits in adults with and without ADHD have also consistently found deficient inhibition for those with ADHD (Lipszyc & Schachar, 2010, Oosterlaan et al., 1998; Lijffijt et al., 2005; Bekker et al., 2005).

However, the question remains if a slower reaction time to the stop-signal in ADHD only reflects problems in inhibition or additional problems in selective attention. Bekker et al. (2005) indeed found that slower reaction time in adults with ADHD may be related to disturbed attentional processing of the stop-signal. Interference control is often measured via the colour Stroop task, which requires reading colour words on a screen, some of which are written in the same colour as the colour name (e.g., the word 'blue' written in blue ink; congruent stimuli), whereas other stimuli are written in a different ink than the colour name (e.g., the word 'blue' written in green ink). Participants thus must inhibit the interruption of competing information – e.g., inhibit the information of ink colour when they are instructed to read out the colour word. Research into interference control deficits in children and adults with ADHD employing the Stroop task is inconsistent (Pennington & Ozonoff, 1996; Homack & Riccio, 2004; van Mourik et al., 2005).

Inhibitory Deficits in University Students

Surprisingly, students with ADHD perform similarly on executive function tests compared to students without ADHD (DuPaul et al., 2009). It appears that, despite their risk factors such as academic underachievement, and high school dropout associated with ADHD, students have somehow surpassed these risk factors and gained admission to third-level education. However, the increased academic demands, less structured environment and fewer routines in university require independent learning and planning abilities that are especially demanding for adults with ADHD (Woltering et al., 2013). Additionally, attending university often marks first-time adults living away from their families, which can be especially challenging for those with ADHD. Students with ADHD often struggle with academic, social, and occupational functional impairments and continue to need support. Compared to students without ADHD, students with ADHD show greater deficits in inhibition (Woltering et al., 2013). However, research concerning the role of inhibition in students with ADHD remains limited, highlighting the need for further research.

The Present Study

The goal of the present study was to gain a better understanding of the association between ADHD symptoms and daily executive functions in students. Specifically, I aimed to investigate behaviourally and cognitively assessed inhibition deficits in students with ADHD. To examine this, ADHD symptoms were assessed via the Conners' Adult ADHD Rating Scale: Long Version (CAARS) and behavioural executive functions were assessed via the Executive Function Index Scale (EFI). An inhibition task (arrow task) was employed to measure cognitive functions of inhibition (Davidson et al., 2006). The task used a spatial compatibility score to assess inhibition by calculating the difference in accuracy and mean reaction time between congruent and incongruent trials.

The first research question (1a) aimed to investigate whether there is an association between ADHD symptoms (measured by the CAARS and EFI). Research consistently demonstrated that executive functions are impaired in adults with ADHD compared to adults without ADHD (Biederman et al., 2006; Biederman et al., 2004; Adler et al., 2017). Along these lines, it is hypothesized that higher levels of ADHD symptoms are related to lower levels of executive functions. Additionally (1b), it was investigated whether there is an association between ADHD symptoms and the impulse control subscale of the EFI. Inhibition plays a significant role in regulating impulse control (Baumeister, 2014), which is why the subscale impulse control for the EFI was of special interest. Because of the theorized relation between inhibition and impulse control, it was hypothesized that higher levels of ADHD symptoms are related to lower levels of impulse control.

The second research question aimed to investigate whether students with higher levels of ADHD symptoms show more inhibitory problems on an inhibition task (i.e., arrow task) than students with lower levels of ADHD. Inhibitory problems are defined as larger differences in reaction time and accuracy between congruent and incongruent trials, which are referred to by 'spatial compatibility reaction time score' and 'spatial compatibility accuracy score' respectively. Studies employing the stop-task to measure inhibition consistently found inhibitory deficits in adults with ADHD compared to adults without ADHD (Lipszyc & Schachtar, 2010, Oosterlaan et al., 1998). However, studies that employed the Stroop task to measure inhibition show inconsistent evidence regarding inhibitory deficits in adults with ADHD (Pennington & Ozonoff, 1996; Homack & Riccio, 2004; van Mourik et al., 2005). Firstly, it is expected that students that score high on ADHD symptoms have a larger difference score of reaction time between congruent and incongruent trials compared to students that score low on ADHD symptoms – thus, having a lower spatial compatibility mean reaction time score (hypothesis 2a). Further, it is expected that students that score high on ADHD symptoms have a higher difference score of accuracy between congruent and incongruent trials than students that score low on ADHD symptoms – thus, having a lower spatial compatibility accuracy score (hypothesis 2b).

The third research question (3a) aimed to investigate whether there is an association between inhibition deficits (measured by using a spatial compatibility score of accuracy and mean reaction time in the arrow task) and problems with executive functions in daily life as measured via the total index score of the EFI. Research has shown that correlations between behavioural measures and cognitive measures of executive functioning are low (Biederman et al., 2007). Nevertheless, it can be expected that cognitive problems in inhibition will influence problems with behavioural executive functions (Barkley, 2012). It is thus expected that higher levels of inhibitory deficits are related to lower executive function scores.

Further (3b), it is investigated whether the impulse control subcategory of behavioural executive functions (EFI) is related to inhibitory deficits (again, measured by using a spatial compatibility score of accuracy and mean reaction time in the arrow task). Since both the inhibition task and the sub-category of impulse control measure similar concepts (Baumeister, 2014), it is predicted that inhibition problems as measured by the arrow are positively correlated with deficits in the behavioural executive functions subscale of impulse control as measured via the EFI.

Methods

Participants

385 undergraduate students from the University of Groningen were recruited via a first-year student research platform (SONA) or via personal contacts (age: M = 20.09, SD = 2.11) and completed the questionnaires. Out of all participants, 293 were females (75.9%) and 92 males (23.8%). All participants that completed the questionnaires received an invitation to participate in the lab study. The experimental sample consisted of participants that were invited after they completed the questionnaire study (n = 32) and students that were invited via personal contacts (n = 17). Out of the total 49 participants, only 41 participants filled in the demographics (age: M = 21,8, SD = 2,4), 21 students were female (51,2 %) and 20 were male (48,8 %). Participants that were recruited via the first-year psychology student participant pool received research participation credits, which added to a requirement they need to fulfil as first-year students. Once the study received approval from the Ethics Committee Psychology of the University of Groningen, the questionnaire data was collected over the course of 8 months (18th of October 2022- 16th of June 2023) and the experimental data was collected over a three-week period, starting from the 7th of May to the 26th of May 2023.

Questionnaires

Conners' Adult ADHD Rating Scale: Long Version (CAARS_S: L)

The CAARS is a self-report questionnaire to assess ADHD in adults developed by Conners et al. (1999). This study employs the long version of the CAARS, which is a valid and reliable measure to test adult ADHD (Erhard et al., 1999). The scale measures ADHD symptoms along four subcategories: a) inattention/ memory problems, b) hyperactivity/restlessness, c) impulsivity/emotional liability, and d) problems with self-concept. To identify individuals at risk for ADHD, a total ADHD Index subscale score is calculated. Further, the CAARS incorporates DSM-V criteria and measures ADHD symptoms through three subscales: Inattentive, Hyperactive-Impulsive Symptoms, and ADHD Symptoms Total. The CAARS comprises 66 items, rated on a four-point Likert scale from 0 (not at all/never) to 3 (very much/very frequently). In this study, t-scores of the ADHD total score index were calculated. Higher t-scores suggest a higher likelihood of ADHD. A t-score of $t > 60$ in the total ADHD total score index has to be examined more closely and possibly indicates an ADHD diagnosis, whereas a total ADHD Index t-score of < 60 indicates that there is probably no ADHD present (Conners, 2002). The CAARS is recognized as a cross-culturally valid measure of ADHD in adults (Christiansen et al., 2012). The ADHD total score index was used for the analysis.

Executive Function Index Scale (EFI)

The EFI is a short, self-rating questionnaire developed to examine executive functions in daily life (Spinella, 2005). The scale was developed employing factor analysis in a normal population. The EFI consists of 27 items measuring five categories: Motivational Drive Organization, Impulse Control, Empathy, and Strategic Planning. The Motivational Drive Organization subscale includes multitasking, distractibility, and the ability to reach decisions. The Impulse Control subscale encompasses socially inappropriate behaviour, sexual impropriety, and impulsivity. The Empathy subscale inquires about social tendencies, concern for others and considering others' feelings. The strategic planning subscale investigates organization skills, future planning, and strategizing. Items are rated on a five-point Likert scale (from 1 = not at all, to 5 = very much). Some items are reverse-coded to control for response biases. A sum of all five categories provides the total executive functions score, in which higher scores indicate better daily executive functions. The EFI is a valid and reliable measure of daily executive functions and demonstrates high correlations with other self-rating executive function scales (Spinella, 2005). The total EFI score and the impulse control subscale score were used for the analysis.

Stimuli and Task

Both the arrow and the GO/No-go task were created and executed in open sesame (Mathôt et al., 2012) utilizing Python programming language and were presented on a 1920 x 1080 mm HP computer display. The Go/No-go task was collected in our study, but ultimately not included in this thesis.

In the arrow task, a single arrow is presented on the screen. The arrow is presented either on the right or the left side of the screen. There are two types of arrows – pointing straight down or pointing diagonally (45°) to the other side. This led to four different combinations of location and direction of the arrow (right side, straight; left side, straight; right side, diagonal; left side, diagonal). The display of the four different types of arrows in Opensesame can be found in Appendix A. The 'f' (left-side response) and the 'j' button (right-side response) on a normal computer keyboard were used as response buttons. In the task, a straight arrow required a button response on the same side as the arrow (congruent trial), whereas a diagonal arrow (pointing to the opposite side of the arrow location) required a button response on the opposite side (incongruent trial). A practise block consisted of 8 trials (each of the four types of arrows was repeated twice). The main block consisted of 20 trials (each of the four types of arrows was repeated five times). A trial started with a fixation point interval of 500 ms (small dot in the middle of the screen, y= 0; x=0). The stimulus (arrow) was then presented for a maximum of 750 ms, terminated by a 'f' or 'j' key response. This resulted in a maximum total trial duration of 1250 ms. The arrow task requires little working memory since the instructions for a correct response to the task are provided in the direction of the arrow itself – the arrow points to the correct button in each trial (Davidson et al., 2006).

The following calculations were performed similarly to Davidson et al. (2006): The accuracy of responses in the arrow task was calculated by dividing the number of correct responses by the number of correct and incorrect responses. A trial was regarded as correct (a) if the first response following the stimuli was correct and (B) if the response time after stimuli presentation was slower than 200 ms. Anticipatory responses were excluded from the accuracy score since reaction times of < 200 ms indicate that the participant either failed to release the button of the previous response or that they pressed the button before they even saw the present stimuli. Spatial compatibility, which is the difference between incongruent and congruent stimuli, was calculated for reaction time and accuracy. The difference score of accuracy on congruent and incongruent trials was calculated by subtracting the mean number of correct responses for the incongruent trials from the mean number of correct responses for the congruent trial (spatial compatibility accuracy). The difference score of the mean reaction time on congruent and incongruent trials was calculated by subtracting the mean reaction time for the congruent trial from the mean reaction time for the incongruent trial (spatial compatibility reaction time).

Procedure

As part of the first study, participants logged into the first-year student platform SONA and completed two questionnaires in the online survey platform Qualtrics via links. Those participants that were recruited via personal contacts received the links to Qualtrics via text messages. The first questionnaire assessed self-rated ADHD symptomatology Conners Adult ADHD Rating Scale (CAARS; Conner et al., 1999) and the second one measured self-rated executive functioning via the Executive Function Index Scale (EFI; Spinella, 2005). Completion of both questionnaires required around 45 minutes. After completion of the two questionnaires, at first, only those students that scored high and low on the ADHD total score were invited to the follow-up experimental study. Due to low participant numbers, it was then decided to invite everyone that participated in the questionnaire study. Participants were informed that the follow-up study consists of two cognitive tasks, namely the arrow task and the Go/No-go task. Further, participants were informed that both tasks are completed on a computer and that no risks are involved.

Those that decided to participate received an information sheet about the study and signed informed consent. The arrow task and the Go/No-go task were sequentially presented, and participants were randomly assigned to experience either task first. Precise instructions and examples were provided to the participants before they started the task (see Appendix B). Participants first completed a practice trial and then the main trial. After the completion of both tasks, the research credit points were given to the applicable students.

Analysis

The study followed a within-subject design, as participants were all randomly presented with both congruent and incongruent stimuli. Concerning the questionnaires, the total ADHD Index score of CAARS was utilized for hypothesis 1 and hypothesis 3, as it signals potential ADHD in adults. Both the total score and the impulse control sub-scale of the EFI were employed to test the first and third hypotheses. The total score of the EFI reflects daily executive functions, whereas the impulse control subscale relates to inhibition.

Participants that took part in the arrow task were allocated either into a high or low ADHD group based on their total ADHD index score. Participants scoring above t = 60 were allocated to the high ADHD group, while those scoring below t = 60 were assigned to the low ADHD group. The cut-off score of t= 60 is in line with Conners (2002).

In the analysis, normality will be checked by the Kolmogorov-Smirnov and the Shapiro-Wilk test. For the first hypothesis, a bivariate correlation will be employed. To test the task effects, a dependent samples t-test will be used if all variables are normally distributed. However, if the relevant variables deviate from normality, the nonparametric

Wilcoxon Signed-Rank test will be employed. To test hypothesis 3, an independent samples t-test will be used if the relevant variables are normally distributed. If normality assumptions are not met, the nonparametric independent samples Whitney-U test will be used.

Results

Out of the 49 participants that took part in the experimental part of the study, five did not fill out either one of the questionnaires. These five participants were excluded from all analyses related to the questionnaires but were included in the analysis of the task effects. Additionally, two participants did not complete the CAARS, but did fill in the EFI, and were thus only excluded from all analyses concerning the CAARS. Another two participants did not fill in the EFI, but filled in the CAARS, and were therefore excluded from all analyses concerning the EFI.

Association Between CAARS and EFI

Firstly, it was hypothesized that higher levels of ADHD symptoms (CAARS total score ADHD index) are indicative of lower levels of general executive functions as measured via the EFI (hypothesis 1a). The Kolmogorov-Smirnov and Shapiro-Wilk test was performed to assess the normality of all subscales and total scores of the CAARS and EFI. The tests indicated a significant deviation from normality on all subscales and total scores (Appendix C, Table C1). There was a significant, negative correlation between the CAARS T-score ADHD Index and the EFI total score ($\rho = -.489$, $p < .001$), as indicated by a Spearman correlation. Higher ADHD scores were indicative of lower executive functions in the current study, which supported the hypothesis.

Secondly, it was hypothesized that lower impulse control (subscale of the EFI) is related to higher levels of ADHD as measured by the CAARS (hypothesis 1b). A Spearman correlation yielded a significant, negative association ($\rho = -.353$; $p < .001$). To sum up, higher ADHD scores were related to lower impulse control, which supported hypothesis 1b.

Arrow Task

Normality for all variables relevant to the arrow task analysis was checked by employing the Kolmogorov-Smirnov and the Shapiro-Wilk test (Appendix C, Table C2).

Task Effects

To ensure the validity of the task effects, the difference in accuracy and mean reaction time between the congruent and incongruent trials was assessed. A dependent samples t-test demonstrated a significant difference in mean reaction between the congruent and incongruent trials (t (48) = -2.77; p = .008; d = -.396). Mean reaction time was significantly faster on congruent trials (M = 497.2; SD = 56.8) than on incongruent trials (M = 516.6; SD = 67.6).

The accuracy variables on congruent and incongruent trials were not normally distributed, which is why the Wilcoxon Signed-Rank test was employed. The test demonstrated that accuracy was significantly lower on incongruent compared to congruent trials (Z = -4.28; $p < .001$). To conclude, significant task effects thus differences between congruent and incongruent trials for both reaction time and accuracy were confirmed.

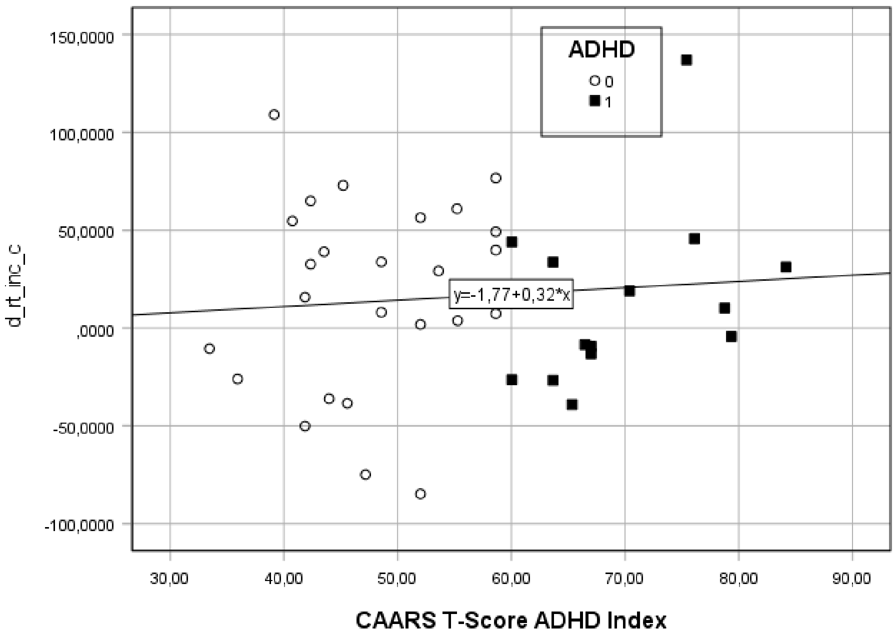
Spatial Compatibility of Reaction Time

Students with ADHD were expected to be slower on both the incongruent and the congruent trials of the arrow task (hypothesis 2a). An independent-sample t-test demonstrated no significant differences in mean reaction time spatial congruency scores (the difference between mean reaction time on incongruent and congruent trials) between students with and without ADHD (t (39) = .213, p =.832, d = .069).

A scatterplot depicting the correlation between the spatial compatibility difference score of mean reaction time and the total CAARS ADHD additionally showed that the difference scores of reaction time between the incongruent and congruent trials are similar for students with and without ADHD (Figure 1). To conclude, both groups (low and high levels of ADHD symptoms) demonstrated similar spatial compatibility scores for reaction time).

Figure 1

Scatterplot with Group Differentiation



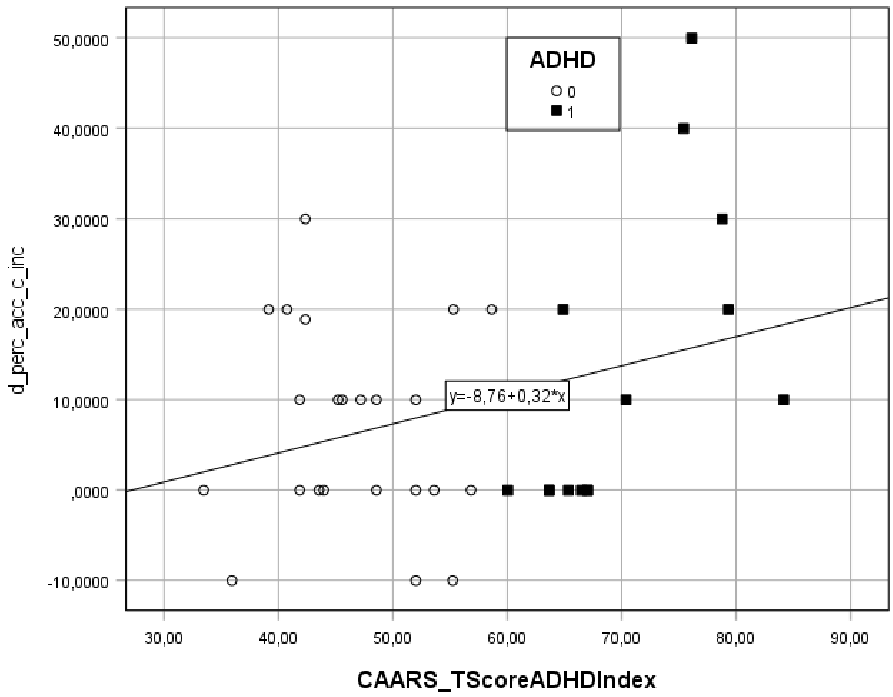
Note. Correlation between the CAARS T-Score ADHD Index and the difference in reaction time between incongruent and congruent trials.

Spatial Compatibility of Accuracy

Students with ADHD were expected to be less accurate on congruent and incongruent trials compared to students without ADHD (hypothesis 2b). Since accuracy scores for congruent and incongruent trials were not normally distributed, the independent samples Whitney-U test was employed to test the hypothesis. The test showed no significant differences between the spatial compatibility accuracy score (the difference between accuracy on congruent and incongruent trials) ($Z = .676$, $p = .529$). Additionally, a scatterplot depicting the association between the spatial compatibility of accuracy and the CAARS t-score ADHD index showed no discernible variation in the difference in accuracy between incongruent and congruent trials between students with and without ADHD (Figure 2). To sum up, both groups (low and high levels of ADHD symptoms) performed similarly in terms of the spatial compatibility effect for accuracy.

Figure 2

Scatterplot with Group Differentiation



Note. Correlation between the CAARS T-Score ADHD Index and the difference in accuracy between incongruent and congruent trials.

Association Between Inhibitory Problems in the Arrow Task and the EFI

It was expected that there is a negative association between inhibitory problems (spatial compatibility effect for accuracy) as measured via the arrow task and executive functions as measured via the total EFI score (3a). A Spearman correlation revealed a non-significant association between spatial compatibility reaction time and the total CAARS index score ($\rho = .089$, $p = .578$). Further, the Spearman correlation between spatial compatibility accuracy and the total CAARS index score demonstrated a negative association ($\rho = .318$, $p = .043$).

In conclusion, hypothesis 3a was not supported as no significant negative association between inhibitory problems (arrow task) and executive functions (EFI) was found. However, the correlation between spatial compatibility accuracy and the total CAARS index score indicated a tendency that higher differences in accuracy between congruent and incongruent trials are indicative of lower executive functions (EFI).

Further, a negative association between inhibitory problems and the subscale of impulse control was expected (3b). The Spearman correlation between spatial compatibility reaction time and the impulse control subscale of the EFI was not significant ($\rho = .054$, $p = .740$). A significant, medium association between the spatial congruency accuracy score and the impulse control subscale of the EFI was found ($\rho = -.412$, $p = .008$). In conclusion, a higher difference in reaction time between congruent and incongruent trials was not indicative of lower levels of impulse control. However, a greater difference in accuracy between congruent and incongruent trials was related to lower levels of impulse control.

Discussion

The present study aimed to investigate executive functions in students with ADHD. Specifically, this study sought to examine what role inhibitory problems as measured via the arrow task play in ADHD in students. Adult ADHD in general and particularly in relation to executive functioning deficits is still an understudied area (Martel et al., 2007).

Consistent with previous research, the present study found that students with ADHD commonly experience daily problems with executive functions. Higher levels of ADHD symptoms were indicative of lower levels of executive functions as measured via questionnaires. This is in line with previous research that consistently finds deficits in self-reported executive functions in adults with ADHD (Biederman et al., 2004; Biederman et al., 2006; Adler et al., 2017).

Specifically, this study investigated inhibitory problems employing a spatial compatibility task (i.e., arrow task). The differences in reaction time and accuracy between congruent (requiring a button response on the same side as the stimulus) and incongruent trials (requiring a button response on the opposite side as the stimulus) were assessed. Reaction times were generally faster on congruent than on incongruent trials. Further, accuracy was higher on congruent compared to incongruent trials. This is in line with consistent findings of the spatial compatibility effect (Craft & Simon, 1970; Fitts & Seger, 1953; Hommel, 1995; Hommel et al., 2004; Simon, 1990) and demonstrates valid task effects.

It was expected that students with ADHD have a higher spatial compatibility effect- indicative of lower levels of interference control. However, this study did not find any differences in the spatial compatibility effect between students with and without ADHD – both groups demonstrated similar differences in accuracy and reaction time between congruent and incongruent trials. These findings contrast the relatively consistent evidence of impaired inhibition in adults with ADHD as measured via the stop-task (Lipszyc & Schachtar, 2010; Oosterlaan et al., 1998). However, it is important to distinguish between two commonly described separable processes of inhibition. In the stop task, participants have to suppress the dominant response (response suppression), while the arrow task similar to the Stroop task measures the ability to prevent interruptions of irrelevant information (interference control). Studies that investigated interference control employing the Stroop task in children and adults with ADHD also demonstrate mixed findings (Pennington & Ozonoff, 1996; Homack & Riccio, 2004; van Mourik et al., 2005).

Further, since the present study encompasses both behavioural and cognitive measures of executive function, the relationship between those two variables was of interest. Often executive functions are studied employing either type of measurement and it is unclear why correlations between behavioural and cognitive measures of inhibition-related executive functions are usually low (Nęcka et al., 2018; Saunders et al., 2017). A low correlation between cognitive and behavioural measures of the same construct does not necessarily undermine their validity. Rather, it could be that both the questionnaire and the cognitive test measure different aspects of inhibition. Additionally, low and non-significant findings could be due to the reliability paradox. Experimental tasks are high in robustness if the variance between participants is low. This causes low reliability to test individual differences between participants which hinders reliable correlations with other variables (Hedge et al., 2017).

In the present study, self-reported executive functions were not indicative of inhibition problems. There are several reasons why this could be the case: For one, students with ADHD are surrounded by other rather high-performing adults in the university setting. It could be that because most of them probably compare their executive functions to those close to them (thus probably often students) that they might underestimate their daily executive function and thus underreport them in the EFI. Further, the reliability paradox additionally constrained our findings.

Interestingly, the current study did find that higher differences in accuracy between congruent and incongruent trials are related to lower levels of executive functions (EFI). Additionally, higher differences in accuracy between congruent and incongruent trials were indicative of worse reported impulse control (subscale of the EFI). It could be hypothesized that if someone takes more time on incongruent trials than on congruent trials, then this is possibly not as detrimental to everyday executive functioning as differences in accuracy between incongruent and congruent trials. That is because if someone takes a little more time generally on everyday tasks that require inhibition this does not necessarily lead to any problems. If, however, someone makes more mistakes in tasks requiring inhibition this will probably restrict their daily executive functioning to a greater degree.

The present study focused on inhibition as a specific aspect of executive functions, instead of employing cognitive tests that intend to measure general executive functions. Since many commonly employed cognitive tests are not uniform and thus tap into various abilities of EF, it has been suggested that future research should rely upon cognitive tests that clearly relate to one set of EF abilities (Boonstra et al., 2005). This has the advantage of investigating one specific clearly defined aspect of executive functions. Further, the present study used a spatial compatibility test (i.e., arrow task), which is an adjusted version of the Simon task that is a valid and reliable measure of interference control (Mullane et al., 2009). The Stroop task is commonly employed to examine interference control but has been subject to critique in recent years. Especially, its reliance on a control condition and that reading-related abilities play a role in it have been criticized (Nigg, 2001; van Mourik et al., 2005). The arrow task employed in the present study does not rely on reading-related abilities and uses accuracy and reaction time as precise measures of the spatial compatibility effect.

Despite the aforementioned strengths of our study, several limitations have to be acknowledged. Firstly, the sample size of the current lab study was relatively small and therefore the power to detect significant differences in spatial compatibility between students with and without ADHD was probably low. This limits the generalizability of the present study's results. Additionally, mainly first-year students participated in the present study, which does not reflect all university students and further limits generalizability.
Secondly, the present study aimed to investigate inhibition deficits in students with ADHD, however, the arrow task does only measure one aspect of inhibition, namely interference control. This limits the validity of the present study. Thirdly, the arrow task was developed to investigate the developmental processes of inhibitory control over age. Although children and adults participated in their study, it is not clear how reliable the task is when only adults are tested.

Additionally, the present study split the participants into a high and low ADHD group based on the amount of ADHD symptoms reported (Conners, 2002). Some participants scored very closely above or below the cut-off score for which significant differences in inhibitory deficits cannot be expected. Future research could aim to test the difference in inhibitory deficits between students with and without ADHD, by recruiting a larger number of participants and for example, using quartile groups, or contrasting the extremes (1 vs 4th quartile). Further, comorbidities were not considered in our analysis but might have affected the present study's results. Out of the 49 participants in the experimental part of the study, five participants were officially diagnosed with ADHD. One out of the five had a present comorbid disorder. Additionally, four participants reported a diagnosed psychological disorder (autism (n=1), borderline personality disorder (n=1), depression (n=2), and depression and anxiety (n=1). Executive functioning problems generally, and inhibitory deficits specifically are common in other psychological disorders as well (Lipszyk & Schachar, 2010). Future studies should exclude participants with comorbid disorders to specifically focus on the role of inhibitory control in ADHD.

The present study investigated executive functions and particularly inhibition in students with ADHD. Self-reported ADHD symptoms were indicative of daily executive functions. To address inhibition as a potential underlying factor in ADHD in students, an experimental study employing a spatial compatibility task was conducted. Although task effects were established, both groups (high vs low levels of ADHD) performed similarly in inhibitory control. Differences in accuracy between congruent and incongruent trials were indicative of worse daily executive functions.

References

Adler, L. A., Faraone, S. V., Spencer, T. J., Berglund, P., Alperin, S., & Kessler, R. C. (2017). The structure of adult ADHD. *International Journal of Methods in Psychiatric Research*, *26*(1), e1555. https://doi.org/10.1002/mpr.1555

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review*, *16*(1), 17-42. https://doi.org/10.1007/s11065-006-9002-x

American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.). https://doi.org/10.1176/appi.books.9780890425787

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65-94. https://doi.org/10.1037/0033-2909.121.1.65

Barkley, R. A. (2004). Adolescents with attention-deficit/Hyperactivity disorder: An overview of empirically based treatments. *Journal of Psychiatric Practice*, *10*(1), 39-56. https://doi.org/10.1097/00131746-200401000-00005

Barkley, R. A. (2010). Differential diagnosis of adults with ADHD. *The Journal of Clinical Psychiatry*, *71*(07), e17. https://doi.org/10.4088/jcp.9066tx1c

Barkley, R. A. (2012). *Executive functions: What they are, how they work, and why they evolved*. Guilford Press.

Baumeister, R. F. (2014). Self-regulation, ego depletion, and inhibition. *Neuropsychologia*, *65*, 313-319. https://doi.org/10.1016/j.neuropsychologia.2014.08.012

Bekker, E. M., Overtoom, C. C., Kooij, J. S., Buitelaar, J. K., Verbaten, M. N., & Kenemans, J. L. (2005). Disentangling deficits in adults with attention-deficit/Hyperactivity disorder. *Archives of General Psychiatry*, *62*(10), 1129. https://doi.org/10.1001/archpsyc.62.10.1129

Biederman, J., Monuteaux, M. C., Doyle, A. E., Seidman, L. J., Wilens, T. E., Ferrero, F., Morgan, C. L., & Faraone, S. V. (2004). Impact of executive function deficits and attention-deficit/Hyperactivity disorder (ADHD) on academic outcomes in children. *Journal of Consulting and Clinical Psychology*, *72*(5), 757-766. https://doi.org/10.1037/0022-006x.72.5.757

Biederman, J., Monuteaux, M. C., Mick, E., Spencer, T., Wilens, T. E., Silva, J. M., Snyder, L. E., & Farone, S. V. (2006). Young adult outcome of attention deficit hyperactivity disorder: A controlled 10-year follow-up study. *Psychological Medicine*, *36*(2), 167-179. https://doi.org/10.1017/s0033291705006410

Biederman, J., Petty, C. R., Fried, R., Black, S., Faneuil, A., Doyle, A. E., Seidman, L. J., & Faraone, S. V. (2008). Discordance between psychometric testing and questionnaire-based definitions of executive function deficits in individuals with ADHD. *Journal of Attention Disorders*, *12*(1), 92-102. https://doi.org/10.1177/1087054707305111

Boonstra, A. M., Oosterlaan, J., Sergeant, J. A., & Buiterlaar, J. K. (2005). Executive functioning in adult ADHD: A meta-analytic review. *Psychological Medicine*, *35*(8), 1097-1108. https://doi.org/10.1017/s003329170500499x

Castellanos, F. X., Sonuga-Barke, E. J., Milham, M. P., & Tannock, R. (2006). Characterizing cognition in ADHD: Beyond executive dysfunction. *Trends in Cognitive Sciences*, *10*(3), 117-123. https://doi.org/10.1016/j.tics.2006.01.011

Cheung, C. H., Rijdijk, F., McLoughlin, G., Faraone, S. V., Asherson, P., & Kuntsi, J. (2015). Childhood predictors of adolescent and young adult outcome in ADHD. *Journal of Psychiatric Research*, *62*, 92-100. https://doi.org/10.1016/j.jpsychires.2015.01.011

Conners, C. K., Erhardt, D., & Sparrow, E. (1999). Conner's adult ADHD rating scales: Technical manual. Multi-Health Systems Incorporated (MHS).

Conners, C. K., Erhardt, D., & Sparrow, E. (2002). Conners' Adult ADHD Rating Scales–Self-Report: Long Version (CAARS–S: L). *Toronto, Canada: Multi-Health Systems*.

Craft, J. L., & Simon, J. R. (1970). Processing symbolic information from a visual display: Interference from an irrelevant directional cue. *Journal of Experimental Psychology*, *83*(3, Pt.1), 415-420. https://doi.org/10.1037/h0028843

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

DuPaul, G. J., Weyandt, L. L., O'Dell, S. M., & Varejao, M. (2009). College students with ADHD: current status and future directions. *Journal of attention disorders*, *13*(3), 234–250. https://doi.org/10.1177/1087054709340650

Epstein, J. N., Conners, C. K., Erhardt, D., March, J. S., & Swanson, J. M. (1997). Asymmetrical hemispheric control of visual-spatial attention in adults with attention deficit hyperactivity disorder. *Neuropsychology*, *11*(4), 467-473. https://doi.org/10.1037/0894-4105.11.4.467

Ferguson, H. J., Brunsdon, V. E., & Bradford, E. E. (2021). The developmental trajectories of executive function from adolescence to old age. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-020-80866-1

Fitts, P. M., & Seeger, C. M. (1953). S-R compatibility: Spatial characteristics of stimulus and response codes. *Journal of Experimental Psychology*, *46*(3), 199-210. https://doi.org/10.1037/h0062827

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General*, *133*(1), 101-135. https://doi.org/10.1037/0096-3445.133.1.101

Hedge, C., Powell, G., & Sumner, P. (2017). The reliability paradox: Why robust cognitive tasks do not produce reliable individual differences. *Behavior Research Methods*, *50*(3), 1166-1186. https://doi.org/10.3758/s13428-017-0935-1

Hervey, A. S., Epstein, J. N., & Curry, J. F. (2004). Neuropsychology of adults with attention-deficit/Hyperactivity disorder: A meta-analytic review. *Neuropsychology*, *18*(3), 485-503. https://doi.org/10.1037/0894-4105.18.3.485

Homack, S., & Riccio, C. A. (2004). A meta-analysis of the sensitivity and specificity of the Stroop color and word test with children. *Archives of Clinical Neuropsychology*, *19*(6), 725-743. https://doi.org/10.1016/j.acn.2003.09.003

Hommel, B. (1995). Stimulus-response compatibility and the Simon effect: Toward an empirical clarification. *Journal of Experimental Psychology: Human Perception and Performance*, *21*(4), 764-775. https://doi.org/10.1037/0096-1523.21.4.764

Hommel, B., Proctor, R. W., & Vu, K. L. (2004). A feature-integration account of sequential effects in the Simon task. *Psychological Research*, *68*(1), 1-17. https://doi.org/10.1007/s00426-003-0132-y

Johnson, D. E., Epstein, J. N., Waid, L., Latham, P. K., Voronin, K. E., & Anton, R. F. (2001). Neuropsychological performance deficits in adults with attention deficit/hyperactivity disorder. *Archives of Clinical Neuropsychology*, *16*(6), 587-604. https://doi.org/10.1093/arclin/16.6.587

Johnson, K. A., Wiersema, J. R., & Kuntsi, J. (2009). What would Karl Popper say? Are current psychological theories of ADHD falsifiable? *Behavioral and Brain Functions*, *5*(1), 15. https://doi.org/10.1186/1744-9081-5-15

Lara, C., Fayyad, J., De Graaf, R., Kessler, R. C., Aguilar-Gaxiola, S., Angermeyer, M., Demytteneare, K., De Girolamo, G., Haro, J. M., Jin, R., Karam, E. G., Lépine, J., Mora, M. E., Ormel, J., Posada-Villa, J., & Sampson, N. (2009). Childhood predictors of adult attention-deficit/Hyperactivity disorder: Results from the World Health Organization World Mental Health survey initiative. *Biological Psychiatry*, *65*(1), 46-54. https://doi.org/10.1016/j.biopsych.2008.10.005

Lezak, M. D., Howieson, D. B., Loring, D. W., & Hannay, H. J. (2004). Neuropsychological assessment (4th ed.). London: Oxford University Press

Lijffijt, M., Kenemans, J. L., Verbaten, M. N., & van Engeland, H. (2005). A meta-analytic review of stopping performance in attention-deficit/Hyperactivity disorder: Deficient inhibitory motor control? *Journal of Abnormal Psychology*, *114*(2), 216-222. https://doi.org/10.1037/0021-843x.114.2.216

Lipszyc, J., & Schachtar, R. (2010). Inhibitory control and psychopathology: A meta-analysis of studies using the stop signal task. *Journal of the International Neuropsychological Society*, *16*(6), 1064-1076. https://doi.org/10.1017/s1355617710000895

Martel, M., Nikolas, M., & Nigg, J. T. (2007). Executive function in adolescents with ADHD. *Journal of the American Academy of Child & Adolescent Psychiatry*, *46*(11), 1437-1444. https://doi.org/10.1097/chi.0b013e31814cf953

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*(2), 314-324. doi:10.3758/s13428-011-0168-7

Mullane, J. C., Corkum, P. V., Klein, R. M., & McLaughlin, E. (2009). Interference control in children with and without ADHD: A systematic review of flanker and Simon task performance. *Child Neuropsychology*, *15*(4), 321-342. https://doi.org/10.1080/09297040802348028

Nęcka, E., Gruszka, A., Orzechowski, J., Nowak, M., & Wójcik, N. (2018). The (In)significance of executive functions for the trait of self-control: A psychometric study. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01139

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin*, *126*(2), 220-246. https://doi.org/10.1037/0033-2909.126.2.220

Nigg, J. T. (2001). Is ADHD a disinhibitory disorder? *Psychological Bulletin*, *127*(5), 571-598. https://doi.org/10.1037/0033-2909.127.5.571

Nigg, J. T., Blaskey, L. G., Huang-Pollock, C. L., & Rappley, M. D. (2002). Neuropsychological executive functions and DSM-IV ADHD subtypes. *Journal of the American Academy of Child & Adolescent Psychiatry*, *41*(1), 59-66. https://doi.org/10.1097/00004583-200201000-00012

Oosterlaan, J., Logan, G. D., & Sergeant, J. A. (1998). Response inhibition in AD/HD, CD, comorbid AD/HD+CD, anxious, and control children: A meta-analysis of studies with the stop task. *Journal of Child Psychology and Psychiatry*, *39*(3), 411-425. https://doi.org/10.1017/s0021963097002072

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *37*(1), 51-87. https://doi.org/10.1111/j.1469-7610.1996.tb01380.x

Quay, H.C. (1997). Inhibition and attention deficit hyperactivity disorder. Journal of abnormal child psychology, 25, 7-13. (1997). *Journal of Attention Disorders*, *2*(3), 199-200. https://doi.org/10.1177/108705479700200315

Saunders, B., Milyavskaya, M., Etz, A., Randles, D., & Inzlicht, M. (2017). Reported self-control is not meaningfully associated with inhibition-related executive function: A Bayesian analysis. https://doi.org/10.31234/osf.io/bxfsu

Schachar, R. J., Tannock, R., & Logan, G. (1993). Inhibitory control, impulsiveness, and attention deficit hyperactivity disorder. *Clinical Psychology Review*, *13*(8), 721-739. https://doi.org/10.1016/s0272-7358(05)80003-0

Senkowski, D., Ziegler, T., Singh, M., Heinz, A., He, J., Silk, T., & Lorenz, R. C. (2022). Assessing inhibitory control deficits in adult ADHD: A systematic review and meta-analysis of the stop-signal task. https://doi.org/10.1101/2022.07.09.22277429

Sergeant, J. A., Geurts, H., & Oosterlaan, J. (2002). How specific is a deficit of executive functioning for attention-deficit/Hyperactivity disorder? *Behavioural Brain Research*, *130*(1-2), 3-28. https://doi.org/10.1016/s0166-4328(01)00430-2

Simon, J. R. (1990). The effects of an irrelevant directional cue on human information processing. *Advances in Psychology*, 31-86. https://doi.org/10.1016/s0166-4115(08)61218-2

Sobanski, E., Brüggemann, D., Alm, B., Kern, S., Deschner, M., Schubert, T., Philipsen, A., & Rietschel, M. (2007). Psychiatric comorbidity and functional impairment in a clinically referred sample of adults with attention-deficit/hyperactivity disorder (ADHD). *European Archives of Psychiatry and Clinical Neuroscience*, *257*(7), 371-377. https://doi.org/10.1007/s00406-007-0712-8

Spinella, M. (2005). Self-rated executive function: development of the executive function index. International Journal of Neuroscience, 115(5), 649-667.

Van Lieshout, M., Luman, M., Twisk, J. W., Van Ewijk, H., Groenman, A. P., Thissen, A. J., Faraone, S. V., Heslenfeld, D. J., Hartman, C. A., Hoekstra, P. J., Franke, B., Buitelaar, J. K., Rommelse, N. N., & Oosterlaan, J. (2016). A 6-year follow-up of a large European cohort of children with attention-deficit/hyperactivity disorder-combined subtype: Outcomes in late adolescence and young adulthood. *European Child & Adolescent Psychiatry*, *25*(9), 1007-1017. https://doi.org/10.1007/s00787-016-0820-y

Van Mourik, R., Oosterlaan, J., & Sergeant, J. A. (2005). The Stroop revisited: A meta-analysis of interference control in AD/HD. *Journal of Child Psychology and Psychiatry*, *46*(2), 150-165. https://doi.org/10.1111/j.1469-7610.2004.00345.x

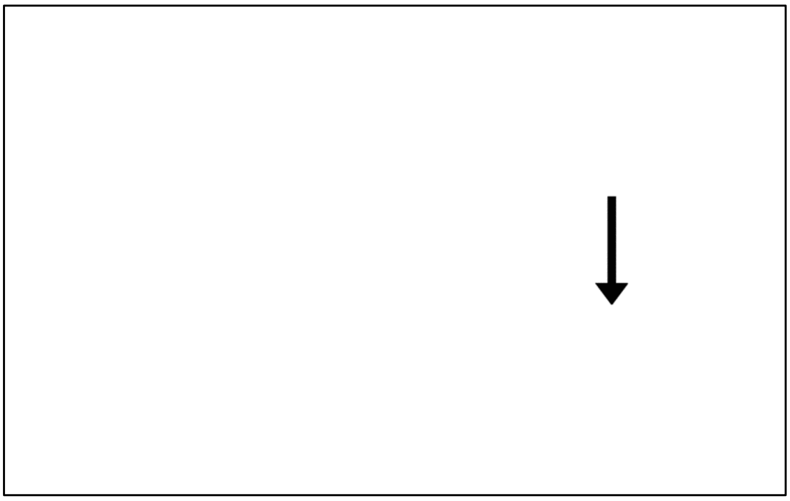
Wilens, T. E., Faraone, S. V., & Biederman, J. (2004). Attention-deficit/hyperactivity disorder in adults. *JAMA*, *292*(5), 619–623. https://doi.org/10.1001/jama.292.5.619

Woltering, S., Liu, Z., Rokeach, A., & Tannock, R. (2013). Neurophysiological differences in inhibitory control between adults with ADHD and their peers. *Neuropsychologia*, *51*(10), 1888-1895. https://doi.org/10.1016/j.neuropsychologia.2013.06.023

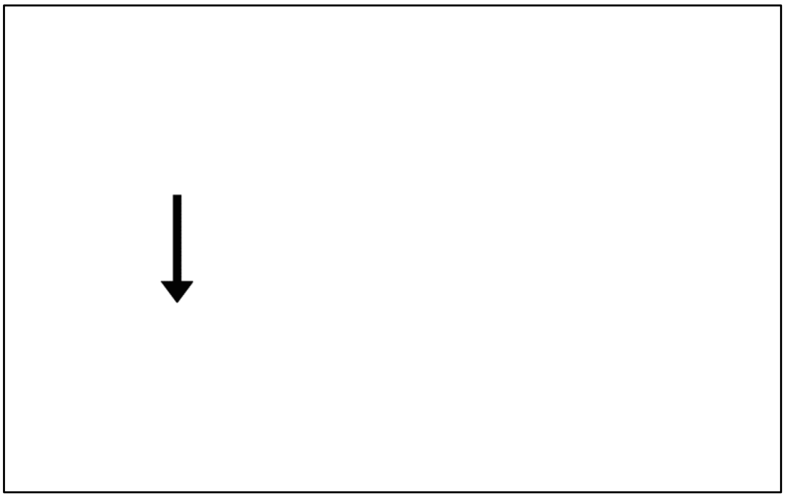
Appendix A

The Four Types of Arrows

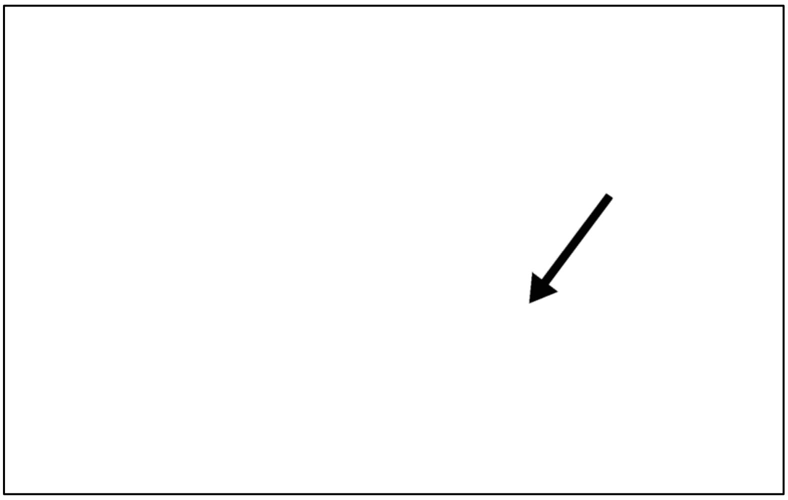
Right side, straight arrow



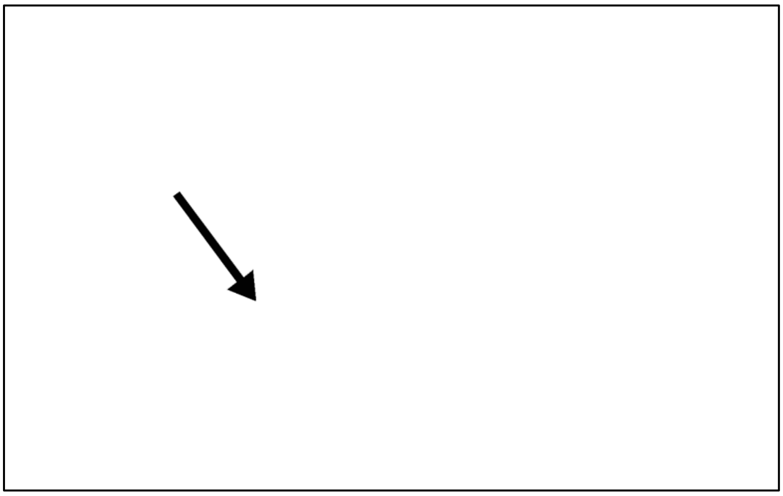
Left side, straight arrow



Right side, diagonal arrow

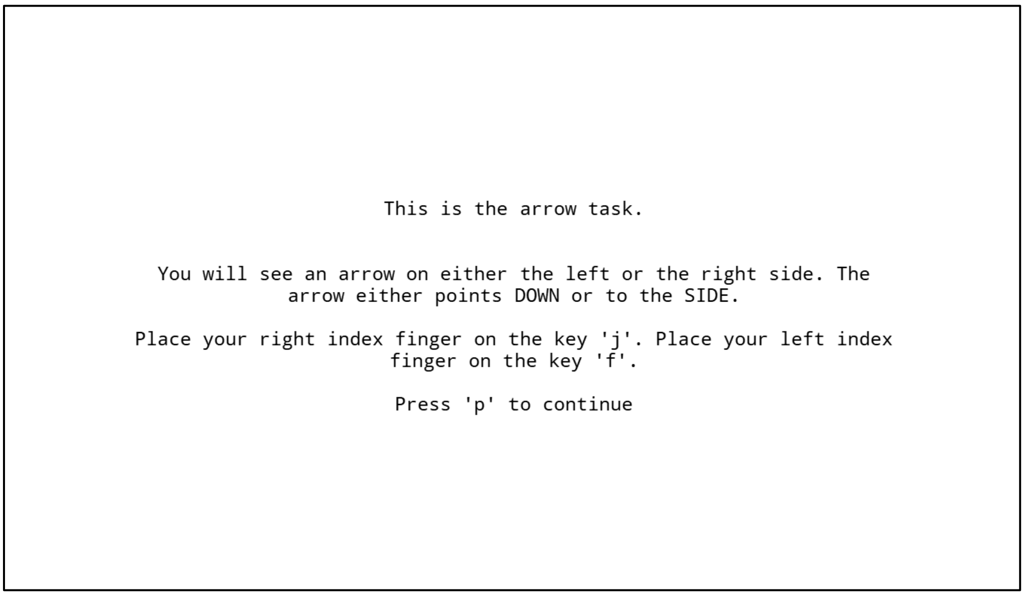


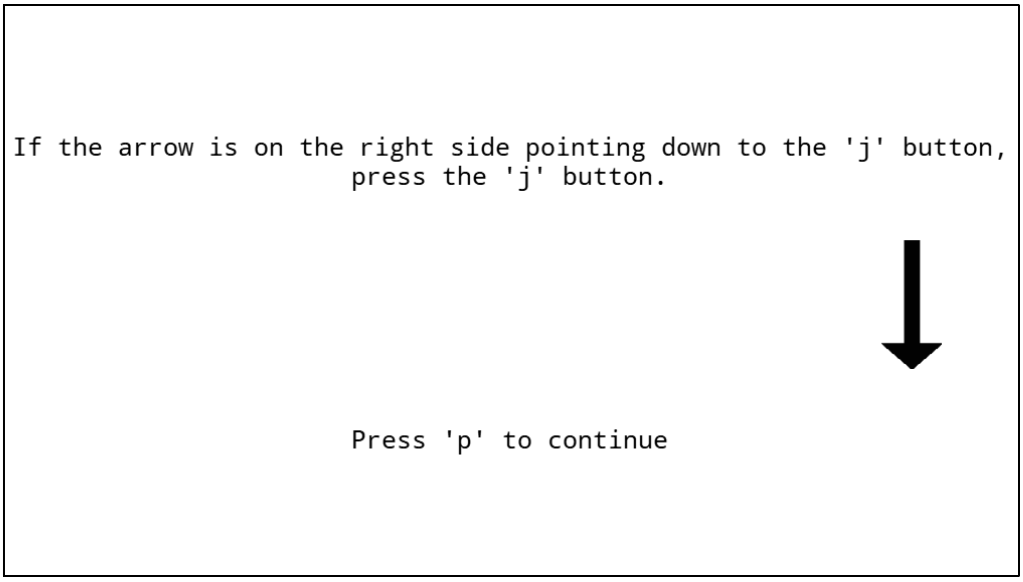
Left side, diagonal arrow

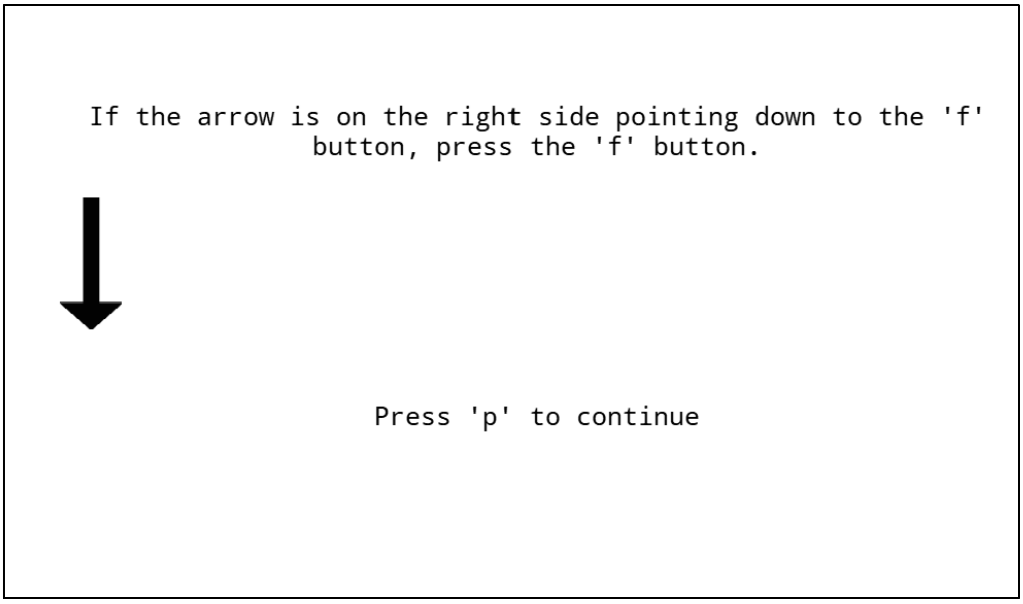


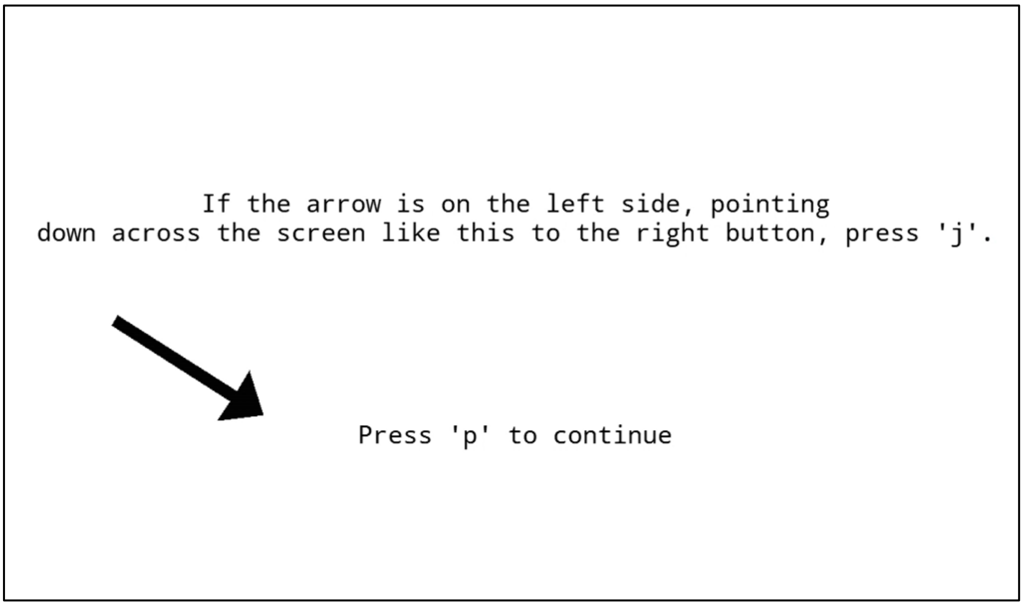
Appendix B

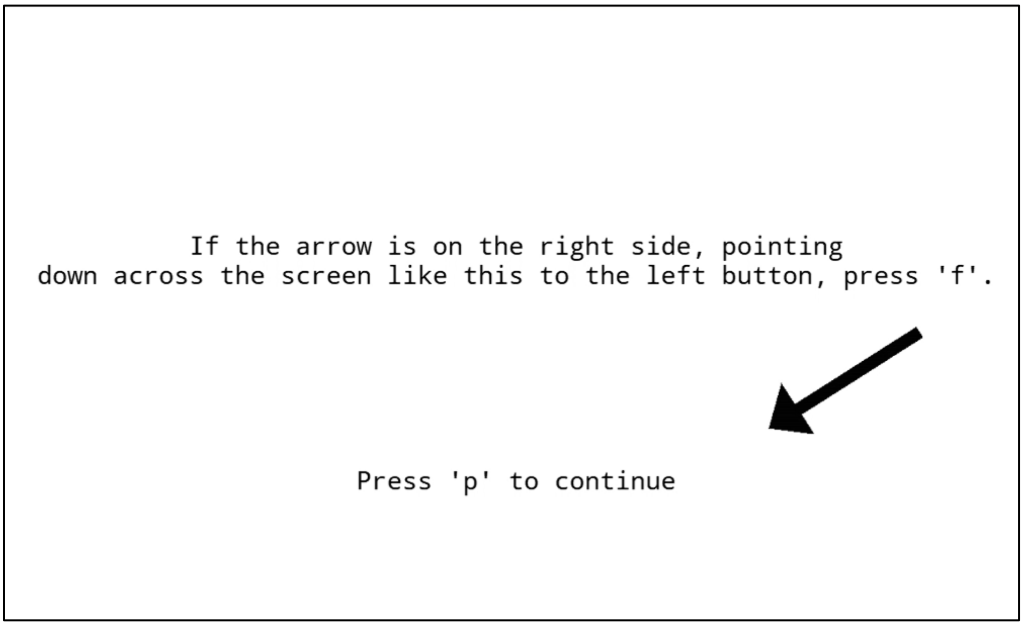
Instructions Arrow Task






If the arrow is on the right side pointing down to the 'f'
button, press the 'f' button.
Press 'p' to continue


If the arrow is on the left side, pointing
down across the screen like this to the right button, press 'j'.
Press 'p' to continue


If the arrow is on the right side, pointing
down across the screen like this to the left button, press 'f'.
Press 'p' to continue

Thank you for reading all the instructions!

Remember to place your right index finger on the key 'j'. Place your left index finger on the key 'f'.

Press 'p' to start the practice trial.

Appendix C

Table C1

Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CAARS_TScoreInat	,095	394	<,001	,975	394	<,001
CAARS_TScoreHyper	,085	394	<,001	,973	394	<,001
CAARS_TscoreImpul	,092	394	<,001	,961	394	<,001
CAARS_TscoreSelfconc	,086	394	<,001	,973	394	<,001
CAARS_TscoreDSM_Inattention	,083	394	<,001	,974	394	<,001
CAARS_TscoreDSM_HypImp	,099	394	<,001	,948	394	<,001
CAARS_TscoreDSM_Total	,089	394	<,001	,956	394	<,001
CAARS_TscoreADHDIndex	,067	394	<,001	,978	394	<,001
EFI_total	,054	394	,007	,990	394	,010
SP	,083	394	<,001	,990	394	,007
MD	,087	394	<,001	,981	394	<,001
IC	,113	394	<,001	,976	394	<,001
ORG	,079	394	<,001	,987	394	,001
EM	,114	394	<,001	,935	394	<,001

a. Lilliefors Significance Correction

Note. Normality tests for all subcategories and total scores of the CAARS and the EFI are depicted.

Table C2

Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
m_rt_comp	.061	49	.200*	.982	49	.648
m_rt_incomp	.108	49	.200*	.976	49	.397
perc_acc_comp	.269	49	<.001	.787	49	<.001
perc_acc_in-comp	.222	49	<.001	.804	49	<.001
d_rt_inc_c	.050	49	.200*	.991	49	.969
d_acc_c_inc	.222	49	<.001	.886	49	<.001

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction