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The relationship between emotion dysregulation and the classical symptoms of Attention Deficit Hyperactivity Disorder

By

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Declaration

I, the author, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (www.sheffield.ac.uk/ssid/unfair-means). This work has not been previously been presented for an award at this, or any other, university.

Conference Poster Presentations

Study 1

- The Psychology Postgraduate Research Conference. Presentation Presented at the University of Sheffield, Sheffield UK, 2018.
- The Psychology Postgraduate Affairs Group (PsyPAG) Annual Conference. Poster Presented at Sheffield Hallam University, Sheffield UK, 2019.
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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder classically defined by either attentional dysfunction, hyperactive/impulsive behaviour, or both. More recently, emotion dysregulation has been proposed as an additional pervasive symptom that should be considered, however its relationship to the classical symptoms is unknown. This thesis aimed to investigate the relationship between emotion dysregulation and ADHD-like traits in non-clinical groups of adults. The first chapter reviewed the background of ADHD and emotion dysregulation as a new core symptom of ADHD, leading to the first study which examined the core ADHD-like traits and emotion dysregulation using self-report measures - the Adult ADHD Self-Report Scale (ASRS) and the Difficulties in Emotion Regulation Scale (DERS). The total ASRS scale scores (as well as with both ASRS subscales) showed a highly significant positive association with the DERS scale, and correspondingly the overall ASRS was a strong independent predictor of the DERS scores. These findings confirm the hypothesis that emotional dysregulation is linked to the typical core symptoms of adult ADHD.

However, self-report measures have a number of drawbacks, and so in the second and third study, we used cognitive tasks (rather than the ASRS alone) to measure ADHD-like traits. The second study looked at the relationship between emotion dysregulation and an aspect of inattention, namely distractibility. We employed a new paradigm to measure distractibility - a modified version of the Sustained Attention to Response Test (SART), with task-irrelevant distractors on some trials. The result shows that the reaction times (RTs) on trials with distractions were faster than those without distractions, and there was no statistically significant variation depending on whether participants were in the High or Low ASRS groups. Furthermore, accuracy was higher on trials with distractors. In other words, the modified SART did not distract; instead, the distractions paradoxically helped with performance, and that facilitation did not differentially affect those with participants depending on

their levels of ADHD-like traits. As a consequence, we could not draw conclusions about the relationship between emotion dysregulation and task-based inattention.

The third study looked at the relationship between emotion dysregulation and impulsivity, using two cognitive tasks: the Iowa Gambling Task and the Go-No/go Task. For the Iowa Gambling Task, both High and Low ASRS groups chose low risk strategies and there were no differences between both groups. In terms of inhibitory control, there was no statistically significant difference between groups. However, for the Go-No/go task, the difference in commission and omission error rates between the High and Low ASRS groups suggests that participants in the High ASRS group had poorer reaction inhibition (faster reaction times), and lower accuracy, indicating that the High group was sacrificing accuracy for speed. In terms of the DERS, the DERS subscales scores (clarity, goal and strategy) were associated with Go reaction times in the Low ASRS group but not in the High ASRS group. Overall, the result suggests that emotion dysregulation may not be related to the classical symptom of impulsivity, at least when the latter is measured using a cognitive task rather than a self-report scale.

The final chapter summarises the finding of this thesis, the limitation and future studies that could help to understand the relationship between emotion dysregulation and the classical symptoms of ADHD. Overall, the thesis offers evidence of some aspects of the classical symptoms of ADHD do overlap with emotion dysregulation when participants are asked to recount their experiences, but that connection is lost when ADHD-like symptoms are assessed experimentally.

Chapter 1. Background to Attention Deficit Hyperactivity Disorder

1.1 Chapter Summary

Attention deficit hyperactivity disorder (ADHD) is a neurobehavioral disorder diagnosed in both children and adults, characterised by the 'classical' symptoms of inattention, impulsivity, and hyperactivity. However, it not only causes deficits to manifest in these core symptoms but also affects emotional regulation. Emotional regulation is a complex process involving an inability to maintain thoughts, behaviours, and expressions within a socially acceptable range. Therefore, it is vital to understand the inter-relationships between symptoms and emotion dysregulation to develop a balanced approach to managing ADHD.

This chapter aims to review the literature on ADHD and the criteria for diagnosis in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-V) and the International Classification for Diseases, 11th revision (ICD-11). It examines the prevalence of ADHD worldwide and traces previous and current perspectives on this disorder from the early 1900s until today. ADHD symptomatology, prevalence of ADHD, and gender balance across the lifespan are reviewed. The chapter then describes the different ADHD measures: scales, interviews, and cognitive function tasks. Since ADHD is a heterogeneous disorder, the co-occurrence is addressed, and several theoretical neurocognitive models of ADHD are reviewed. The final part of the chapter defines and describes emotion dysregulation and how it is related to ADHD.

1.2 Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is one of the most common neurodevelopmental disorders, with diagnosis based on the criteria of inattention, impulsivity, and hyperactivity (the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision - DSM-5-TR™; American Psychiatric Association [APA], 2022; World Health Organization; 2021; Taylor, 1998). The onset of symptoms usually occurs in the developmental period before the age of 12, leading to deficits in academic and social performance, career achievement, as well as car accidents, unhealthy social associations, and unacceptable behaviour (Biederman, 2005).

In 2018, the International Classification of Mental and Behavioural Disorders – 11th revision (ICD-11) referred to ADHD as characterised by abnormal levels of inattention and hyperactivity-impulsivity symptoms that have an impact on different life functions with a continuous pattern, with symptoms appearing before the age of 12 in different settings (World Health Organization [WHO], nd). The DSM-5-TR™ and ICD-11 categorise ADHD as a mental disorder with an above-average level of inattention, impulsivity, and hyperactivity. However, the symptoms in adults go beyond those mentioned in children and adolescents.

The symptoms of ADHD are not constrained to childhood but continue into adulthood, so impairments continue or progress in the next life stage (Barkley, 2016) and these impairments are the key for diagnosing the disorder. Indeed, the earliest written descriptions of ADHD by Melchior Adam Weikard, who described a disorder of inattention in 1775, and Alexander Crichton in 1798, both acknowledged the existence of ADHD in both children and adults (Barkley & Peters, 2012). Studies have found that ADHD symptoms persist into adulthood in 8% to 43% of cases (Spencer et al., 2002). However, there is evidence that it's possible to develop ADHD in de novo in adulthood; some young adults who fulfil the diagnostic criteria for ADHD did not fully meet the criteria for the disorder when they were younger (Asherson & Agnew-Blais, 2019). Hence, the deficits that start in childhood or later

in life may well affect developmental milestones in adolescence and adulthood and take different forms.

There has been insufficient research on ADHD in adults given the significance of the problem, unlike ADHD in children, who have attracted much more attention from researchers (Seidman, 2006). The developmental sensitivity of the ADHD criteria in DSM-V have been questioned; for example, the H/I descriptor 'Often leaves the seat in situations when remaining seated is expected' relates to children, but as they grow there may be many improvements in inhibitory control and also the brain improves as a result of socialization, hence enabling them to overcome any development challenges. Also, these symptoms do not apply to adults as they are not 'expected' to sit for extended periods as children are in school (Faraone, Biederman, & Mick, 2006). As the list of symptoms provided in DSM-V does not apply to adults, there are no clear diagnostic guidelines for the disorder in adulthood.

The symptoms of ADHD are multi-dimensional and fall along a continuum of 'normal' behaviour (Panagiotidi, Overton, & Stafford, 2017). The core symptoms of ADHD are graded among the non-clinical population as ADHD-like traits, but in those diagnosed with ADHD who meet the DSM-V criteria, the signs are more excessive, with the severity ranging from mild, to moderate, to severe (the latter negatively interfering with everyday life). While some degree of ADHD traits can be healthy for children and adults, described a kind of creativity, willingness to take risks, persistence, challenge, and adventure, these traits become deficits if the symptoms are problematic.

People with ADHD are unique regardless of their mental disorder; understanding the pros and cons of the condition will help improve their quality of life by focusing on the positive aspects and mitigating the adverse effects of the disorder. To achieve this, it is necessary to attain a sound understanding of ADHD. People with ADHD have contradictory tendencies that illustrate the complexity of the disorder: they struggle with concentration, but sometimes super-focus; they have the ability to focus intensely on some work, but procrastinate at other times; they are impulsive, but innovative; the list goes on (Hallowell & Ratey, 2021).

Depending on how intensive the ADHD symptoms are, those with ADHD can be considered to have a disability according to the law. The Equality Act (2010) defines disabled persons as those who have a physical or mental impairment that has a ‘substantial’ and ‘long-term’ negative effect on their ability to do normal daily activities. People with ADHD who have long-term adverse consequences related to their abilities will be disabled according to the Equality Act (GOV.UK, 2013). In the UK, people who have been diagnosed with ADHD are required to report to the Driver and Vehicle Licensing Agency (DVLA) as they have a medical condition that could affect the way they drive. Failure to report such conditions to the DVLA could result in a fine of up to £1,000 since safe driving requires attention, concentration, self-monitoring, and the ability to control impulsive aggression.

1.3 The History of ADHD

The concept of ADHD has changed over the last hundred years or so and has been given numerous names; in 1798, the Scottish-born physician Sir Alexander Crichton was way ahead of his time in identifying and labelling the essential features of the inattention subtype of ADHD in a manner which very much conformed to the current DSM criteria, and he referred to it as "mental restlessness". In his book, *an inquiry into the nature and origin of mental derangement*, in the chapter on 'Attention' (p.271), he wrote that the disorder was characterized by "The incapacity of attending with a necessary degree of constancy to any one object”. The first scientific account of ADHD was given in 1902 by British pediatrician Sir George Still, who reported “an abnormal defect of moral control in children”. In 1917-18 it was known as brain-injured child syndrome; in the 1940s, it was called minimal brain damage and minimal brain dysfunction; in 1967, the term hyper-kinetic reaction of childhood disorder was introduced.

In 1968 the Diagnostic and Statistical Manual of Mental Disorders (DSM-II) started to recognise the disorder as hyperkinetic impulse disorder for the first time. The most significant transformation occurred in the 1970s when attentional difficulty was identified as the essential feature of ADHD. In 1980, DSM-III introduced the term attention deficit disorder (ADD) with or without

hyperactivity in adults. Then in 1987, the revised DSM-III-R identified the main symptoms of the disorder as inattentiveness, impulsivity and hyperactivity and ADD became ADHD, combined the three signs (inattentiveness, impulsivity, and hyperactivity) into a single type.

In 1994, DSM-IV added the three subtypes of ADHD; combined type ADHD, predominantly inattentive type and the predominantly hyperactive-impulsive type. In 2013, the American Psychiatric Association published DSM-V in which the diagnosis of ADHD included the motor and behavioural problems of inattentiveness, hyperactivity and impulsiveness. The DSM-V revisions reduced the minimum number of ADHD symptoms from six to five for older adolescents and adults and added information about how symptoms may present in adolescence and adulthood (Epstein & Loren, 2013). The age of onset criteria altered from symptoms and impairments beginning before age 7 to symptoms beginning before age 12. From 1902 to now, the mental health profession still struggles to define ADHD in adults.

1.4 ADHD Symptomatology

According to the DSM-V (2013), ADHD can be divided into three different subtypes: attention-deficit/hyperactivity disorder (combined type), predominantly inattentive type, and predominantly hyperactive-impulsive type.

1.4.1 Predominantly inattentive type

"Inattention refers to significant difficulty in sustaining attention to tasks that do not provide a high level of stimulation or frequent rewards, distractibility and problems with an organisation" (WHO, nd). Attention is defined as consisting of many different and connected parts of mental operations, such as eliminating distractions, concentrating closely, being engaged in the current moment, stimulus encoding, and shifting and sustaining focus (Seidman, 2006). Problems with attention have been defined as a core feature of ADHD since it was first described.

For the DSM-V criteria, there are nine symptoms of inattention, including losing important things and having difficulties prioritising and completing tasks, or avoiding tasks that require mental effort, and difficulty maintaining attention or a short attention span**,** procrastination, not appearing to be listening even when spoken to directly, and not following through on instructions. Five or more of these symptoms should be present in adults for diagnosis (APA, 2013).

1.4.2 Predominantly hyperactive-impulsive type

Hyperactivity refers to constant moving, restlessness or fidgeting, and excessive physical movement that affects people's cognitive, social, and functional lives. Impulsivity tends to entail responding to immediate stimuli with quick cognitive decision-making and unexpected risky behaviours without deliberation. Children with ADHD have high levels of activity that are inappropriate for their age in the no-stimulation condition, but not in the stimulation condition (Antrop, Roeyers, Van Oost, & Buysse, 2000). They become less hyperactive as they grow into adulthood, but distraction and poor impulse control continue (Wolf, Simkowitz, & Carlson, 2009). Adults have a broader range of deficits as executive dysfunction and emotional dysregulation (Adler et al., 2017).

The DSM-V details the symptoms for diagnosis, i.e. the appearance of at least six of nine hyperactivity and impulsivity symptoms, such as restlessness, talkativeness, fidgeting, interrupting, taking risks, and weariness (APA, 2013; Biederman, 2005).

1.4.3 Combined type

A diagnosis of the combined type of ADHD is made if both the predominantly inattentive type and predominantly hyperactive-impulsive type are exhibited together.

1.5 Prevalence of ADHD

The first National Health Interview Survey (NHIS) in 1997 reported a prevalence of ADHD in children and adolescents aged 4–17 years of 6.1% in the US; since then, there has been an increasing

trend in ADHD diagnosis over the years, reaching 10.2% in 2015–2016 (Xu, Strathearn, Liu, Yang, & Bao, 2018). In 2011, the Centre for Disease Control and Prevention (CDC) has established that 11% of American children aged 4 to 17 have an ADHD diagnosis (Holland & Riley, 2014). This figure has increased sharply by 42% from the turn of the millennium, hence indicating the need to shed more light on this condition.

According to a survey of the national prevalence of parent-reported ADHD conducted in 2016 by the Centres for Disease Control and Prevention (CDC), approximately 6.1 million (9.4 %) children aged 2–17 in the US were diagnosed with ADHD (Danielson et al., 2018). In terms of the prevalence of ADHD in the WHO World Mental Health (WMH) Surveys, there are more adults with ADHD than children (2.8% versus 2.2% across the surveys) (Fayyad et al., 2017).

The most striking finding emerging from recent longitudinal studies of ADHD is the rate of continuance of ADHD from childhood to adolescence in the range of 50–80% and into adulthood of 35–65% (Eme, 2017). Predicting the persistence of ADHD from childhood to maturity depends on the severity of ADHD and comorbidities, the conduct of the disorder at a young age and adverse outcomes experienced during adulthood (Eme, 2017). In 2019, the Saudi National Mental Health Survey (SNMHS) conducted by the King Salman Centre for Disability Research and undertaken with 4,004 participants published an account of the most common mental health problems in Saudi Arabia. There was a considerable prevalence of ADHD among participants at around 8%, with an estimated 10% of males and 6% of females having the condition (AlTwaijri, Al-Subaie, & Al-Habeeb, 2019).

1.6 Gender balance acrose the lifespan

The sex ratio in childhood and through adolescence to adulthood changes substantially in its prevalence and presentation. Cross-sectional and longitudinal research findings come to the following conclusions about attention-deficit/hyperactivity disorder in girls and women: (a) girls exhibit symptoms consistent with ADHD at slightly lower rates than boys, a ratio that approaches parity by adulthood (b) women and girls with ADHD show a predominance of inattention and associated

internalizing issues, while men and boys show higher levels of hyperactive-impulsive symptoms and related externalizing issues (c) females with ADHD typically suffer from severe deficits, with a higher-than-normal risk for interpersonal conflict and self-harm (d) girls adopt a compensatory strategy to cover up deficits. (Hinshaw et al., 2022).

Also, girls may feel more impaired than boys (Williamson & Johnston, 2015). A systematic review of research that looked at gender variations in how ADHD symptoms are presented in adults support the idea that most of the effects of ADHD, including social functioning, time perception, stress management, and mood disorder, were more severe in women than in men while working memory and educational functioning were both worse in men than in women (Faheem et al., 2022).

A meta-analysis of 11 studies of adults and 86 studies of children and adolescents found that males more likely than females to meet the requirements for an overall diagnosis of ADHD as well as for each of the DSM-IV subtypes (Willcutt 2012). They also found that in samples of children (42% of females vs. 36% of males based on parent report; 57% vs. 47% based on teacher ratings) and adults (55% vs. 49%), a considerably higher proportion of girls than males met criteria for ADHD-I (Willcutt 2012). In contrast, men with ADHD were more likely to meet the criteria for ADHD-C than women (28% vs 22% based on parent evaluations, 27% vs 17% based on teacher ratings, and 26% vs 18% in studies of adults) (Willcutt 2012).

The sex ratio difference may occur at least in part because of the under diagnosis of ADHD in females, who are more likely to present with the inattentive subtype than the hyperactive-impulsive subtype generally observed in boys. Additionally, girls with ADHD were more likely to also have coexisting anxiety and depression (Quinn & Madhoo, 2014). Regarding clinical samples, this phenomenon is probably partially explained by referral bias, for example a greater inclination to refer boys at a young age due to hyperactivity and behavioural issues, and in contrast a tendency for females to seek out treatment in adulthood) (Sonuga-Barke et al., 2022). A meta-analysis of 11 studies of ADHD in adults suggests that it is necessary to conduct more research to ascertain the cause of the

higher incidence of ADHD in males compared to females and to understand whether socioeconomic position or ethnicity affects the prevalence of the disorder (Willcutt, 2012).

Overall, ADHD affects both genders throughout their lifespan, although the gender ratio may change depending on the diagnostic criteria utilized. When diagnosing and treating ADHD in both boys and girls, gender differences in symptom presentation and comorbidity with other illnesses should be taken into consideration (Gaub, & Carlson, 1997).

1.7 Measuring ADHD

To measure ADHD symptoms, information should be obtained from assessment by health professionals, self-report data, and partners' reports, as well as behavioural observation. Barkley Knouse, and Murphy (2011) contend that doctors can collect information about adults who display the symptoms of ADHD from their relatives. To address the lack of an appropriate measure for ADHD in the general adult population that met the DSM-IV criteria, the WHO developed a self-report scale, the Adult ADHD Self-Report Scale (ASRS-v1.1), a short screening scale for use with adults. ASRS-v1.1 helps to show whether a person is suffering from the symptoms of ADHD, covering 18 DSM-IV-TR criteria and addressing how often each symptom is experienced in six months. There are nine questions for each for the inattention and hyperactive/impulsive symptom subscales (Ustun et al., 2017). ASRS-v1.1 was the main scale to measure ADHD-like traits in our studies because it's a valid, reliable instrument with very good internal consistency.

Other measures are the Conners' Adult ADHD Rating Scale (CAARS) and the Conners' Adult ADHD Diagnostic Interview for DSM-IV™ (CAADID™). These are best used in conjunction with each other to aid the process of ADHD diagnoses. There are long and short versions, used widely in clinical and research settings. The CAARS was developed by Keith Conners, Drem Erhardt, and Elizabeth Sparrow and comprises a long self-report measure. A computerised scoring system is used to create an interpretive report, comparing the individual's score to that of a normative group (N = 1026 non-clinical adults). The CAARS measures individual function related to inattention/memory

problems, hyper-activity/restlessness, impulsivity/emotional lability, problems with self-concept, DSM-V inattentive symptoms, DSM-V hyperactive-impulsive symptoms, ADHD index (index identifies individuals at risk for ADHD), DSM-IV ADHD symptoms total (MHS Beyond Assessments, 2021a).

The CAADID™ is a structured interview in a paper-and-pencil format. It comprises two parts that are administered separately; each part takes 90 minutes to complete. The first part contains items on the patient's history, the demographic history of the patient, the developmental course of the patient's attention problems, associated risk factors, and comorbidity questions, covering the biological, psychological, and social aspects. The second part covers the diagnostic criteria, asking questions about the age of onset, pervasiveness, and level of impairment (MHS Beyond Assessments, 2021b).

1.8 Laboratory Cognitive Tasks to Assess Symptoms of ADHD

Researchers use different cognitive tasks to measure ADHD symptoms. The Iowa Gambling Task measures cognitive impulsivity (impulsive decision making); participants see four virtual decks (A, B, C, or D), each of which holds cards that will either reward or penalise them using game money. They need to choose one of four buttons with the mouse. The Go/No-Go task uses two repeated conditions that measure motor response inhibition/ impulsivity by looking at the commission error rate. The first condition requires a "Go" response to the letter P and a "No-Go" response to the letter R; the second condition requires the reverse.

The Sustained Attention to Response Test (SART) measures distractibility. Participants are shown a series of letters and need to press the space bar every time they see an X. The primary measure is reaction time on a specific number of trials, and reaction time on trials with the distractor are compared to reaction times on trials without distractor.

The Continuous Performance Test (CPT) is a well-known test that measures attention and impulse control; it is a computerized presentation of different stimuli (visual or auditory). Participants must respond to the target and withhold their response to non-target stimuli. It measures errors of commission (false alarms) and omission (misses). Deficits are characterised by shorter reaction times, inability to inhibit inappropriate responses, and inability to focus during a task for a fixed time.

In the Stop Signal Task (SST), participants are required to respond as quickly as possible depending on the way an arrow points. In the first section, the participant has to press the left button when they see a left-pointing arrow and the right button when they see a right-pointing arrow. In the second section, the participant is instructed to keep clicking the buttons when they see the arrows but to hold off and not do so if they receive an auditory cue (a beep). It measures inhibitory control, and the primary dependent measures are reaction time and response errors.

1.9 Co-Occurrence

ADHD frequently co-occurs with other neurodevelopmental disorders, such as autism spectrum disorder (ASD) (Antshel & Russo, 2019). ADHD and ASD both present with similar social-cognitive impairments (Harikumar, Evans, Dougherty, Carpenter, & Michael, 2021), and executive function impairments such as communication difficulties, poor attention to detail, inability to tolerate and adapt to change, impaired imagination and social skills (Benallie, McClain, Bakner, Roanhorse, & Ha, 2021). Hence, there is considerable overlap between the two disorders. It can be challenging to distinguish the symptoms of ADHD and ASD from one another; they are associated with attention issues and difficulties controlling emotions, respectively, so the correlation of ADHD with autism is quite significant (Joshi et al., 2017). Children with either condition can experience trouble communicating and concentrating and might show a lack of concern or an inability to react to other people's emotions or feelings (Benallie, McClain, Bakner, Roanhorse, & Ha, 2021).

The non-random comorbidity between ADHD and ASD can occur in different ways. First, ADHD can have a direct effect on ASD. For example, a main feature of ADHD, attentional

difficulties, can lead to ASD's core symptom: social communication challenges. Second, ADHD can have indirect effects on ASD, namely ADHD might have possible emotional and social impacts which could lead to a diagnosis of ASD. The third link between the two disorders is that comorbidity could result from common causes, for example, biological factors. Examining the relationship between the two disorders' symptoms could help shed light on the relationship between these common conditions. As well as ASD, there is also an overlap between ADHD and other disorders, such as depression (Riglin et al., 2021; Turgay & Rubaba, 2006), learning disabilities (DuPaul, Gormley, & Laracy, 2013), anxiety (O'Rourke, Bray, & Anastopoulos, 2020), and antisocial behaviour (Thapar et al., 2006), all of which have features, especially those of appearance, in common with ADHD.

Learning disabilities are neurologically-based processing problems, such as dyslexia (reading), dysgraphia (writing), and dyscalculia (mathematics) (Kariyawasam et al., 2019). Students with ADHD are at a particular disadvantage when it comes to learning, as the disorder presents challenges when it comes to focusing on learning. Moreover, the possibility of substance abuse, inter-parental conflict, and poor academic performance can all be factors related to ADHD impairment (Biederman, 2005); as a result, students might fail to complete tasks or understand things. Students with ADHD typically find it difficult to concentrate on a task and solve problems, resulting in lower performance, especially in critical areas such as science, technology, engineering, and mathematics (STEM subjects).

1.10 Treatment

The most common treatment for ADHD is pharmacological; it is part of a comprehensive plan alongside alternative interventions. In particular, stimulants are used for the treatment of ADHD, including the amphetamine (Dexedrine, approved in 1976) and the methylphenidate (Ritalin, used for many decades). The psychostimulant Ritalin was approved as a treatment for people with ADHD by the Food and Drug Administration (FDA) in 1955. It helps to improve executive function and reduces hyperactive, impulsive behaviour and inattention, and increases attention span (FDA, 2021). Such

stimulants increase dopamine and noradrenaline levels in the brain by blocking norepinephrine and dopamine reuptake by the presynaptic nerve once it has been released (FDA, 2021).

The stimulants described above have side effects, such as increased heart rate, blood pressure and weight, and a high potential for abuse (Overton, 2008). The psychostimulants do not cure ADHD and the response to medication varies for each person; as methylphenidate has different effects on different people, some show moderate improvement, and others have significant improvement. ADHD medication reduces the symptoms, but the symptoms return after the medicine is stopped. Understanding the fundamental deficit in ADHD will help avoid adverse medication outcomes; in other words, researchers need to understand the pathophysiology of ADHD to stimulate the development of novel therapeutic approaches.

The combination of stimulant medication and alternative interventions in evidence-based treatment of ADHD may have positive effects on core ADHD symptoms (Johnston & Park, 2015). Several studies have revealed that behavioural, neurocognitive, and dietary therapies (e.g. play therapy, cognitive therapy and psychotherapy, mindfulness, parent management training, school-based support, and specific ADHD eating plans), along with medication, could reduce hyperactivity and improve concentration, enabling those diagnosed with ADHD to cope with the condition since it cannot be cured.

However, some patients might not respond well to stimulants or might experience side effects that prevent them from being used. Non-stimulant medicines, such as Atomoxetine (Strattera), Guanfacine XR, and Clonidine XR (Clavenna & Bonati, 2017), may be utilized in these situations as second line (second choice) therapy. The second-choice treatments may take up to several weeks before they reach maximum effectiveness.

Some individuals have found these drugs to be useful in lessening the symptoms of ADHD because they operate through processes different from those of stimulants (amphetamine and methylphenidate). Geffen, & Forster, (2018) report three points about non-stimulant usage for adult

ADHD; first, non-stimulants can be used as a type of treatment for people who can't take stimulant medication alone; second, they help to make treatment stronger by using them in conjunction with substances that increase activity in the body and finally, non- stimulants are a way to treat both depression and anxiety that can happen at the same time, while also treating the symptoms of ADHD directly, using wise prescribing. Parents may decide to select non-stimulant drugs as the first line of treatment for their children if they are worried that stimulants may be used for substance abuse.

Stimulant-based pharmaceutical treatment for ADHD requires cardiovascular monitoring observing especially in children and adolescents (Hennissen et al., 2017), and stimulant have been found to have an impact on autonomic function in ADHD (Idrees et al., 2022). Children under taking stimulant medication have common problems with decreased appetite and trouble with their emotions, headaches, and stomach pain (Clavenna & Bonati, 2017). As a consequence, non-stimulant medications may be the preferred treatment.

For some ADHD groups, maintaining medication adherence can be challenge. This may be the result of problems with cognitive skills leading to forgetfulness, organizational issues, or worry about adverse effects which affect pursue their goals. Healthcare professionals may suggest strengthening core executive function skills by increased self-awareness, self-motivation, control of impulsive actions, setting reminders, using pillboxes or smartphone applications, or incorporating medication into daily routines to solve adherence issues. It is very important for the clinician to have a good working relationship with their patient; clinician, parents and young people should work together to make sure they take their ADHD medication regularly (Charach & Fernandez, 2013).

1.11 Emotional dysregulation

More recently, there has been a focus on another aspect of the ADHD syndrome, namely emotional dysregulation. In the 1940s, when ADHD was known as “minimal brain damage”, emotion dysregulation was presented as a diagnostic criterion, but DSM-III changed it to an associated feature. Shu et al. (2018) use the term “emotion” to refer to an automatic psychological state which does not

require a conscious effort and results in physical and physiological changes in the heart, skin, blood flow, facial expressions, and voice. Thus, an emotional response to a stimulus causes physical and psychological changes and controls behaviour – fight-or-flight or calm responses. Emotion regulation is defined as the conscious or unconscious control of emotions that guides individuals to modulate their emotions (Gross, 1998). Emotion regulation is essential for children as it helps them interact successfully with the environment (Berkovits, Eisenhower, & Blacher, 2017) and supports adaptive performance (Ahmetoglu, Ilhan Ildiz, Acar, & Encinger, 2018).

"Between stimulus and response there is a space. In that space is our power to choose our response. In our response lies our growth and our freedom".

~ Viktor Frankl

People with healthy emotion regulation respond to stimulation with perfect cognitive control of their emotions and manage their physical reactions when responding to threats (Linehan, 2014). People with ADHD feel differently from ordinary people and have a high and intense physiological response that remains elevated and becomes more intense so that they cannot tolerate experiencing the emotion (Fogleman, Leaberry, Rosen, Walerius, & Slaughter, 2018). When the emotions are triggered, they experience inattention, impulsivity, hyperactivity, executive function deficit, and emotion dysregulation (Corbisiero, Stieglitz , Retz, & Rösler, 2013).

Emotion dysregulation is characterised by an inability to control emotional reactions within a socially acceptable range. It cannot be defined as a disorder on its own; it seems to be tied to self-control, which can be trained. Emotion dysregulation is a central component of the suite of ADHD symptoms (Shaw et at., 2014). It is known that children with ADHD struggle to control their emotions (Northover, Thapar, Langley, & van Goozen, 2015; Shaw, Stringaris, Nigg, & Leibenluft, 2014). Children with ADHD find it difficult to control their emotions and display challenging behaviour (Holland & Riley, 2014). The struggle experienced by those with ADHD can also be manifest through explosive or uncontrollable reactions to situations, such as outbursts of anger or frustration (Bovin *et*

al., 2016). These extreme reactions by children with ADHD children can occur without warning, and can significantly threaten the child's association with his or her peers (Grant *et al*., 2015). Such children who do not receive help might thus grow up to lead solitary lives due to rejection by the rest of society (Steinberg & Drabick, 2015). The deficits will continue into adulthood – adults exhibit not just the classical core ADHD symptoms, but also emotion dysregulation. A recent systematic review showed that ADHD seems to particularly affect emotional reactivity, i.e. the threshold, intensity and duration of affective arousal (Graziano and Garcia, 2016). Emotion dysregulation leads to negative emotions, such as anger, annoyance, and over-excitability (Barkley, 2016).

There are different scales to measure emotion dysregulation in adults; the Emotional Processing Scale (Baker et al., 2009), a 25-item self-report questionnaire designed to identify emotional processing styles and deficits, which is used to explore the relationship between self-reported indices of emotional processing and physiological measures in the same individual. Also, Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004) is a brief, 36-item self-report questionnaire designed to assess multiple aspects of emotional dysregulation such as non-acceptance of emotional responses, difficulties engaging in goal-directed behaviour, impulse control difficulties, lack of emotional awareness, inadequate access to emotion regulation strategies and lack of, emotional clarity. Higher scores suggest greater problems with emotion regulation (Gratz and Roemer, 2004).

The Barkley Deficits in Executive Functioning Scale (BDEFS for Adults); it is an ecologically valid assessment that was developed by Russell Barkley, a leading researcher in ADHD. The BDEDS is based on Barkley's conceptualization of emotional dysregulation as a central feature of ADHD, and it has been used primarily to assess emotional dysregulation in individuals with ADHD or other psychiatric disorders. BDEFS assesses executive functioning deficiencies in daily life for people in the age range from 18 to 81. It has a high internal consistency (Cronbach's alpha ranging from .91 to .95 scores across the five scales) and good validity in clinical and research settings.

The BDEFS appears to be considerably more predictive of deficits in important everyday activities than more time-consuming and expensive standard EF assessments. The BDEFS provides an ecologically valid picture of the capacities involved in time management, organization and problem solving, self-control, self-motivation, and emotion regulation. It includes both self- and other reports in both a long (15-20 minute) and short (4-5 minute) format. An adult ADHD risk index in the extended form is one of the special characteristics (Guilford Press).

A meta-analysis by Graziano & Garcia, (2016) looked at emotion regulation and the overlap of several domains within the construct. The first domain is emotion recognition/ understanding (ERU), which may be tested by asking adults to indicate how they feel when they see photos of people or video vignettes. Emotion recognition/understanding, or the capacity to properly recognise emotional states in others and oneself, is important in children's social-emotional development and is frequently targeted in early intervention programmes (Denham, 1986; Hare, Garcia, Hart, & Graziano, 2021). Children can complete a standardized ERU task, for example affective labeling - identifying 8 distinct emotions (sad, joyful, angry, terrified, startled, disgusted, humiliated, guilty) that are presented graphically via human and cartoon expressions, both expressively (say what the emotion is) and receptively (point to the emotion) (Denham, 1986).

The second domain is emotion reactivity/negativity/lability (ERNL), which is measured by utilizing the Children's Behaviour Questionnaire, the Conners' Parent and Teachers Rating Scales, or the Emotion Regulation Checklist's lability/negativity subscale. The third domain is emotion regulation (EREG) and the Behaviour Rating Inventory of Executive Function is used to examine it; also a parent-report version of the Difficulties in Emotion Regulation Scale (DERS-P) for ages 11 to 17 (Bunford et al., 2020). The last domain is empathy/callous-unemotional characteristics (ECUT), which may be assessed using the 'My Child' questionnaire or coding systems that respond to different vignettes showing a character's emotional state.

Finally, the Emotion Expression Scale for Children (EESC) is a 16-item self-report questionnaire that assesses children's difficulties in emotion expression (i.e., poor emotion awareness and reluctance to express emotions), which are skills of emotional competence (Caiado, Canavarro, & Moreira, 2023). Since emotional dysregulation is symptom of several mental disorders, and is multi-faceted, a comprehensive assessment is highly recommended. Hence beside the above self-report questionnaires, clinical interviews can also be used to assess emotional experiences and symptoms. In this thesis we used the Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004) because it has been used in research studies to investigate emotional dysregulation in various populations.

1.12 Neurocognitive Models of ADHD and Emotional Dysregulation

Different models, such as Gross's (1998) model of emotion generation and Barkley's (1997) model of deficient behavioural inhibition, explain the deficits in ADHD and how they are related to emotion dysregulation in terms of executive function and cognitive control. However, there are no theories that adequately explain all aspects of the disorder due to its complexity. Cognitive theories explain the relationship between ADHD and emotion dyregulation based on understanding of executive function and cognitive control. Issues with executive function are a core symptom of ADHD, as it is responsible for various cognitive aspects, such as: behavioural inhibition, self-monitoring, planning/organisation, shifting attention, initiating, task monitoring, emotional control, and working memory (see Figure 1.1.). People with ADHD exhibit impaired executive function, which causes deficits in communal, individual, educational, and professional skills (APA, 2013). The lack of ability to regulate emotions and behaviours results in those with ADHD being talkative, fidgeting, being distracted easily, failing to think about the consequences of actions, and experiencing emotional intensity, difficulty with organisation, and hyperactivity. Essentially, emotion dysregulation can affect the severity of ADHD symptoms as it is associated with executive function.

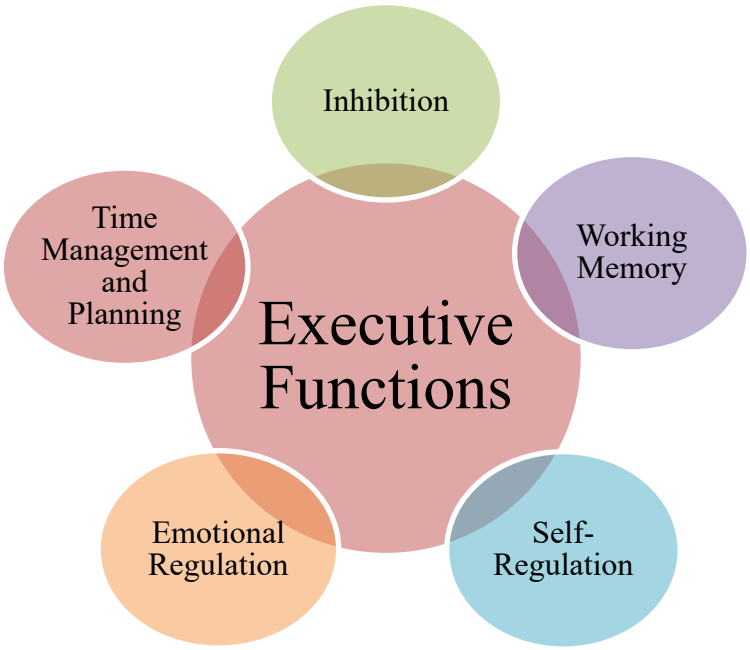

Figure 1.1. Barkley's theory of executive functioning deficits in ADHD

Based on behavioural inhibition, Barkley (1997) proposed that deficient behavioural inhibition is a core symptom of ADHD. Response inhibition is also known as inhibitory control and behavioural inhibition. Barkley focused on behavioural inhibition, i.e. the suspension of responses to external stimuli, which allows time to apply executive function skills. Neuropsychological research supports the proposition that poor behavioural inhibition could accurately predict ADHD, leading to unacceptable goal-directed behaviour.

Gross (1998) developed a model of emotion generation comprising emotion recognition/understanding (ERU), emotion reactivity/negativity/lability (ERNL), emotion regulation (EREG), and empathy/callous-unemotional traits (ECUT). Graziano and Garcia (2016) conducted a meta-analysis of 77 studies with a sample of 32,044 youths to understand the associations between ADHD and several aspects of emotion dysregulation articulated in the emotion generation model. They found that adolescents with ADHD showed extreme impairments in emotional reactivity (ERNL), followed by emotion regulation (EREG). Also, deficits in executive function were found to have a strong effect on youths with ADHD and emotion reactivity/negativity/lability (ERNL).

According to Gross's (1998) model, the association between ADHD and executive function deficits is responsible for initial emotional reactivity; hence those with ADHD need to learn how to control challenging situations, rather than just responding with high emotional reactivity. Because emotional reactivity and impulsivity tend to be linked to negative outcomes, those with ADHD may have strong emotional reactions and experience more intense negative or positive emotions than others. The early social rejection of a child by peers leads to a negative response and such children will experience high levels of emotional reactivity (ERNL) in young adulthood. Emotional lability concerns rapid changes in mood, i.e. the back and forth or up and down of the emotional reactivity process. Thus, ADHD results in greater and more intense expression of emotion than in the average person.

1.13 Emotion dysregulation in attention deficit hyperactivity disorder (ADHD)

It is increasingly being recognised that ADHD affects emotion regulation, although the relationship between the classic symptoms of ADHD and emotion dysregulation is unknown. The estimated prevalence of emotion dysregulation in children with ADHD is 25–45% compared to 30–70% in adults (Shaw et al., 2014). A search of articles published before 1 January 2013 conducted by Shaw et al. (2014) identified three models summarising the relationship between ADHD and emotion dysregulation: (i) emotion dysregulation is a core symptom of ADHD, manifesting as inattention, impulsivity, and hyperactivity, with incredibly high correlations; (ii) emotion dysregulation and ADHD are distinct entities, although there is an overlap between them in terms of the association between ADHD and ASD; (iii) ADHD and emotion dysregulation differ and ADHD is a condition on its own (Shaw et al., 2014).

Given the multi-faceted nature of ADHD, a natural question is the extent to which the symptoms are related. While evidence suggests that attentional and activity/behavioural symptoms can be separate, the relationship between these symptoms and emotion dysregulation is unknown. There is, therefore, a need to explore the relationship between ADHD-like traits and difficulties in the regulation of emotions. This is essential for two reasons. First, evidence of the inter-relationships between the

core symptoms of ADHD suggests that it could be possible to treat more than one symptom through interventions with a more restricted focus than has been the case thus far.

Second, the extent to which the symptoms inter-relate could give clues to the nature of the underlying pathophysiology. In naïve terms, highly inter-related symptoms might suggest the existence of a common locus of change: something that is important to know when searching for the substrate(s) underlying such a complex disorder, as is necessary as part of the drug discovery programme. Sines one of the issue within the treatment of ADHD is the need of evidence that stimulants and non-stimulant address emotional dysregulation. It is critical to comprehend emotion dysregulation since it is a problem, and existing pharmacological therapies do not adequately manage it. Some researchers have suggested that behavioral treatments, such as cognitive-behavioral treatment or mindfulness-based mediations, (Soler-Gutiérrez, Pérez-González, & Mayas, 2023) may be successful in diminishing emotional dysregulation in ADHD, but more investigatino is required in this area.

It is hoped that the findings of this thesis can be used to increase understanding of ADHD and help adults with the condition. It is important to note that the nature of ADHD has been researched for several decades and that more information about its causes and consequences is constantly being produced. Although much research has concentrated on children, more information is needed to understand ADHD in adults since the symptoms of ADHD can continue into adulthood. The overarching theme for the research in the thesis is the relationship between the classical symptoms of ADHD, namely hyperactivity, impulsivity, and inattentiveness, and the more recently identified symptom of emotion dysregulation, in an adult population.

1.14 The Structure of the Thesis

This thesis will include four studies that measure the classical symptoms of ADHD and emotion dysregulation with the appropriate methods, and the questions to be addressed within the thesis are as follows:

Study 1: What is the relationship between the classical symptoms of ADHD and emotion dysregulation, as measured by appropriate scales in a non-clinical population with varying levels of ADHD-like traits.

Aim: to explore the relationship between ADHD-like traits and difficulties in emotion regulation in a non-clinical population with varying levels of ADHD-like traits.

Study 2: What is the relationship between the classical ADHD symptom of distractibility and emotion dysregulation as measured by appropriate scales and a distractibility task in a non-clinical population with varying levels of ADHD-like traits.

Aim: to see whether distractibility is related to emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits.

Study 3: What is the relationship between the classical symptom of impulsiveness and emotion dysregulation as measured by appropriate scales and impulsiveness tasks in a non-clinical population with varying levels of ADHD-like traits.

Aim: to see whether impulsiveness is related to emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits.

Chapter 2. Emotion dysregulation and classical ADHD symptoms

2.1 Chapter Summary

Attention Deficit Hyperactivity Disorder (ADHD) is a developmental neurobiological condition classically characterised by pervasive inattention, hyperactivity, and impulsivity symptoms. However, more recently emotion dysregulstion has also been identified as a symptom with widespread prevalence. The study aimed to explore the relationship between classical ADHD-like traits and difficulties in emotion regulation. Two hundred eighty participants were administered a series of questionnaires via Qualtrics. The Adult ADHD Self-Report Scale (ASRS-v1.1) and the Barratt Impulsiveness Scale were used to measure ADHD-like traits. The Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004) was used to measure emotion dysregulation. Given the high degree of inter-relationship between ADHD and Autism Spectrum Disorder (ASD), the Autism Spectrum Quotient (AQ) was also examined. There was a highly significant positive correlation between the DERS and the overall ASRS scale scores, and with both subscales of the ASRS (Inattention & Hyperactivity-Impulsivity). The overall ASRS was a significant independent predictor of the DERS scores, and the inattention subscales of the ASRS and AQ attention-switching subscales were also significant independent predictors. These results support our hypothesis emotional dysregulation is related to the standard core symptoms of adult ADHD symptoms.

2.2 Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental condition classically characterised by inattention, hyperactive/impulsive behaviours, or both (DSM-V; American Psychiatric Association [APA], 2013; Taylor, 1998). ADHD has a high prevalence rate, and increasing health costs highlight the importance of understanding ADHD. Typically, the condition begins in childhood and extends into adulthood, presenting as a functional and social impairment. To diagnose adults with ADHD, they must have a childhood history of ADHD symptoms (Adler, 2004). Although ADHD symptoms reduce with age (Simon, Czobor, Bálint, Mészáros, & Bitter, 2009), in part because people with ADHD develop coping mechanisms to live with the disorder, some adults report that ADHD symptoms and impairment appear first during adolescent or early adult without being noticed in childhood (Asherson, & Agnew-Blais, 2019).

ADHD has several common comorbidities (Biederman, 2004; Kooij et al., 2012; Stevens et al., 2013; Kessler et al., 2006), such as substance abuse (Van et al., 2020), bipolar disorder (Klassen, Katzman, & Chokka, 2010), autism spectrum disorder ([ASD]; Panagiotidi, Overton, & Stafford, 2019), and anxiety (Reimherr, Marchant, Gift, & Steans, 2017). A large study by Plana-Ripoll et al. (2019) investigated comorbidity within mental disorders among 5.9 million Danish subjects over the period 1900–2015. The results supported the proposition that there is a substantial risk of comorbidity in mental disorders and pinpointed the importance of monitoring other mental disorders and applying primary comorbidity prevention. The study showed that the elevated risk of comorbidity in mental disorders is the rule, not the exception (Plana-Ripoll et al., 2019).This raises the possibility that if ADHD is not treated, there will be a chance of developing other mental illnesses.

For effective primary comorbidity prevention in adults with ADHD, the disorder should be well-defined beforehand. In DSM-V, ADHD symptoms are divided into inattention or hyperactivity/impulsivity for children and teenagers; however, there is no clear indication of the symptoms in adults. Also, hyperactivity remains present internally or weakens in adulthood, but there

are more deficits than in childhood (Hirsch, Chavanon, Riechmann, & Christiansen, 2018). Thus, it is necessary to ensure ADHD diagnostic criteria are appropriate for adulthood and adequate for life demands. Understanding what is inherent to ADHD in adults will help manage the symptoms over the long term and discern similar conditions, such as bipolar disorder or other comorbidities.

ADHD is multi-faceted, and in addition attentional and hyperactivity/impulsivity problems, people with ADHD exhibit emotion-related problems (Surman & Walsh, 2022). Therefore, it is necessary to understand the essential characteristics of emotion in ADHD and how they differ from a mood disorder or other mental disorders. Such understanding is crucial for clinical recognition and intervention (Stephen et al., 2019). Emotion refers to a response to a stimulus that causes physical and psychological changes and controls behaviour. Emotional symptoms are described in various terms and hence are indiscriminate in terms of diagnostic criteria (Stephen et al., 2019). Emotional symptoms are known as emotional lability or impulsivity, deficient emotional self-regulation (DESR), distress intolerance (Stephen et al., 2019), or emotion dysregulation. In the DSM-V, several mental disorders present emotion dysregulation as a feature (e.g., ASD) or even as a core feature (e.g., borderline personality disorder [BPD]; Carpenter & Trull, 2016). In early ADHD conceptualisations, emotion dysregulation was considered a core symptom of ADHD. However, in the ADHD literature, the relative importance of emotion dysregulation has increasingly been questioned; is it a core feature or an aspect of associated symptoms?

The diagnostic guidelines for ADHD in both DSM-V and ICD-11 focus on a two-factorial structure, comprising inattention and hyperactivity-impulsivity (DSM-V, APA, World Health Organization, 2019), neglecting emotion dysregulation because it cannot be measured as regularly (Barkley, 2015). However, many studies argue that emotion dysregulation is an essential element in ADHD that researchers and clinicians should consider in their work (Graziano & Garcia, 2015; Hirsch et al., 2018; McQuade & Breaux, 2017). People with ADHD and emotion dysregulation have problems managing and responding to internal or external stimuli that lead to positive emotional experiences and aid in maintaining goal-directed behaviour. Researchers have found that emotion

dysregulation contributes independently to behavioural issues, along with the cardinal symptoms of ADHD (Corbisiero, Mörstedt, Bitto, & Stieglitz, 2017; Shaw, Stringaris, Nigg, & Leibenluft, 2014; Wolfgang, Rolf-Dieter, Salvatore, Petra, & Michael, 2012). Importantly, a study by Corbisiero, Mörstedt, Bitto, & Stieglitz (2017) aiming to understand emotion dysregulation in ADHD found that emotion dysregulation is not a result of a comorbid disorder even when other mental disorders are present in ADHD.

Reviewing the nature of emotional symptoms in ADHD, Stephen et al. (2019) found that emotion commonly plays a role in ADHD. More specifically, emotional impulsivity and DESR cause significant impairments and should be considered core symptoms of ADHD, but irritability should not (Stephen et al., 2019). Moreover, Barkley and Fischer (2010) found that emotional impulsivity contributes independently to ADHD and leads to impairment, as do previously defined core symptoms. Also, Graziano and Garcia (2017) conducted a meta-analysis of 77 studies examining ADHD and four domains of emotion dysregulation. They found that adolescents with ADHD showed extreme impairments in emotional reactivity/negativity/lability (ERNL), followed by emotional regulation (EREG). It is thus essential to consider emotion dysregulation in ADHD to understand the interrelationships between its components (Carpenter & Trull, 2016) and the domains inherent to or more prevalent in ADHD.

Rethinking the most common presentation of ADHD in DSM-V, Reimherr, Marchant, Gift, and Steans (2017) proposed different categories for ADHD in adults. Reimherr et al. (2017) distinguished between inattentive presentation and emotion dysregulation presentation in ADHD. According to Barkley's theoretical model; emotion dysregulation is a component of ADHD, characterised by an inability – consciously or unconsciously – to control emotional reactions within a socially acceptable range and difficulty sustaining goal-directed behaviours. Dysfunction in emotion regulation processes has been defined as disruption of an individual's ability to modify an emotional state to promote adaptive, goal-oriented behaviours (Thompson, 1994). Gratz and Roemer (2004)

provided four bases that could be used to index and predict emotional dysregulation: awareness and understanding of emotions, acceptance of emotions, the ability to control impulses and engage in goal-directed cognition, and access to emotional regulation strategies. Examining the psychometric properties of the Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004), the ability to control impulses and engage in goal-directed cognition has a more significant effect in predicting emotional dysregulation than the other factors (Hallion, Steinman, Tolin, & Diefenbach, 2018).

When people with ADHD and emotion dysregulation exhibit strong emotions (emotional reactions), they have a deficit in adaptively regulating their emotions; they often engage in inappropriate behaviour and show irregular physiological arousal in the sympathetic nervous system, including an increase in blood pressure, breathing faster, perspiration, and dilated pupils. So emotional lability in ADHD has a significant impact and thus it is not acceptable to evaluate ADHD impairments only based on the core symptoms of ADHD (Vidal et al., 2014). Although the underlying cause of emotion dysregulation in ADHD is unknown, as is its relationship to the other symptoms of ADHD, the presence of emotion dysregulation in ADHD has been explained by the relationship between executive function and emotion dysregulation. Executive function empowers the mind by shifting attention when necessary, regulating emotions, enabling self-monitoring, and fostering goal-directed behaviour (Logue & Gould, 2014).

Emotion dysregulation is a fundamental component of an executive function deficit and both are associated with ADHD (Predescu, Sipos, Costescu, Ciocan, & Rus, 2020). Issues with emotion dysregulation have also been found in other disorders, such as ASD. Indeed, Berkovits, Eisenhower, and Blacher (2017) and Michelle (2009) note that emotional dysregulation is an essential component of ASD. The strong relationship between all the core features of ASD and emotion dysregulation has led to the recommendation that future studies aim to develop therapeutic strategies that can act effectively to address emotion dysregulation (Samson et al., 20

Given the multi-faceted nature of ADHD, a natural question is the extent to which symptoms are distinct or related to other disorders. Also, within ADHD itself, while evidence suggests that attentional and activity/behavioural symptoms can be distinguished, the relationship between these symptoms and emotion dysregulation is unknown. Hence, the current study aims to discern the relationship between the classical symptoms of ADHD and difficulties in emotion regulation. Given the presence of emotion dysregulation in ASD, emotion dysregulation is compared between ADHD and ASD.

The DSM-V classifies psychopathological disorders based on a categorical approach, not a dimensional approach, so an individual's ADHD symptoms are assessed in qualitative terms rather than quantitative. To gain a better understanding of mental health disorders, we need to accept the dimensional nature of symptoms (Goldberg, 2000). Research argues that ADHD should be conceptualised based on the dimensional approach, with symptoms distributed continuously in the population (Panagiotidi, Overton, & Stafford, 2017). For this reason, the participants in this study were drawn from the general population with ADHD-like traits (and ASD-like traits) to avoid challenges in clinical trials, such as medication effects that could improve the core ADHD symptoms and cognitive function.

2.2.1 Current Study

This study aimed to explore the relationship between ADHD-like traits, ASD-like traits and difficulties in emotion regulation in non-clinical adult participants, via the administration of several scales in the form of an online questionnaire. We hypothesise that adult ADHD-like traits, and ASD-like traits, will be associated with emotion dysregulation. We expect emotion dysregulation to be associated with both inattentive and hyperactive/impulsive symptoms.

2.3 Methodology

2.3.1 Participants

280 English-speaking participants were administered a series of questionnaires; participants were over 18. They were recruited via an email to the University's staff volunteers list (myAnnouncement system), and via social media and departmental undergraduate recruitment (SONA system – for which they received course credit). The Department of Psychology's Research Ethics Committee approved the procedures of this study. Most of the sample were female (F 209, M 66, Other 5), never married, and white. Participants ranged in age from 25 to 34 and they were employed full time and had completed a Bachelor's degree (see Table 2.1.).

Table 2.1. *Demographics of Participants*

Characteristic			
Age, n (%)		Employment	
18-34	192 (68.6)	Employed full time	169 (60.3)
35-54	72 (25.7)	Unemployed	12 (4.3)
55- over	16 (5.7)	Retired	3 (1.1)
Gender		Student	95 (33.9)
Male	66 (23.6)	Disabled	1 (.4)
Female	209 (74.6)	Education	
other	5 (1.8)	Less than a high school diploma	1 (.4)
Ethnic		High school degree or equivalent	12 (4.3)
White	213 (76.1)	Some college, no degree	20 (7.1)
Hispanic or Latino	4 (1.4)	Associate degree (e.g., AA, AS)	9 (3.2)
Black or African American	12 (4.3)	Bachelor’s degree (e.g., BA, BS)	157 (56.1)
Asian / Pacific Islander	22 (7.9)	Master’s degree	157 (56.1)
Other	29 (10.4)	Professional degree (e.g., MD, DDS, DVM)	67 (23.9)
Marital status		Doctorate	11 (3.9)
Married	91 (32.5)		
Divorced	10 (3.6)		

Separated	3 (1.1)
Never married	176 (62.9)

Note. N = 280

11 participants disclosed that they had been diagnosed with ADHD, and 17 participants with ASD or dyslexia. 68 participants were previously diagnosed with other major mental illnesses Disclosure of mental illness is reported in detail in Table (2.2.).

Table 2.2. *Disclosure Mental Disorder*

	ADHD	Dyslexia	ASD	Mental disorder
Yes	6 (2.1%)	7 (2.5%)	4 (1.4%)	60 (21.4%)
Prefer not to say	5 (1.8%)	3 (1.1%)	3 (1.1%)	8 (2.9%)
No	269 (96.1%)	270 (96.4%)	273 (97.5%)	212 (75.7%)
Total	280 (100%)	280 (100%)	280 (100%)	280 (100 %)

2.3.2 Materials

The Adult ADHD Self-Report Scale (ASRS-v1.1) was used to measure ADHD-like traits, alongside the Barratt Impulsiveness Scale, and the Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004). Given the widely documented co-occurrence of ADHD and ASD (Panagiotidi et al., 2017), we also administered the Autism Spectrum Quotient (AQ). Participants were not aware of the research purpose, so we invited them to take part in a research study about attentional difficulties and emotional control.

2.3.2.1 Adult ADHD Self-Report Scale (ASRS-v1.1)

ASRS-v1.1 is a self-report, 18-questions scale developed by the World Health Organization (Kessler et al., 2004). It covers the 18 DSM-IV-TR criteria and measures inattention and hyperactivity/ impulsivity symptoms. ASRS-v1.1 is designed to identify the classical symptoms of ADHD and score the frequency of symptoms (from 0 to 4) ("never," "rarely," "sometimes," "often," "very often") (Kessler et al., 2004). Participants are likely to have ADHD if they score between 17-23. Scores of 24

and more indicate more severe ADHD-type characteristics in adulthood. Adults are likely not to have ADHD if they score 0-17.

ASRS-v1.1 has two subscales: inattention (for example: ‘when you have a task that requires a lot of thought, how often do you avoid or delay getting started?’) and a hyperactivity/ impulsivity (for example: ‘how often do you feel overly active and compelled to do things, like you were driven by a motor?’) and each subscale contains nine items.

In this study, the internal consistency (Cronbach's alpha) of the total ASRS scale was 0.86, consistent with previous studies (e.g. .81, Panagiotidi et al., 2017). The reliabilities for the two subscales, inattention and hyperactivity, were also high (Cronbach's alpha .81, .77, respectively).

2.3.2.2 The Barratt Impulsiveness Scale (BIS)

Barratt Impulsiveness Scale (Barratt, 1995) is a 30 item self-report scale used to measure impulsiveness. Items are scored on a 4-point scale: (Rarely/Never = 1 Occasionally = 2 Often = 3 Almost Always/Always = 4). It is divided into three second-order factors (attentional, motor, and non-planning impulsiveness).

The scale has three sections; the attentional facet measures cognitive stability; (‘I have “racing” thoughts’). The motor facet identifies impulsive decisions (‘I “act” on impulse’). The planning facet pinpoints self-control and cognitive aptitude for complexity (‘I am more interested in the present than in the future’). In this study, the internal consistency for the total scale was .85.

2.3.2.3 Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004)

The DERS is a brief, 36-item self-report questionnaire designed to assess multiple aspects of emotional dysregulation: non-acceptance of emotional responses, difficulties engaging in goal-directed behaviour, impulse control difficulties, lack of emotional awareness, and inadequate access to emotion regulation strategies and lack of emotional clarity (Gratz and Roemer, 2004).

The DERS scale indicates how people are often clear about their feelings when they are upset, feel out of control, have difficulty concentrating, or control their behaviour. Participants have to indicate how often the statement in each item applies to them, rated on a 5-point scale ("almost never (0-10%)," "sometimes (11-35%)," "about half the time (36-65%)," "most of the time (66-90%)," "almost always (91-100%)").

One of the features of DERS is that it has high internal consistency (=.93), with Cronbach's >.80 for each subscale. Our results support the high internal consistency for the DERS (.94). Table (2.3.) presented the reliabilities for each DERS subscale.

Table 2.3. The Items Constituting the six Subscales of the DERS and the Cronbach's Alphas of Each

Nonaccent	Goals	Impulse	Aware	Strategies	Clarity
Non-acceptance of emotional responses	Difficulties engaging in goal-directed behaviour	Impulse control difficulties	Lack of emotional awareness	Limited access to emotion regulation strategies	Lack of emotional clarity
a =.90	a =.88	a =.90	a =.83	a =.92	a =.83

2.3.2.4 Autism-Spectrum Quotient (AQ)

The Autism Spectrum Quotient (Baron-Cohen, 2001) is a 50 item self-report questionnaire. The AQ is used to evaluate autistic spectrum traits in intellectually competent adults and measures social skills (‘I prefer to do things with others rather than on my own’), attention switching (‘I prefer to do things the same way over and over again’), attention to detail (‘I often notice small sounds when others do not’), communication (‘other people frequently tell me that what I’ve said is impolite, even though I think it is polite’), and imagination (‘if I try to imagine something, I find it very easy to create a picture in my mind’). The cronbach’s alpha coefficients ranged between moderate to high (communication = .65; social skills, = .77; imagination = .65; attention to detail = .63; attention switching = .67).

Scoring the AQ is as follows; participants scored 1 point when they responded “Definitely agree” or “slightly agree”, on the following questions: 1, 2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45, 46, and scored 1 point when they responded “Definitely disagree” or “slightly disagree”, on the following questions: 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50.

Individuals score in the range 0–50; scores in the range 0-25 indicate low autistic traits, whereas scores in the range 26-32 indicate some autistic traits; last, the scores in the range 33-50 indicate significant autistic traits.

2.3.3 Procedure

Participants were provided with password-protected access to the survey. Before accessing the questionnaire, all participants were asked to read an information sheet and give their informed consent to participate. Participants were then administered a series of questionnaires via Qualtrics. These were: Adult ADHD Self-Report Scale (ASRS-v1.1), The Barratt Impulsiveness Scale (BIS), Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004), and Autism-Spectrum Quotient (AQ). Participants were required to disclose if they had a previous diagnosis with ADHD, dyslexia, ASD, or any mental disorder. After completing the questionnaire, participants were debriefed online about the purpose of the study. Completing the questionnaire took approximately 20 min.

2.4 Data analysis

Data management and analysis were performed using the Statistical Package for the Social Sciences (SPSS). Pearson's correlation coefficients were conducted to test the relationship between the DERS and the Adult ADHD Self-Report Scale, and the relationship between the DERS and both Barratt Impulsiveness Scale and the Autism Spectrum Quotient. To test the null hypothesis, we accept $P<0.05$ as the significance level two-tailed probabilities. Linear multiple regression analyses were conducted to test the extent to which ASRS and AQ scores predicted the DERS scores.

2.5 Results

Questionnaires Characteristics

Scales data reported below were normally distributed. More specifically, on the assumption that skewness and kurtosis values in the range +2 to -2 indicate that a dataset are normally distributed (George and Mallery, 2010), with a skewness of .525 (*SE*=.146) and kurtosis of .774 (*SE* =.290), ASRS-v1.1 met the assumption of normality. DERS scores were also normally distributed (skewness .420 (*SE* = .146), kurtosis: -.384 (*SE* = .290). The BIS also appeared to be normally distributed (skewness: .276 (*SE* =.146), kurtosis: -.416 (*SE* 31=.290) as was the AQ (skewness: .544 (*SE* =.146), kurtosis: .624 (*SE* =.290).

Participants were recruited from the University and consisted of any gender over the age of 18. Most of the sample were female (F 209, M 66, Other 5), never married, and white. Participants ranged in age from 25 to 34 and they were employed full time and had completed a bachelor's degree. An a priori sample size calculation was undertaken using G*power 3.1.9.4 (Faul et al., 2007) and Cohen's (1992) table. Prior studies suggested medium effect size was to be expected for the planned multiple regression (Faul, Erdfelder, Buchner, & Lang, 2009). Power analysis suggested that with a medium effect size (.15), for an alpha of 0.05 and a power of 0.8, a group size of 123 would be required to achieve a robust statistical outcome. The potential predictors using multiple regression were 15 and include gender, overall ASRS (subscales: inattention- hyperactivity), overall Barratt Impulsiveness Scale **(**subscales: attentional facet- motor facet**-** planning facet), overall Autism Spectrum Quotient **(**subscales: social skills**-** attention switching**-** attention to detail**-**communication- imagination) and independently predicted overall DERS scores**.** In this study, a sample consisted of 209 participants. Therefore, the study was adequately powered.

Age

One-way analysis of variance (ANOVA) was used to examine whether questionnaire scores differed based on age. For the ASRS, F (6,273) =.678, P<.668 and for the DERS, F (6,273) =.4.65, P<.001. (Table 2.4).

Table 2.4. Characteristics of Age Group M (SD)

Age group	ASRS Score	DERS score	Frequency
18-24	31.89 (10.16)	100.88 (23.06)	92
25-34	32.55 (10.28)	90.96 (26.11)	100
35-44	32.40 (1113)	85.40 (20.88)	45
45-54	33.00 (9.23)	82.85 (21.47)	27
55-64	27.75 (9.25)	74.75 (12.38)	12
65-74	39.50 (12.50)	99.50 (22.50)	2
75-84	37.00 (1.41)	84.50)24.74	2

M = mean, SD = standard deviation

Gender

An independent samples t-test was performed to examine the effect of gender of the participant on the overall ASRS scores (t (225) =-.181, p=.857), overall DERS scores (t (225) =-.621, p=.942), overall BIS scores (t (225) = .073, p=.535) and overall AQ score (t (225) = .660, p=.510) (Table 2.2). For the ASRS subscales, the independent samples t-test for the inattention subscale was (t (225) = -.403, p=.687) whereas for the impulsivity/hyperactivity subscale it was (t (225) = .072, p=.943). (Table 2.5).

Table 2.5. *Gender Differences in different scales* M (SD)

Variable	Overall scales	M(SD)
Males		
	ASRS	32.03(11.40)
	Inattention	17.12 (5.81)
	Impulsivity/hyperactivity	14.92 (6.34)
	DERS	89.35(22.78)
	Barratt Impulsiveness	63.63(11.85)
	Autism Spectrum Quotient	21.68(8.10)
Females		
	ASRS	32.34(11.29)
	Inattention	17.49 (6.29)
	Impulsivity/hyperactivity	14.85 (6.03)
	DERS	91.63(25.02)
	Barratt Impulsiveness	63.51(11.12)
	Autism Spectrum Quotient	20.94(7.24)

M = mean, SD = standard deviation

The relationship between the different variables in males (N=66)

The ASRS was significantly positively correlated with the overall DERS (r (66) =.598**, p<.01) and the overall BIS (r (66) =.603**, p<.01) and the overall AQ (r (66) =.372**, p<.01). A strong correlation was found between all the overall DERS and the overall BIS and the overall AQ (at p<.01 level). The overall BIS scale did not correlate with the overall AQ (r (66) =.241).

The relationship between the different variables in females (N= 209)

As with the males, in females the ASRS was significantly positively correlated with the overall DERS (r (209) =.500**, p<.01) and the overall BIS (r (209) =.692**, p<.01) and the overall AQ (r (209) =.258**, p<.01). A strong correlation was found between all the overall DERS and the overall BIS and the overall AQ (at p<.01 level). However, unlike the males, the overall BIS correlated with the overall AQ (r (209) =.163).

Adult ADHD Rating Scale (ASRS-v1.1)

The mean overall ASRS score was 32.23 (*SD*= 10.24), with a range of 9 to 61.00. The mean score on the inattention subscale was 17.43 (*SD*= 5.74) and the mean score on the hyper-activity subscale 14.80 (*SD*= 5.58). The two ASRS subscales were strongly correlated, r (280) =.535, p<.01. The overall ADHD score was correlated with both the inattention (r (280) = .907**, p<.01) and the hyperactivity subscale (r (280) = .901**, p<.01).

The effect of neurodevelopmental disorder diagnosis on the ASRS score was investigated. Participants (N=11) previously diagnosed with ADHD (M = 35.82, *SD*= 14.49) had higher overall ASRS scores than participants (N= 269) without ADHD (M = 32.08, *SD*= 10.04). However, there was no statistically significant difference in mean ASRS score between those previously diagnosed with and without a previous diagnonis of ADHD (t (278) = 1.186, p = .237).

Barratt Impulsiveness Scale (BIS)

The mean score in the overall BIS was 63.19 (*SD*= 10.74). The range of scores on the BIS was 38 to 95.00. The mean score on the attentional facet subscale was 17.39 (*SD*= 4.54) and the planning facet subscale score was 23.82 (*SD*= 4.62) and the motor facet subscale 21.99 (*SD*= 4.57).

The effect of neurodevelopmental disorder diagnosis on the BIS were investigated. Participants (N=11) previously diagnosed with ADHD *(M* = 68.45, *SD*= 8.23) had significantly higher scores than participants (N= 269) without a past or current diagnosis (*M* = 62.98, *SD*= 10.78). There was no statistically significant difference in mean BIS score between those previously diagnosed with ADHD and those without a previous diagnosis of ADHD (*t* (278) = 1.663, *p* = .097).

Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004)

The mean score on the overall DERS was 91.86 (*SD*=24.37). The range of scores was from 39 to 160.00. The mean scores for each of the six DERS subscales is as the follows: the non-acceptance of emotional responses was 15.98 (SD= 6.24), difficulties engaging in goal-directed behaviour 15.83 (SD= 4.86), impulse control difficulties 14.09 (SD= 5.84), lack of emotional awareness 15.91 (SD= 5.05), inadequate access to emotion regulation strategies 20.49 (SD= 8.11) and the lack of emotional clarity 12.35 (SD= 4.28).

The effect of mental or neurodevelopmental disorder diagnosis on the DERS score was investigated. Participants (N=11) previously diagnosed with ADHD had also higher score on the DERS, (*M* = 102.73, *SD*= 11.54**)** than participants (N= 269) without a past or current diagnosis (*M* = 91.42, *SD*= 24.67, min= 39, max= 169). However, there was no a statistically significant difference in mean ASRS score between previously diagnosed with ADHD and those without a previous diagnosis of ADHD (*t* (278) = 1.511, *p* = .132).

ASRS groups

We divided the participants into groups based on the overall ASRS scores: a “low” group who scored 29 and less in the overall ASRS score (Low ASRS group N=115**;** Males =34 & Females =81) and a “high” group who scored 35 and more in the overall ADHD score (High ASRS group N= 112**;** Males= 26 & Females= 86). The cut off for the high group was based on a study conducted by

Panagiotidi et al., (2017) exploring ADHD-like traits in 800 healthy participants. They had the mean score 31.83, and a score of 35 (the cut-off in the current study) was at the 75th percentile. (Table 2.6).

Table 2.6. *ASRS Level*

	ASRS Level	
1	Low	115 participants (34 Males & 81 Females)
2	High	112 participants (26 Males & 86 Females)

High ADHD group had higher mean scores on all variables than the low ASRS group and the overall ASRS group (Table 2.7). An independent-samples t-test was run to determine if there were differences in overall ASRS and DERS scores between the High and Low ASRS groups. For the overall ASRS score there was no statistically significant difference between groups, M = -.30, 95% CI [-3.66, 3.05], t (225) = -.181, p = .857. Also for the overall DERS there was no statistically significant difference between groups, M = -2.28, 95% CI [-9.26, 4.69], t (225) = -.621, p = .535

Table 2.7. *ASRS Level and different variables M (SD)*

	Low (115)	High (112)	N (280)
ASRS	22.77(4.68)	42.00(6.95)	32.23 (10.24)
ASRS Inattention	12.67(3.31)	22.24(4.37)	17.43(5.74)
ASRS Hyperactivity	10.10(3.04)	19.76(4.31)	14.80(5.58)
DERS	79.83(18.88)	102.53(24.17)	91.86(24.37)
DERS Clarity	10.68(3.59)	14.27(4.23)	12.35(4.28)
DERS Aware	15.41(4.49)	16.88(5.50)	15.91(5.05)
DERS Impulsiveness	11.63(4.40)	16.28 (6.35)	14.09(5.84)
DERS Non-acceptance	13.43(5.26)	17.64 (6.23)	15.98(6.24)
DERS Goal	13.98(4.21)	17.22 (4.98)	15.83(4.86)
DERS Strategies	17.25(6.77)	23.33(8.22)	20.49(8.11)
Barratt Impulsiveness Scale	56.43(7.88)	70.84(9.48)	63.19(10.74)
Attentional facet	14.37(3.31)	20.52(4.02)	17.39(4.54)
Motor facet	20.14(3.58)	24.51(4.75)	21.99(4.57)
Planning facet	21.94(4.02)	25.81(4.58)	23.82(4.62)
Autism Spectrum Quotient	19.59(7.43)	22.72(7.19)	21.00(7.11)
Social skills	3.30(2.58)	3.78(2.43)	3.49(2.44)
Attention switching	4.88(2.09)	5.70(2.41)	5.29(2.21)
Attention to detail	5.55(2.26)	5.83(2.20)	5.73(2.25)
Communication	3.15(2.23)	4.31(2.12)	3.65(2.17)
Imagination	2.71(1.87)	3.11(1.87)	2.85(1.86)

M = mean, SD = standard deviation

The Relationship between ASRS and different variables - low ADHD group (N=115)

The ASRS was significantly positively correlated with the overall DERS (r (115) =.204**, p<.01) and the overall BIS (r (115) =.201**, p<.01). There was no significant correlation between ASRS and the AQ (r (115) =.153). A strong correlation was found between the overall DERS and the overall BIS (r (115) =.332**) and the overall AQ (r (115) =.415**) (at p<.01 level). The overall BIS did not correlate with the overall AQ (r (115) =-.102).

The Relationship between ASRS and different variables - High ADHD group (N= 112)

The ASRS was significantly positively correlated with the overall DERS (r (112) =.453**, p<.01) and the overall BIS (r (112) =.479**, p<.01) and the AQ (r (112) =.309**, p<.01). A strong correlation was found between all the overall DERS and the overall BIS (r (115) =.425**) and the overall AQ (r (112) =.394**) (at p<.01 level). The overall BIS correlated with the overall AQ (r (112) =241**, p<.01)

The relationship between DERS and ASRS

The overall ASRS score was strongly correlated with the overall DERS score (Figure 2.1.), (r (269) = .545**, p<.01).

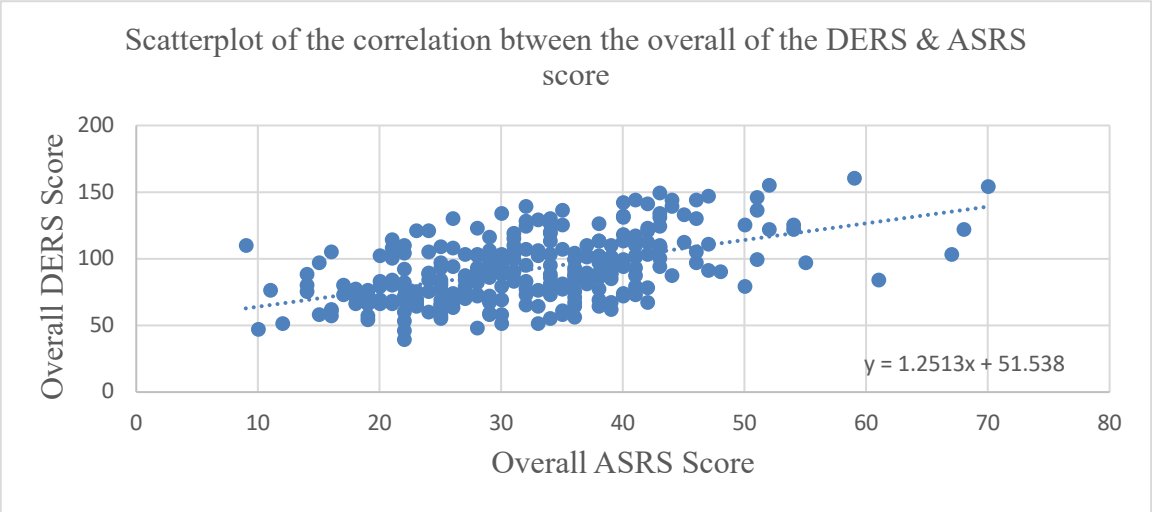

Figure 2.2. Scatterplot showing the relationship between the ASRS and the DERS

The DERS was significantly positively correlated with the inattention (r (269) =.549**, p<.01) and the hyperactivity (r (269) =430**, p<.01) subscales of the ASRS. A strong correlation was found between all the DERS subscales and the overall ASRS (at p<.01 level); the non-acceptance of

emotional responses was (r (269) =392**, p<.01), difficulties engaging in goal-directed behaviour (r (269) =414**, p<.01), impulse control difficulties (r (269) =461**, p<.01), inadequate access to emotion regulation strategies (r (269) =459**, p<.01) the lack of emotional clarity (r (269) =456**, p<.01) and lack of emotional awareness (r (269) =156*, p<.01). For those with a previous clinical diagnosis of ADHD group (N=11), there was no correlation between ASRS and DERS.

The relationship between DERS and BIS

The overall BIS scores were strongly correlated with the overall DERS score (r (269) = .554**, p<.01; see Figure 2). The DERS was also significantly correlated with BIS subscale as the following: the attentional facet subscale (r (269) =.585**, $p<.01$) and the planning facet subscale (r (269) = .404**, p<.01) and the motor facet subscale (r (269) = .321**, p<.01). (see Figure 2.2.).

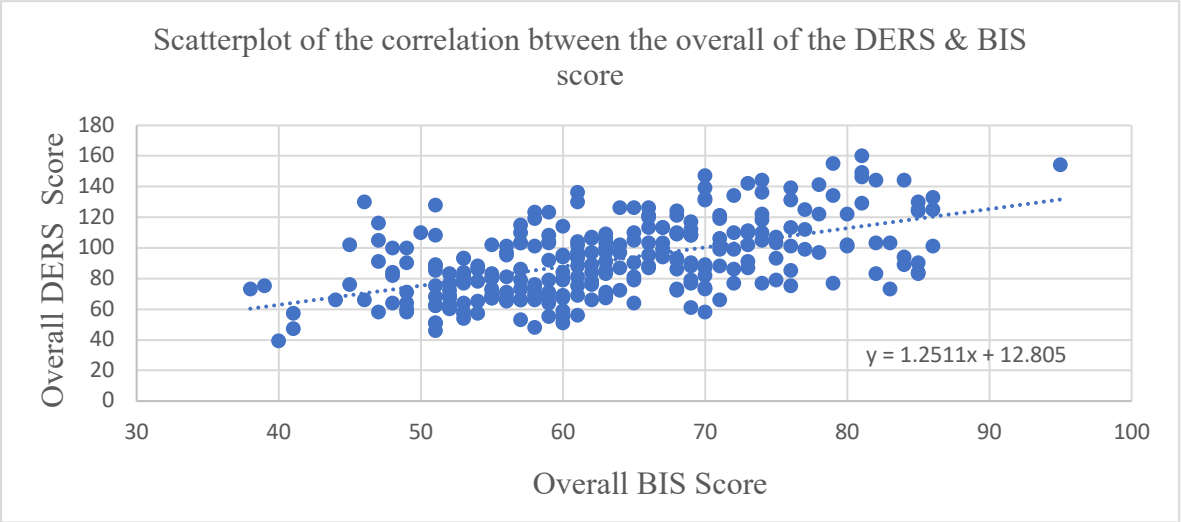

Figure 3.2. Scatterplot showing the relationship between the BIS and the DERS

Autism-Spectrum Quotient (AQ)

The mean score on the overall AQ was 21.00 (SD=7.11). The range of scores was from 5 to 46. The mean scores for each of the 5 AQ subscales was as the follows: social skills 3.49 (SD= 2.44), attention switching 5.29 (SD= 2.21), attention to detail 5.73 (SD= 2.25), communication 3.65 (SD= 2.17), and imagination 2.85 (SD= 1.86). There was a positive correlation between the AQ and ASRS (r (269) =294**, p<.01). Also, the inattention subscale of the ASRS correlated with AQ (.300**, p<.01), as did the hyperactivity/ impulsiveness subscale (.228**, p<.01). (see Figure 2.3.).

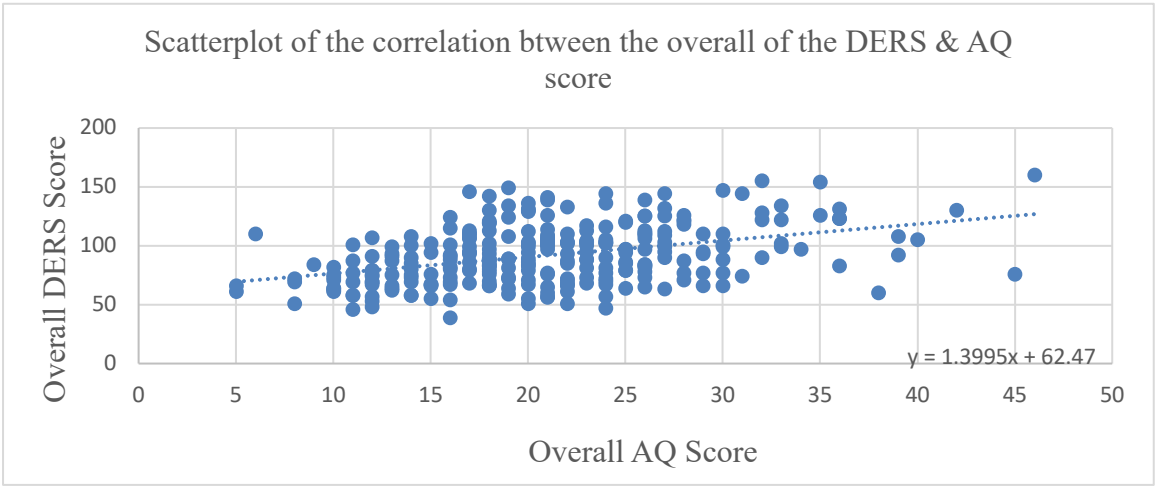

Figure 2.4. Scatterplot showing the relationship between the AQ and the DERS

A strong correlation was also found between all the DERS subscales and the overall AQ (r (269) =410**, p<.01); the non-acceptance of emotional responses was (262**, p<.01), difficulties engaging in goal-directed behaviour (345**, p<.01), impulse control difficulties (384**, p<.01), inadequate access to emotion regulation strategies (365**, p<.01) the lack of emotional clarity (332**, p<.01). There was no correlation between overall AQ and lack of emotional awareness.

Predicting DERS scores with the overall ASRS, BIS & AQ scores

Hierarchical multiple regressions were run to determine if the overall ASRS, BIS and AQ scores independently predicted overall DERS scores**.** Gender was added as a covariate given the gender imbalance in our sample set. Linearity was confirmed by partial regression plots and plots of studentised residuals against the predicted values. The scale scores were independent, as evaluated by a Durbin-Watson statistic of 2.17. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. The assumption of normality was met, as evaluated by Q-Q Plots. **However,** there was homoscedasticity, as assessed by visual inspection of a plot of studentised residuals versus unstandardised predicted values.

Initially, the regression was run using total scores for the ASRS, BIS, AQ, and gender. The full model with ASRS, BIS, AQ scores and gender predicting DERS was statistically significant, R^2 = .424, F (4, 270) = 49.65, p < .001; adjusted R^2 =.415. Overall ASRS scores predicted overall DERS

scores (Model 1), contributing a significant proportion of the variance R^2 = .271, F (1, 273) = 101.52, p < .001. Adding BIS to the prediction of DERS scores (Model 2) led to a statistically significant increase in R^2 of .342, F (1, 272) = 70.77, p < .001. The further addition of the AQ to the prediction of DERS (Model 3) led to a statistically significant increase in R^2 of .418, F (1, 271) = 64.91, p < .001. However, the addition of gender did not significantly improve the prediction of DERS in (Model 4) R^2 of .454, F (1, 270) = 49.65, p =.103. The ASRS, BIS and AQ were all independent predictors of DERS scores. (See Table 2.8.).

Table 2.8. *Hierarchical multiple linear regression analysis of the ASRS, BIS & AQ scores predicting overall DERS scores*

	B	β	R^2	F	R^2 change	F change
Model 1						
Constant	52.29**					
ASRS	1.22**	.521				
			.281	101.52	.271	101.52
Model 2						
Constant	19.54					
ASRS	.66**	.281				
BIS	.804**	.358				
			.380	70.77	.071	29.45
Model 3						
Constant	5.07					
ASRS	.460**	.196				
BIS	.813**	.362				
AQ	.970**	.288				
			.448	64.91	.076	35.31
Model 4						
Constant	-3.01					
ASRS	.448**	.191				
BIS	.822**	.366				
AQ	.988**	.293				
Gender	4.28	.076				
			.454	49.65	.006	2.68

DERS – Difficulties in Emotion Regulation Scale; ASRS - Adult ADHD Rating Scale; AQ – Autism Spectrum Quotient; *β*= standardized regression coefficient.

* P < .05; ** p < .001.

Predicting overall DERS scores with the subscales of the ASRS, BIS &AQ

The regression was run again using the ASRS, BIS and AQ subscale scores and gender. The full model of ASRS, BIS, AQ subscales scores predicting overall DERS scores was statistically significant, $R^2 = .424$, F (11, 263) = 19.86, $p < .001$; adjusted $R^2 = .431$. The two ASRS subscales, inattention and hyperactivity, predicted the overall DERS scores (Model 1), contributing a significant proportion of variance $R^2 = .271$, F (2, 272) = 53.22, $p < .001$. They were both independent predictors of DERS scores. The addition of the BIS subscales (Model 2) to the prediction of DERS scores led to a statistically significant increase in R^2 of .342, F (5, 269) = 23.92, $p < .001$. Adding the AQ subscales to the prediction of DERS scores (Model 3) led to a statistically significant increase in R^2 of .418, F (10, 264) = 21.43, $p < .001$. In the presence of AQ subscale scores, ASRS inattention and hyperactivity scores were no longer independent predictors of DERS scores. Instead, in the full model, Attentional Facet and Planning Facet (BIS) scores, and Attention Switching (AQ) scores were independent predictors. The addition of gender in the full model did not add significantly to the predict of DERS scores (Model 4, R^2 of .424, F (11, 263) = 19.86, $p < .001$) (See Table 2.9.).

Table 2.9. Hierarchical multiple linear regression analysis ASRS, BIS & AQ subscale scores predicting overall DERS scores

	B	β	R^2	F	R^2 change	F change
Model 1						
Constant	51.06**					
ASRS- Inattention	1.73**	.409				
ASRS_H/I	.702*	.164				
			.281	53.22	.281	53.22
Model 2						
Constant	24.01**					
ASRS- Inattention	.831*	.196				
ASRS_H/I	.037	.009				
BIS- Attentional Facet	2.02**	.383				
BIS- Motor Facet	.124	.024				
BIS- Planning Facet	.619*	.117				
			.380	32.92	.098	14.21
Model 3						
Constant	8.80					
ASRS- Inattention	.549	..129				
ASRS_H/I	.084	.020				
BIS- Attentional Facet	1.55**	.293				
BIS- Motor Facet	.312	.059				
BIS- Planning Facet	.811*	.154				
AQ_SocialSkill	.876	.089				
AQ_Attention Switching	1.79**	.165				
AQ_Attention To Detail	.616	.058				
AQ_Communication	.930	.084				
AQ_Imagination	-.178	-.014				
			.448	21.43	.068	6.55
Model 4						
Constant	.622					
ASRS- Inattention	.519	.122				
ASRS_H/I	.088	.021				
BIS- Attentional Facet	1.56**	.296				
BIS- Motor Facet	3.20	.061				
BIS- Planning Facet	.821*	.156				
AQ_SocialSkill	.900	.091				
AQ_Attention Switching	1.83**	.168				
AQ_Attention To Detail	.646	.060				
AQ_Communication	.915	.083				
AQ_Imagination	-.159	-.012				
Gender	4.26	.076				
			.454	19.86	.006	2.72

DERS – Difficulties in Emotion Regulation Scale; ASRS - Adult ADHD Rating Scale; AQ – Autism Spectrum Quotient; β= standardized regression coefficient; β= standardized regression coefficient, SE= Standard Error.

* $p < .05$; ** $p < .001$.

2.6 Discussion

The primary objective of this study was to investigate the relationship between ADHD-like traits and difficulties in emotion regulation. As mentioned in the literature review, people with ADHD not only suffer from the core symptom as described in the DSM 5 but also struggle to regulate their emotions. ADHD has important components; emotion dysregulation is a new addition to the symptom set, and its relationship to the classical symptoms of ADHD is poorly researched.

Overall, we had 208 participants, so the requisite sample size was satisfied, allowing us to draw appropriate conclusions about the relationship between ADHD and ED in the main analysis. However, because the clinical group was so small, we could only draw pilot conclusions for the analyses of the associated data, therefore, this should be considered when drawing conclusions about the findings in relation to this group.

The ASRS scale was strongly correlated with the DERS scale. There was a highly significant positive correlation between the DERS and both subscales of the ASRS (inattention and hyperactivity), suggesting that the symptoms of ADHD do indeed cluster together. The mean total ASRS score was high (32.23) for the non-clinical sample when scores above 24 are considered to be indicative of ADHD. Only 11 of our sample had a current diagnosis of ADHD, and hence the figures have not been distorted by a clinical presence. Similar scores have been reported before in non-clinical samples (e.g., 33.02 in Pauli, Liljeberg, Gustavsson, Kristiansson, & Howner, 2019). The DERS scores were also high (mean, 91.86). Again, similar scores have been reported elsewhere in non-clinical samples (Mestre-Bach et al., 2021). The results also found that AQ was correlated with the DERS, a finding which adds to previous research linking the symptoms of ADHD to ASD (Hayashi et al., 2021; Panagiotidi, Overton, & Stafford, 2019; Ghirardi et al., 2019). Since there is an overlap between ADHD and ASD, emotional symptoms should be considered when managing ADHD and ASD. Indeed, managing emotion dysregulation may help to manage both ADHD and ASD when co-morbid.

The hierarchical multiple regressions supported the predictability of emotion dysregulation via ASRS scores and AQ scores. We can see from the results that each model (from "1" to "2", total scores for the ASRS and AQ) explains a greater amount of the variation in the DERS scores as more variables are added (i.e., R^2 = .274 and .344 respectively). Essentially, the models get better at predicting emotion dysregulation. The overall ASRS and AQ added with each model are statistically significant. The overall ASRS and AQ were significant independent predictors of the DERS scores. Furthermore, the subscales of the ASRS on their own, and the inattention subscale in the presence of the AQ subscales and were statistically significant independent predictors, alongside attention switching from the AQ. Overall, the pattern of results suggests that at least as far as emotional dysregulation is concerned, ADHD and ASD have some degree of separation from each other as disorders.

Young adults with high ADHD scores and difficulties in emotion regulation have a problem with internet addiction because they seek immediate gratification to regulate negative emotions; this finding is consistent with our results (Evren, Evren, Dalbudak, Topcu, & Kutlu, 2018). People who have trouble controlling their emotions may be more susceptible to developing problematic internet use; Gioia, Rega, & Boursier (2021) demonstrated that problematic internet use might serve as a coping mechanism to make up for emotional control impairments. In our sample, participants previously diagnosed with ADHD had higher ASRS, and DERS scores mean (M = 35.82 & M= 102.73, respectively). These results accord with previous studies in clinical populations, which reported a high ASRS mean scale score of M= 35.4 (Guo et al., 2021).

These results support the hypothesis that emotion dysregulation has a close connection with the classical ADHD symptoms and therefore suggest common mechanisms for the generation of a range of ADHD symptoms. Those common mechanisms can be understood at the cognitive level, as support for the role of executive dysfunction in the generation of ADHD symptoms. They can also be understood at the neural level, as support for mechanisms previously proposed to be dysfunctional in these disorders. In particular, the possibility that ADHD may in part reflect a hyperresponsiveness on

the midbrain superior colliculus (Overton, 2008) has a natural connection with emotionality given that stimulation of the colliculus leads to a physiological arousal (Keay, Dean & Redgrave, 1990) resembling that which accompanies emotional responses.

2.7 Limitations and suggestions for future research

One limitation of this present study is that it is based on self-reports rather than observed behaviour. Accordingly, there is the possibility of bias between what participants' self-report and what would be observed behaviourally (e.g., in behavioural tests of emotion dysregulation, or tasks that assays dysfunctions in ADHD or ASD). Alternative methods may be considered that involve behavioural assessments. Nevertheless, self-report measures are often well-correlated with actual behaviour, and so should be considered indicative of what may be expected in behavioural studies (e.g., Wash, Rader, & Fennell, 2017). Regardless of the drawbacks of self-report, the high internal consistency was observed for ASRS, DERS, BIS, and AQ. Use of both subscales of the ASRS, measuring inattention and hyperactivity, is one of the strengths of the study in that it allows us to identify participants as having differing ADHD-related symptom patterns and hence the possibility of correlating these with the DERS.

In terms of future research, while ADHD drugs help to treat the classical symptoms of ADHD, they are less successful in treating the mechanisms causing emotion dysregulation (Lenzi, Cortese, Harris, & Masi, 2018). New pharmacological and non-pharmacological treatments for emotion dysregulation in adults with ADHD require more study (Lenzi, et al., 2018). However, our results suggest that - given the close relationship between the classical symptoms of ADHD and emotion dysregulation – drugs effective against the latter may end up also having efficacy in the context of inattention and/or impulsivity/hyperactivity. Emotion dysregulation is a pertinent issue in ADHD and should be given as much consideration as the three main symptoms of ADHD.

The study can be used as the basis of further research on emotional dysregulation in adults with ADHD and the association with emotional responsiveness, given the closeness of these subjects. As

mentioned above, rather than a survey paradigm, further studies might benefit from should use an experimental paradigm. Therefore, Study 2 will investigate the classical symptom of inattention in relation to emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits.

2.8 Conclusion

The current study's main goal was to determine the relationship between the classical symptoms of ADHD and emotion dysregulation, as measured by appropriate scales in a non-clinical population. The analysis of DERS and both ASRS subscales have extended our knowledge about the natural role of emotion dysregulation in ADHD. Even though emotion dysregulation is considered a feature of ADHD, it is not included in the ADHD disorder's diagnostic criteria. Our findings support the idea that emotion dysregulation is inherent in ADHD adults. Our result could improve the diagnostic criteria accuracy and develop a new treatment for adults with ADHD since the available medication does not target the emotional symptoms. We expect that it could be possible to treat more than one symptom by intervention with a more restricted focus.

Chapter 3. Distractibility & Emotion dysregulation

3.1 Chapter Summary

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterised by inattention, hyperactivity, and impulsiveness. However, the effects of emotion dysregulation in ADHD disorder has been questionable for a long time, and its relationship with the classical symptoms of ADHD is under-researched. Emotion dysregulation is associated with several mental health disorders but to what degree is it embedded in the symptoms of ADHD, such as distractibility, is unidentified. The primary purpose of this study was to explore whether distractibility – a key aspect of inattention - was related to emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits. 402 participants undertook a modified version of the Sustained Attention to Response Test (SART) with distractors presented on some trials, and the Adult ADHD Self-Report Scale (ASRS) and the Difficulties in Emotion Regulation Scale (DERS).

The overall ASRS scale was correlated with the overall DERS scale. The reaction times (RTs) on trials with distractors were faster than those without distractors and there was no significant difference depending on the severity of ADHD-like traits, when participants were split into those with low and high levels of traits. The reaction times distractor cost and accuracy distractor cost were also very similar for all groups. A difference was found between trials without and with distractors in accuracy; accuracy was higher with distractors. However, again, there was no significant difference between the ADHD groups. So, overall, the modified SART task failed to provoke distraction but rather the distractors had a paradoxical facilitatory effect on performance. In both groups, the overall DERS score correlated with the total omission errors on trials with and without distractors. In the low ASRS group, the overall DERS correlated with reaction times on trials with distractors whereas the high ASRS group correlated with accuracy. The DERS subscale in both groups correlated with task performance.

3.2 Introduction

ADHD is one of the most common neurodevelopmental disorders; the American Psychiatric Association (APA) DSM-5 (2013) classifies ADHD as predominantly inattentive, predominantly hyperactive/impulsive or combined type, with different levels of severity of ADHD - mild, moderate or severe. Although ADHD is primarily thought of as a childhood disorder (Taylor, 1998), studies have found that ADHD symptoms persist into adulthood in between 8% and 43% of cases (Spencer *et al*., 2002). ADHD is considered to be a continuum disorder, with symptoms grading into the non-clinical population (Panagiotidi *et al*., 2017).

Core symptom: Inattention

Inattention is the most common symptom of ADHD in both children and adults. In DSM-5, the predominantly inattentive criteria appear as difficulty sustaining attention, failure to follow instructions, inability to focus on details and being distracted by unimportant stimuli (APA, 2013). People with ADHD perform well when they have novel stimuli, interesting stimuli, immediate rewards, and coming up deadlines (Willer, 2017); and the positive side of ADHD drugs is that they help to manage the inattention.

To understand attention, Posner and Petersen (1990) divided attention into three parts; (a) orienting attention to sensory events - an automatic reaction to new occurrences, including pupil dilation, abnormal heart rate, and skin conductivity changes. Underlying the orientation of attention is a system consisting of the posterior parietal lobe, the lateral pulvinar nucleus of the postero-lateral thalamus and the superior colliculus (Posner and Petersen, 1990). (b) directing attention to the current stimuli (detecting signals for focal (conscious) processing) The orienting reflex toward events becomes weak when we expect them to occur, but when the stimulus is altered (changing the onset time of the stimuli or changing the frequency of presentation), the reflex returns to its original state and (c)

maintaining vigilance - reacting to stimuli and ignoring irrelevant information (Posner and Petersen, 1990).

In terms of ADHD symptoms, distractibility, the dysfunctional side of sensory orienting, has been considered by many to be one of the most common symptoms of the disorder in children (Barkley & Ullman, 1975), a position that goes back to the neuropsychiatrist A.A Strauss in the 1940s and 50s (e.g. Werner & Strauss, 1940). Clinical accounts often describe ADHD children as distractible. For example, Thorley (1984) states that hyperkinetic children show significantly more 'distractibility on examination' than controls. The impact of distractors can vary depending on the stress level, the intensity of emotion, experiences, and type of tasks. Forster & Lavie (2008) found that task performance was negatively affected when the chance to perform with an interruption from irrelevant distractions increased. More generally, internal distractors such as thoughts and feelings and external distractors such as sights and sounds could make it challenging to maintain attention. Therefore, for better cognitive function, adults need to learn a coping strategy such as managing overwhelming tasks by modifying the environment or refocusing the attention if distraction arises.

Sustained attention is essential for people whose work demands multiple tasks or deep hyper-focus without being distracted**.** Various neuropsychological tests are available for measuring sustained attention. The TOVA measures response speed, response accuracy and measures reaction times with millisecond accuracy (Nikolas et al., 2019). Non-normal reaction times and increased errors may indicate impairments in sustained attentional capacity. The Sustained Attention to Response Task (SART) is another test of sustained attention where participants have to respond to a target in a set of non-targets. In addition to reaction times and accuracy, the task also measures intra-individual variability (IIV) or reaction time variability (RTV). RTV can be measured by looking at reaction time standard deviation (RTSD) or the coefficient of variation (CV) (CV = RTSD/mean reaction time) (Tamm, Narad, Antonini, 2012).

People with ADHD perform differently on the SART that healthy controls (Loo *et al*., 2009; Tucha *et al*., 2017). Reaction times measure the time in milliseconds between the presentation of a stimulus and the response to that stimulus, and people with ADHD exhibit elevated levels of variability in response times. So, when an individual does not respond to the target, omission errors increase, leading to longer overall reaction times and high RTV. Some studies suggest that high RTV in ADHD results from intermittent long reaction times (Tamm, Narad, Antonini, 2012). A meta-analysis review of 319 studies between 1972 and 2011 supports the idea of increased RTV in adults with ADHD compared to control and participants with other forms of psychiatric issues other (Kofler *et al*., 2013). In addition, greater RTV was found in ASD, especially when diagnosed with ADHD; RTV resulted from cognitive control, arousal, and motor output problems (Karalunas, Geurts, Konrad, Bender, Nigg, 2014).

People with high levels of ADHD symptoms have increased error rates (Emser, Johnston, Steele, *et al.* 2018). Omission error rates indicate they have a problem with attention. In contrast, commission error rates indicate they cannot control their impulsive behaviour. A deficit of sustained attention could explain the long reaction times and high RTV and increases in both types of error in ADHD. Meta-analyses of 24 studies with 867 people with ADHD versus 806 controls found small to moderate effect sizes in functional neuropsychological domains such as sustained attention and executive functions; there was a significant difference in sustained attention domain between the groups (Schoechlin & Engel, 2005).

Increased distractibility impairs the ability to sustain attention. As an aspect of inattention, there is good reason to select distractibility in the context of ADHD. Evidence suggests that the superior colliculus – a structure in the brain that is intimately related to distractibility, is dysfunctional in ADHD. Evidence is wide-ranging, from studies in animals to studies in patients with ADHD (Overton, 2008). The SART task can be modified to allow the study of the impact of distractors on sustained attention. The standard paradigm, where participants have to respond to a target in a set of non-targets can be adapted by introducing distractors during target (and non-target) presentations and

examining the reaction time cost encountered on distractor vs non-distractor target trials. This is the approach we adopted in the present study, where the basic idea was to examine the relationship between the classical symptom of inattention (via distractibility) and emotion dysregulation (ED), this time experimentally rather than via self-report.

Core symptom: Emotion dysregulation

Inattentiveness, hyperactivity, impulsiveness, and ED are components that contribute separately to ADHD (Shaw *et al*., 2014). ED disrupts an individual's ability to modify an emotional state and promote adaptive, goal-oriented behaviours (Thompson, 2019) and is a central element of the suite of ADHD symptoms (Shaw *et al*., 2014). There are different aspects to emotion regulation: emotion awareness, emotion acceptance, impulse control, engaging in goal-directed behaviour, clarity, and flexible emotion regulation. Any lack of competence in one of them can lead to emotion regulation deficits, and this is what is measured by the DERS scale (Gratz & Roemer, 2004).

Difficulties with emotional regulation experienced by youths with ADHD complicate their ability to maintain stable relationships with their peers (Gardner and Gerdes, 2015). People with ADHD symptoms and emotional difficulties cannot control emotional reactions within a socially acceptable range. However, the relationship between ED and the classical symptoms of ADHD is underexplored. Previous research has suggested that emotion and attention are connected in different networks of brain regions to maintain attentional focus, ignore irrelevant information, and determine *appropriate* behaviour responses (Compton, Banich, Mohanty, et al., 2003). So differences in the ability to maintain attentional focus are related to emotion, such that those who experience those difficulties appear outwardly more emotional.

A recent meta-analysis between an ADHD group and a healthy group explored the relationship between severe ADHD symptoms and ED dimensions; emotional lability and negative emotional responses correlated strongly with the severity of attentional difficulties (Beheshti, Chavanon, & Christiansen, 2020). Similarly, in Experiment 1, the DERS was found to correlate significantly with

the inattention subscale of the ASRS. However, Experiment 1 was based on self-reports. In Experiment 2, we used a task to assay inattention rather than relying on self-report data.

Previous work has almost exclusively used children, and emotionality has been assessed by observing behavioural expression. In this study, we wanted to change the emphasis to adults, exploring whether distractibility is related to ED in a non-clinical population with varying levels of ADHD-like traits. Assessing the relationship between ED and distractibility will help to establish whether the two symptoms arise from a common dysfunction, and given our understanding of the neural basis of distractibility, will give clues about the dysfunction underlying two core symptoms of ADHD.

3.2.1 Current Study

This study aimed to see whether distractibility is related to ED in a non-clinical population with varying levels of ADHD-like traits. Participants undertook a modified SART and completed scales measuring classical ADHD symptoms and ED. We hypothesised that the reaction times on target trials for participants with high levels of ADHD-like traits would be slower on distractor trials than on trials without distractors and would be associated with ED. We also hypothesised there would be a difference between trials without and with distractors regarding accuracy. In addition, the RTV will be increased in those with high levels of ADHD-like traits compared to low levels of ADHD-like traits. We expect those with high levels of ADHD-like traits to exhibit high levels of emotional dysregulation and sustained attention problems.

3.3 Methods

3.3.1 Participants

402 English-speaking participants (220 Female, 175 Males, and 7 other) over the age of 18 took part. Around 65.6% of the participants between the age 18 to 24, and 52.9% identified as female, and 65.9% white people. Participants were provided with study details and a link to Gorilla, an online experiment builder, and undertook a modified Sustained Attention to Response Test (SART),

presented online. Once the study ended the participants were debriefed immediately about the study aims. The Department of Psychology's Research Ethics Committee approved the procedures of this study. (Table 3.1.)

Table 3.1. *Demographics of Participants*

Characteristic	
Age, N (%)	
18-24	273 (65.6%)
25-34	106 (25.5%)
35-44	19 (4.6%)
45-54	3 (.7%)
55-64	1 (.2%)
Gender, N (%)	
Male	175 (42.1%)
Female	220 (52.9%)
Other	7 (1.7%)
Ethnicity, N (%)	
White	274 (65.9%)
Black / African / Caribbean / Black British	29 (7.0%)
Mixed / Multiple ethnic groups	27 (6.5%)
Asian / Asian British	62 (14.9%)
Arab	2 (.5%)
Other	6 (1.5%)
Prefer not to say	2 (.5%)

Note. N = 402

Participants were asked to disclose if they had a previous diagnosis of ADHD, dyslexia, autism, or any mental health disorder or were currently experiencing such an illness or if they were taking any psychotropic medication. The overall number of participants who had another mental health disorder was 90 (21.6%) and the number of participants who had previously been diagnosed with ADHD was 24 (5.8 %). The proportion of people who had dyslexia or an ASD diagnosis was smaller - 12 (2.9%) and 12 (2.9%), respectively. 33 (7.9 %) of participants answered Yes, they are taking psychotropic medication. (see Table 3.2.).

Table 3.2. *Disclose mental illness*

	ADHD	Autism	Dyslexia	Mental disorder	Medication
Yes	24 (5.8%)	12 (2.9 %)	12 (2.9 %)	90 (21.6%)	33 (7.9%)
Prefer not to say	1(.2%)	2 (.5%)	3 (.7%)	5 (1.2%)	4 (1.0%)
No	377 (90.6%)	388 (93.3%)	387 (93.0%)	307 (73.6%)	365 (87.7%)
Total	402 (100%)	402 (100%)	402 (100%)	402(100 %)	402 (100 %)

3.3.2 Materials

To measure distractibility, we used a modified Sustained Attention to Response Test (SART). The Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004) was used to measure six facets of emotion regulation, and the Adult ADHD Self-Report Scale (ASRS-v1.1) was used to measure ADHD-like traits. Participants were unaware of the research purpose, so we invited them to participate in a study about attentional difficulties and emotional control.

3.3.2.1 Adult ADHD Self-Report Scale (ASRS-v1.1; Kessler et al., 2004)

ASRS-v1.1 is a self-report, 18-questions scale developed by the World Health Organization. It covers the 18 DSM-IV-TR criteria and measures inattention and hyperactivity/ impulsivity symptoms. ASRS-v1.1 is designed to identify the symptoms of ADHD and score the frequency of symptoms (from 0 to 4) ("never," "rarely," "sometimes," "often," "very often"). Participants are likely to have ADHD if they score between 17-23. Scores of 24 and more indicate more severe ADHD-type characteristics in adulthood. Adults are likely not to have ADHD if they score 0-17.

The ASRS consists of two subscales, one measuring inattention (for example: ‘when you have a task that requires a lot of thought, how often do you avoid or delay getting started?’) and the other impulsivity/hyperactivity (for example: ‘how often do you feel overly active and compelled to do things, like you were driven by a motor?’). In this study, the internal consistency (Cronbach's alpha) of the total ASRS scale was 0.86, consistent with previous studies (e.g. .81, Panagiotidi et al., 2017). The

reliabilities for the two subscales, inattention and hyperactivity, were also high (Cronbach's alpha .81, .77, respectively).

3.3.2.2 Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004)

The DERS is a brief, 36-item self-report questionnaire designed to assess multiple aspects of emotional dysregulation: non-acceptance of emotional responses, difficulties engaging in goal-directed behaviour, impulse control difficulties, lack of emotional awareness, inadequate access to emotion regulation strategies and lack of emotional clarity. The DERS scale indicate how people are clear about their feelings, and when they are upset, do they feel out of control, have difficulty concentrating, or have difficulty controlling their behaviors.

Items are rated on a scale from one, almost never (0-10%), to-5, almost always (91-100%). Higher scores suggest more significant problems with emotion regulation. One of the features of DERS is that it has high internal consistency (=.93), with Cronbach's >.80 for each subscale, and it has good test-retest reliability ranges from 4 to 8 weeks ($p < 0.1$) as well as adequate construct and predictive validity (Gratz and Roemer, 2004). This study had high reliability (.89) and our previous study (Chapter 2) also supported the high internal consistency for the DERS; the reliability was high (.94).

3.3.3 Procedure

Participants were provided with with password-protected access the study. Before accessing the task and questionnaires, all participants were asked to maximise the browser window, switch off phone/e-mail/music and anything else distracting, read the information sheet for the study and to give their informed consent to participate.

To measure distractibility, participants undertook a modified version of the Sustained Attention to Response Test (SART), presented online via the Gorilla Experiment Builder. Participants were shown a series of letters, and they needed to press the space bar every time they saw an **X**.

On some trials, there was a distractor - a big black bar at either the top, bottom, left or right of the letter. The letter stimulus was black in the centre of the screen, and the distractor bars were approximately 2 times as wide (top/ bottom) and were twice as high (left/ right) in relation to the letter stimuli. Participants were presented with 16 letters (letters without distractor; A, D, F, H, N, R, T, W, U, and X) and (letters with distractor; A, D, R, W, Y, and X).

Letters were displayed for 0.1 seconds with a variable inter-stimulus interval ranging from 1.0 - 2.5-seconds. The task started with instructions, then a practice with 15 trials (target without distractors = 2 and non-target without distractors =13). The main task involved 303 trials divided into three blocks of 101 trials (target without distractors = 11, target with distractors = 4, non-target without distractors 81, and non-target with distractors= 5) with a break of 60 seconds after each block. Finally, the participants filled in a series of questionnaires, including a measure of emotion dysregulation and a measure of ADHD-like traits.

Completing the study took approximately 18 minutes. After completing the questionnaires, participants were debriefed about the purpose of the study. Data management and analysis were performed using the Statistical Package for the Social Sciences (SPSS).

3.4 Data Analysis

402 participants completed the study and in the analysis we divided the participants into groups based on their total ASRS scores: a “low” group who scored 29 and less in the overall ASRS score (N= 160) and a “high” group who scored 35 and more in the overall ADHD score (N= 143). The cut off for the high group was based on a study conducted by Panagiotidi et al., (2017) exploring ADHD-like traits in 800 healthy participants. They had the mean score 31.83, and a score of 35 (the cut-off in the current study) was at the 75th percentile. We also separately examined the group of individuals who had an ADHD diagnosis (N= 25), referred to below as the ‘clinical group’.

The effect of the distractor was investigated by looking ‘RT distractor cost', the difference in reaction times (RTs) on trials with distractors – reaction times on trials without distractors. To measure

accuracy, we examined two types of errors; errors of omission and errors of the commission, which we merged together to give an overall score for accuracy. The errors of omission were where the participant did not respond on X trials and errors of commission were where they did respond on non-X trials. Accuracy distractor cost was calculated by looking at the percentage of correct responses (the accuracy on trials with distractors - accuracy on trials without distractors), with positive values indicating a detrimental effect of the distractor.

Intra-individual variability (IIV), an index of efficient cue utilisation, was also calculated for each participant, by measuring the standard deviation of the reaction times. The effect of the distractor on IIV was calculated by measuring the difference in variability on trials with distractors and trials without distractors (IIV on trials with distractors—IIV on trials without distractors). Finally, the speed and accuracy measures were correlated with the overall ASRS and DERS scores. A p-value of 0.05 (two-tailed) was accepted as statistically significant.

3.5 Results

Questionnaires Characteristics

ASRS scale data for the full 402 participants met the assumption of normality (skewness, .28 (*SE* =.122), kurtosis, .47 (*SE* = .243), as did the DERS scale data (skewness, .23 (*SE* = .12), kurtosis, -.60 (*SE* = .24)).

Participants were recruited using the recruitment website Prolific Academic and consisted of any gender over the age of 18. An a priori sample size calculation was undertaken using G*power 3.1.9.4 (Faul et al., 2007) and Cohen's (1992) table. Prior research suggested that a medium effect size was to be expected for the planned correlations. Therefore, the power analysis suggested that with a medium effect size (0.3), for an alpha of 0.05 and a power of 0.8, a group size of 80 will be required to achieve a robust statistical outcome. In this study, a sample consisted of 402 participants. Therefore, the study was adequately powered.

Age

The Kruskal-Wallis H test was used to examine whether questionnaires scores differed based on age. Fewer symptoms were reported in the older age group, but the difference was not statistically significant for ASRS score χ^2 (4) = 14.468, p = .062. However, there was an association between age and the overall DERS scores (χ^2 (4) = 9.69, p = .046). The youngest and oldest age groups had higher scores than those aged 25-44 (Table 3.3).

Table 3.3. *Characteristics of Age Group M (SD)*

Age group	ASRS Score	DERS score	Frequency
18-24	33.67 (10.67)	98.22 (23.18)	273
25-34	30.90 (10.40)	91.42 (24.77)	106
35-44	28.84 (10.25)	87.59 (27.27)	19
45-over	29.67(11.93)	110.33 (47.48)	4

M = mean, SD = standard deviation

Gender

A Mann-Whitney U test was run to determine if there were differences in the total ASRS and DERS scores between the males and females. The ASRS scores for females (Mdn =33.00) were statistically significantly higher than for males (Mdn = 31.00), U = 21580.500, z = 2.57, p < .039. The DERS scores for females (Mdn =95.00) were statistically significantly higher than for males (Mdn = 93.00), U = 21535.500, z = 2.02, p < .043. The median for total gender (N= 402) in the ASRS was Mdn = 32.00, whereas for DERS it was Mdn = 95.00. (Table 3.4).

Table 3.4. *Gender Differences in different scales* M (SD)

Variable	Overall scales	Mdn
Males		N=175
	ASRS	31.00
	DERS	93.00
Females		N= 220
	ASRS	33.00
	DERS	95.00

Total gender		N=402
	ASRS	32.00
	DERS	95.00

ASRS Scores

The mean overall ASRS score for 402 participants was 32.67 (*SD*= 10.64), whilst mean score for the inattention subscale was 17.58 (*SD*= 6.02) and the hyperactivity subscale 15.09 (*SD*= 5.89). These values are very similar to those in Experiment 1 (mean overall ASRS score was 32.23, *SD*= 10.24, inattention subscale was 17.43, *SD*= 5.74, and the hyperactivity subscale 14.80, *SD*= 5.58).

DERS

The mean overall score on the DERS was 96.00 (*SD*= 24.16), again similar to Experiment 1 91.86 (*SD*= 24.37). The mean scores for each of the six DERS subscales are presented in Table 3.5.

Table 3.5. *The mean and SD scores in the six DERS Subscales*

DERS Subscale	Clarity	Impules	Aware	Nonaccept	Goals	Strategies
Mean (SD)	12.56 (4.20)	14.20 (5.40)	15.15 (4.33)	16.35 (6.25)	16.65 (4.63)	21.09 (7.80)

The Relationship Between ASRS and DERS Scores

The overall ASRS score was correlated with both the inattention subscale (r (402) = .895, p<.000) and the hyperactivity subscale (r (402) = .89, p<.000), and the two ASRS subscales were strongly correlated, r (402) =.60, p<.000. As in Experiment 1, the DERS was strongly correlated with the overall ASRS score (r (402) = .56, p<.000). The DERS was also significantly associated with the inattention (r (402) =.53, p<.01) and the hyperactivity (r (402) = .47, p<.01) subscales of the ASRS. A strong correlation was found between the ASRS and all the DERS subscales (at the p<.000 level).

Reaction Time and Accuracy Data – Distributional Properties

The reaction time data for the SART was not normally distributed (reaction times on trials without distractors (skewness, 5.17 (*SE* = .122), kurtosis, 37.57 (*SE* = .24); reaction times on trials with distractors (skewness, 6.03 (*SE* = .122), kurtosis, 56.75 (*SE* = .24)). RT distractor cost (skewness, .869 (*SE* = .122), kurtosis, 10.26 (*SE* = .243)). In addition, the total the accuracy (skewness, 2.36 (*SE* = .122), kurtosis, 7.42 (*SE* = .243)) and accuracy distractor cost data was not normally distributed (skewness, -2.88 (*SE* = .122), kurtosis, 12.99 (*SE* = .243)). Therefore, we decided to use nonparametric tests to analyse performance, and initially examined overall performance on the task.

SART Performance - overall

Reaction times: A Wilcoxon signed-rank test was conducted to determine if there were differences in the reaction times on trials without distractors and reaction times on trials with distractors as well as accuracy in 377 participants without participants who had previously been diagnosed with ADHD. Reaction times on trials without distractors were longer (*Mdn* = 467.29) than reaction times on trials with distractors (*Mdn* = 450.12). This difference was statistically significant, $z = -9.65$, $p < .000$, such that reaction times on trials with distractors were faster than on those without distractors. It did not appear to be the case that participants were using the distractors as proxys for X trials, simply pressing the bar when they saw the distractor, because commission errors on non-target distractor trials were lower (*Mdn* = .000) than on non-target trials without distractors (*Mdn* = .823; $z = -6.51$, $p < .000$).

Accuracy: There was a statistically significant difference between trials without distractors and trials with distractors (*Mdn* = .040; *Mdn* = .010, respectively) in terms of accuracy; $z = -15.76$, $p < .000$; participants were more accurate on distractor trials. In summary, participants were faster and more accurate on distractor trials.

There was a strong positive correlation between the overall ASRS scores, and also the hyperactivity subscale of the ASRS, with intra-individual variability (IIV), on trials with and without

distractors (see Table 3.4.). As overall ASRS scores and hyperactivity subscale scores increased, the IIV on trials with and without distractor also increased.

For the DERS subscales (see Table 3.6), the impulse control difficulties subscale had a positive correlation with reaction time on trials with and without distractors, and with IIV on trials with and without distractors, and with total accuracy (errors of omission and commission merged) and omission errors on trials with distractors. Therefore, as the scores on impulse control difficulties increased, the reaction times with and without distractors became longer and accuracy was reduced, leading to higher IIV. The lack of emotional awareness subscale of the DERS was negatively correlated with commission errors on trials without distractors. As the awareness score increased, the commission errors on trials without distractors were reduced.

Table 3.6. *Correlations (Spearman's rho) between ASRS scores and other variable*

	RT with distractors	RT without distractors	RT distractor cost	IIV with distractors	IIV without distractors	Accuracy	Accuracy distractor cost
ASRS	.055	.057	-.010	.124**	.136**	.072	.051
inattention	.009	-.012	.015	.071	.046	.045	.069
Hyperactivity	.089	.100	-.009	.156**	.174**	.085	.024
DERS	.094	.075	-.004	.036	.074	.007	.035
No acceptance	.075	.045	.038	.025	.020	-.032	.083
Clarity	.086	.067	.010	.052	.061	-.013	-.002
Aware	-.007	-.008	-.022	-.064	-.015	-.085	-.079
Impulsiveness	.151**	.145**	-.050	.104**	.196**	.102*	.008
Goal	.005	-.007	.017	-.001	-.044	-.016	.100
Strategies	.093	.084	-.025	.041	.081	.045	.010

Correlation is significant at the 0.01 level (2-tailed). **

(N=377) RT, reaction time; IIV, intra-individual variability: ASRS, Adult ADHD Rating Scale

SART Performance – Effect of ADHD-like Traits

Reaction times: A Kruskal-Wallis H test was conducted to determine if there were differences between groups of participants with different ADHD levels: the "low" (n = 160) and "high" (n = 143) ASRS groups. Reaction times on trials with distractors were shorter for the low group (Mdn = 450.89) than for the high group (Mdn = 461.02), although this difference did not reach statistical significance

($\chi^2(1) = 1.51$, $p = .218$). Likewise, reaction times on trials without distractors were shorter for the low (*Mdn* = 466.86), than the high (*Mdn* = 476.13) ADHD groups, but again not significantly so ($\chi^2(1) = 2.49$, $p = .114$). Given than the high group were slower than the low group for X trials with and without a distractor, it is not surprising that the reaction time distractors costs were very similar for both groups low (*Mdn* = -18.21) to high (*Mdn* = -18.29; $\chi^2(1) = .683$, $p = .409$).

The Intra-individual variability (IIV) on trials with and without distractors was lower for the low group (*Mdn* = 62.61 and *Mdn* = 76.26 respectively) than for the high group (*Mdn* = 72.46 and *Mdn* =82.59 respectively). The high ADHD group were more variable in their reaction times on both trials with and without distractors than the low ADHD group. The differences between both groups were statistically significant on IIV on trials without distractors $\chi^2(1) = 8.35$, $p = .004$; and on trials with distractors $\chi^2(1) = 4.86$, $p = .043$.

Accuracy: In terms of accuracy, the differences between the groups were not statistically significant in terms of overall accuracy (two types of errors; errors of omission and errors of the commission combined) for low and high groups *Mdn* =.05; $\chi^2(1) = .07$, $p = .796$. There was no statistically significant difference in accuracy on trials when the target was presented with and without distractors between the different groups (accuracy on trials when the target was presented with distractors, *Mdn* = .01 for the low and high groups; $\chi^2(1) = .15$, $p = .695$; accuracy on trials when the target was presented without distractors, *Mdn* = .04 for the low and high groups; $\chi^2(1) = .48$, $p = .488$).

However, there was a difference in accuracy within the groups on distractor vs non-distractor trials in the high ADHD group (with distractor *Mdn* = .010 and without distractor *Mdn* =.040; $z = -9.78$, $p = .000$) and the low group (with distractor *Mdn* = .010 and without distractor *Mdn* =.040; $z = -10.41$, $p = .000$). Overall, participants were more accurate on distractor trials. There were no statistically significant differences in the accuracy distractor cost between the different ADHD groups

(*Mdn* = -.010 for the low and high groups; $\chi^2(1) = 1.28$, $p = .257$), suggesting that the distractor has a similar effect on accuracy in the both ADHD groups.

The Relationship Between ASRS Groups, SART and the DERS - Low ADHD group (N=160)

The overall DERS scale (see Table 3.7.) correlated with reaction times on trials with distractors, and also with total omission errors on trials with and without distractors, and with omission errors on trials with distractors. For the DERS subscales, the non-acceptance of emotional responses subscale was correlated with total omission errors on trials with and without distractors and with omission errors on trials without distractors, and with omission errors on trials with distractors. The lack of emotional clarity subscale was correlated with total omission errors on trials with and without distractors and with omission errors on trials with distractors and negatively with total accuracy. The lack of emotional awareness correlated with omission errors on trials with distractors and negatively with total accuracy. The impulse control difficulties subscale was correlated with the intra-individual variability (IIV) on trials without distractors with and reaction times on trials with and without distractors. Finally, the limited access to emotion regulation strategies subscale correlated with reaction times on trials with and without distractors.

Table 3.7. *the relationship between low ADHD group and DERS (DERS subscales) scores and the task*

	RT with distractors	RT without distractors	RT distractor cost	IIV with distractors	IIV without distractors	Accuracy	Accuracy distractor cost
ASRS	-.007	-.045	.104	.091	-.059	-.014	.102
Inattention	-.108	-.100	-.022	-.056	-.137	-.009	.069
Hyperactivity	.078	-.005	.172*	.185*	.013	-.029	.088
DERS	.171*	.127	-.038	.007	.003	-.148	.087
No acceptance	.060	.032	-.045	-.042	-.055	-.212**	.104
Clarity	.133	.120	-.066	.002	-.007	-.194*	.094
Aware	.089	.019	.020	.001	-.053	-.181*	-.011
Impulsiveness	.190*	.176*	-.064	.092	.170*	.028	.030
Goal	.040	.007	.014	-.017	-.125	-.080	.095
Strategies	.196*	.165*	-.029	.006	.037	-.037	.040

Correlation is significant at the 0.01 level (2-tailed) **

Correlation is significant at the 0.05 level (2-tailed) *
RT, reaction time; IIV, intra-individual variability: ASRS, Adult ADHD Rating Scale

The Relationship Between ASRS Groups, SART and the DERS - High ADHD group (N=143)

The overall DERS scores (see Table 3.8.) correlated with omission errors on trials with and without distractors, omission errors on trials with distractors, and total accuracy. The non-acceptance of emotional responses subscale correlated with omission errors on trials with distractors. The lack of emotional clarity subscale correlated with omission errors on trials with and without distractors. The impulse control difficulties subscale correlated with omission errors on trials with and without distractors, omission errors on trials without distractors, omission errors on trials with distractors, and with IIV on trials without distractors, and negatively with total accuracy. Finally, the limited access to emotion regulation strategies subscale correlated with omission errors on trials with and without distractors, omission errors on trials with distractors and total accuracy.

Table 3.8. *The relationship between high ADHD group and DERS (DERS subscales) scores*

	RT with distractors	RT without distractors	RT distractor cost	IIV with distractors	IIV without distractors	Accuracy	Accuracy distractor cost
ASRS	.042	-.061	.100	.065	.024	.175*	-.049
inattention	-.092	-.170*	.069	.015	-.122	.073	.067
Hyperactivity	.133	.098	.024	.079	.176*	.178*	-.071
DERS	-.025	-.030	.019	.043	.054	.198*	.021
No acceptance	.007	-.022	.078	.048	.032	.162	.075
Clarity	.012	.000	.066	.036	.013	.129	-.110
Aware	-.050	.007	-.058	-.100	-.018	-.031	-.052
Impulsiveness	.099	.092	-.012	.098	.202*	.229**	-.043
Goal	-.025	-.056	.061	-.009	-.095	.048	-.105
Strategies	-.087	-.091	-.009	.084	.064	.202*	.026

Correlation is significant at the 0.01 level (2-tailed) **
Correlation is significant at the 0.05 level (2-tailed) *
RT, reaction time; IIV, intra-individual variability: ASRS, Adult ADHD Rating Scale

The Clinical Group

As in the non-clinical groups, in the clinical group, reaction times on trials with distractors (*Mdn* = 464.79) were significantly shorter than reaction times on trials without distractors (*Mdn* = 487.10; $z = -2.43$, $p < .015$). There was significant difference in accuracy on trials with and without

distractors (*Mdn* = .014, *Mdn* =.054, respectively*; z* = -4.03, *p* < .00), again with performance being more accurate on distractor trials. Kruskal-Wallis test was used to compare the clinical group with the other two groups (high & low ADHD). There was a statistically significant difference between the groups on IIV on trials with distractors (χ^2 (2) =11.529, *p* = .003), with the clinical group exhibiting greater variability than either of the other two groups (the median for the low ADHD group was 62.61, for the high group 72.46 and for the clinical group 91.02). In addition, there was a difference in IIV on trials without distractors (χ^2 (2) =8.928, *p* = .012), although this time the high ADHD group had the greatest variability (the median for low ADHD, high ADHD and clinical groups were 76.26, 82.59 and 78.43, respectively). There was no difference between the clinical group and the other two groups (low and high) on RT distractor cost (χ^2(2) =.810, *p* = .667; the median for the low, high, and clinical ADHD group was -18.21, 18.29 and 21.85; respectively); also, on the accuracy distractor cost (χ^2(2) =1.41, *p* = .493; the median for the low and high clinical groups -.01, -.01 and -.02).

In the clinical group (see Table 3.9.), reaction time on trials with distractors correlated with the overall DERS, and with the DERS subscales of impulse control difficulties, limited access to emotion regulation strategies, and clarity. There was also a correlation between reaction times on trials without distractors and the impulse control difficulties subscale. Accuracy was negatively correlated with aware subscale of the DERS.

Table 3.9. *The relationship between clinical, high & low ADHD groups and DERS with the task*

	RT with distractors	RT without distractors	RT distractor cost	IIV with distractors	IIV without distractors	Accuracy	Accuracy distractor cost
ASRS	.082	.063	.015	.158**	.115*	.050	.053
inattention	.013	.004	-.008	.103	.044	.038	.049
Hyperactivity	.132*	.108	.032	.188**	.169**	.044	.052
DERS	.130*	.100	-.003	.054	.122*	.006	.081
No acceptance	.069	.044	.016	.032	.059	-.030	.112*
Clarity	.120*	.104	.000	.064	.081	-.035	.025
Aware	.041	.032	-.013	-.055	-.033	-.134	-.003
Impulsiveness	.186**	.170**	-.039	.116**	.254**	.091	.033
Goal	.040	.014	.032	.025	-.021	-.002	.100
Strategies	.118**	.084	-.004	.052	.137*	.064	.053

Correlation is significant at the 0.01 level (2-tailed) **

Correlation is significant at the 0.05 level (2-tailed) *
RT, reaction time; IIV, intra-individual variability: ASRS, Adult ADHD Rating Scale

3.6 Discussion

This study aimed to see whether distractibility - a key aspect of inattention - is related to emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits. Overall, we had 402 participants, so the requisite sample size was satisfied, allowing us to draw appropriate conclusions about the relationship between ADHD and SART performance. In addition, the clinical group consisted of 25 participants, so we were able to evaluate it statistically.

It was hypothesised, based on the neural systems involved, the reaction times on target trials for participants with high levels of ADHD will be slower on distractor trials than on trials without distractors, and this will correlate with the scores of emotion dysregulation. In fact, the reaction times on trials with distractors were faster than those without distractors for participants, and there was no significant difference between those with high and low levels of ADHD-like traits (the high and low ADHD groups). A difference was found between trials with and without distractors in terms of accuracy; accuracy was higher on trials with distractors; however, there was no significant difference between the ADHD groups in terms of accuracy.

As a consequence of reaction times being faster for both those with high and low levels of ADHD-like traits, the RT distractor costs were very similar for both groups. Additionally, there was no statistically significant difference in the accuracy distractor cost score between the different ADHD groups. However, the high ADHD group showed increased intra-individual variability (IIV) both on trials with and without distractors than the low ADHD group. This result supports the contention that IIV is a feature of ADHD, in line with previous studies (Rosenberg, Noonan, DeGutis, *et al.,* 2013; Vaurio, Simmonds, & Mostofsky, 2009; Lin, Hwang-Gu, & Gau, 2015). Adams, Roberts, Milich, & Fillmore, (2011) support the use of RT variability as a valid measure of inattention in ADHD and the find show a relationship between RT variability and distractibility among adults with ADHD. The results for the clinical group support the idea that ADHD leads to high IIV in reaction time. IIV on

trials with a distractor was a statistically significantly greater in the clinical group than in the other groups.

As in Experiment 1, overall ASRS and DERS scores were significantly related. Also, the DERS was strongly correlated with the ASRS inattention and the hyperactivity subscales. Even though the there was no reaction time impairment, or accuracy impairment as a result of the distractor, for the participants as a whole, and no differential negative effects relating to the high and low ADHD groups, we still looked at the relationship between performance in the SART and DERS scores in the two ADHD groups. The total DERS scores were related to reaction times on trials with and without distractor in the three ADHD groups. In the high and low ADHD group, the DERS correlated with the total accuracy and omission errors on trials with and without distractors. Likewise, the DERS subscales; non-acceptance, clarity, impulsiveness, strategies and awareness correlated with the total accuracy across different ADHD groups. The coeerlation between the total DERS scores and the performance measures was greater in the clinical group than the high group and than the low ASRS group.

One major problem with the study was that the distractors 'distractors' did not really distract – instead, they assisted task performance (leading to shorter RTs), i.e. participants benefitted from the extra-task distraction. This benefit did not seem to result from an increase in guessing – guessing that all distractor trials were target trials because commission errors on non-target distractor trials were lower than on non-target trials without the distractor. The present findings are consistent studies that suggest distraction does not necessarily have a negative impact on performance (Pinnow, Hubbard, Meulenbroek, 2021; Hong, Kim, Kwon, Eom, Kim 2021); the arousal level can lead to a reduced omission rate (van Mourik, Oosterlaan, Heslenfeld, Konig, Sergeant, 2007). For participants, the distractor may have had an arousing effect hence the task was facilitated, lowering their level of distractibility. Research by Panagiotidi, Overton, & Stafford (2017) shows that novel distractors can facilitate reaction times.

So the optimal stimulation theory explains the result of the study on why high ADHD groups benefit from extra-task distractions by increasing their arousal levels closer to an optimal level. People are frequently motivated to pursue acts that will get them closer to optimal levels of arousal. Therefore, added stimulation could increase arousal and subsequently motivation.

According to load theory, the ability to maintain concentration while ignoring distractions is influenced by whether the task involves perceptual load. Perceptual load means "the amount of information involved in processing the task stimuli" (Macdonald and Lavie, 2011). Swallow and Jiang (2013) showed that perceptual processing could be improved by attending to a target with concurrently presented information. The distractor stimuli in the study had a low perceptual load. The increased perceptual load could improve attentional focus and reduce distractor interference. Hence, load theory could be another possible explanation for this result.

3.7 Limitations and suggestions for future research

Firstly, the self-report questionnaires have some limitations, as subjectivity, bias with limited context because that we had added an objective measure to ensure a more accurate. Also, our experiment was conducted online, and although the instructions we gave constrained performance conditions as far as possible (participants were asked to maximise their browser window and switch off phone/e-mail/music and anything else distracting), however it is difficult to control all the external distractions for the participant's environment. It was not possible to investigate the significant relationships of the distractibility in the laboratory because of the Covid -19 restrictions.

In future investigations, it might be possible to repeat the study in the laboratory, with eye movement measures to look at the fixation, blink, and saccade frequency and study the effect of distractors on high and low ADHD traits to ensure that the participants maintained focus during the task. In addition, we only used visual distractors, so in the future, researchers could add different types of distractors (visual distractors, auditory distractors, and a combination of them) for better differentiation between ADHD and health groups (Cassuto et al., 2013). It has been shown that

participants with ADHD-like traits have particular difficulty with multi-modal stimuli (Panagiotidi et al, 2017). Finally, problems like dyslexia can present challenges related to letters and reading. Given that we used letters as stimuli, in the future it might be useful to take account of reading difficulties.

Despite these limitations, several strengths enhance the validity and reliability of the study's findings the high internal consistency was observed for both the ASRS, DERS, and the subscales. Use of both subscales of the ASRS, measuring inattention and hyperactivity, is one of the strengths of the study in that it allows us to identify participants as having differing ADHD-related symptom patterns and hence the possibility of correlating these with SART performance. Furthermore, the significant association between the ASRS and DERS, as in study 1, continues to imply that these two variables are related.

Although our adapted SART test allowed us the present stimuli and distractors for the participants, the distractors did not really distract. One limitation is that we did not gather feedback from the participants about the distractors, whether they noticed them, found them distracting, found them helpful in some way. Nonetheless, the result was contrary to our hypothesis. It would be useful to replicate the finding that the 'distractors' improved performance in a clinical population in future studies. If the distractors help performance it might suggest that some version of distraction could be added to effective teaching methods and practices to help pupils learn.

3.8 Conclusion

Distractibility is a core symptom of ADHD; it often refers to inability or difficulty sustaining attention. This study explored whether distractibility is related to emotion dysregulation among adults in a non-clinical population with varying levels of ADHD-like traits using a modified SART. However, distractors in the SART had a beneficial effect on cognitive task performance, although RT IIV was greater in participants with higher levels of ADHD-like traits. The DERS subscales also correlated with IIV without distractors. Given the issues with the SART and distractibility

(inattention), following on from this study, we decided to look at the next ADHD symptom set, hyperactivity/impulsivity and its relationship with emotion dysregulation.

Chapter 4. Impulsiveness & Emotion dysregulation

4.1 Chapter Summary

Attention Deficit Hyperactivity Disorder (ADHD) is a chronic disorder. The classical clinical symptoms of ADHD are usually considered to be hyperactivity, impulsiveness, and inattentiveness (Taylor, 1998). However, emotion dysregulation is present in many ADHD adults and causes a serious problems (Moukhtarian, Mintah, Moran, 2018; Christiansen, Hirsch, Albrecht, 2019). Emotion dysregulation is defined as a disruption of an individual's ability to modify an emotional state to promote adaptive, goal-oriented behaviours - as a central component of the suite of ADHD symptoms (Shaw et at., 2014).

This chapter aimed to explore whether impulsiveness is related to emotion dysregulation (ED) and whether both are related to more general issues concerning the control of impulsive behaviour in a non-clinical population with varying levels of ADHD-like traits. 399 participants undertook two neuropsychological tasks, the Iowa gambling task IGT and the Go/No-go task next, filling several scales in an online questionnaire, measuring classic ADHD symptoms and emotion dysregulation.

For the Iowa Gambling Task, both the High and Low ASRS groups chose low risk strategies, and there were no differences between the two groups. There was no statistically significant difference between groups in terms of inhibitory control. For the Go-No/Go task, The difference in commission and omission error rates between the High and Low ASRS groups suggests that participants in the High ASRS group had poorer reaction inhibition (faster reaction times) and lower accuracy, indicating that the High group was sacrificing accuracy for speed. The DERS subscales (clarity, goal, and strategy) were associated with Go reaction times in the Low ASRS group but not in the High ASRS group. Overall, the findings suggest that emotion dysregulation is unrelated to the classic symptom of impulsivity, at least when measured with a cognitive task rather than a self-report scale.

4.2 Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision - DSM-5-TR™, inattention and hyperactivity and/or impulsivity are three clusters of attention-deficit/hyperactivity disorder (ADHD) symptoms (American Psychiatric Association, 2022; World Health Organization; 2021). ADHD symptoms typically occur before 12 years old, but can also be noticed in adulthood, with later-onset symptoms involving neuropsychological deficits that interfere with daily functioning and impact quality of life (Ptacek et al., 2019; Sjöwall & Thorell, 2022). An international consensus statement from the World Federation of ADHD points out that worldwide, 5.9% of young people and 2.8% of adults have the disorder, which usually begins in childhood or early adolescence (Faraone et al., 2021), but can occur de novo in adulthood (Asherson, & Agnew-Blais, 2019).

People with the hyperactive-impulsive prsentation tend to be “on the go”, feel restless or fidgety, squirm when they sit down for a long time, and continuously interrupt others when they are talking (Kessler et al., 2005). Their personality traits are classified as urgent, lacking persistence, seeking sensation, and having an inability to act or plan in advance. Adults diagnosed with ADHD tend to engage in risky behaviors, with a lack of premeditation and perseverance (Pollak et al., 2019), and develop comorbid conditions such as anxiety disorder (D’Agati et al., 2019); as a result, they may experience stigmatizing attitudes toward ADHD (Lebowitz, 2016).

Barkley (2022) argues that the core symptoms of ADHD described in DSM-5-TR™ are not adequate for accurate diagnosis since there are also impairments related to deficient emotional self-regulation that should be considered. Understanding ADHD in adults, in particular how emotion dysregulation relates to impulsive behaviour, may help manage the symptoms more effectively.

Core symptom: Impulsivity

People differ in terms of the extent to which they have difficulty controlling impulsive behaviour in clinical and non-clinical populations. At the more extreme end, this may lead to a diagnosis of ADHD, whether as a combined presentation or a predominantly hyperactive-impulsive presentation. Impulsivity has been defined as a reaction to various stimuli without thinking about the consequences (Archer & Bright, 2012) and the tendency to act with little deliberation (Dickman, 1990). Research refers to impulsivity as a complex construct reflecting a disposition for behaviours that affect goal-directed outcomes.

Dysfunctional impulsivity is a diagnostic criterion for several disorders (Mirabella, 2021); it affects adults' lives and leads to various psychological comorbidities, such as conduct disorder, antisocial personality disorder, anxiety, and depression. Impaired behavioural control, which can lead to a reduced capacity to engage in socially appropriate behaviours, may be caused by neurocognitive deficiencies (Kertzman, Grinspan, Birger, and Kotler, 2006). Impulsivity can improve with age, and medication, combined with learning certain techniques, may reduce vulnerability to impulsive behaviour. Research shows that ADHD medication influences cognitive task performance – in particular, methylphenidate helps with inhibitory control (Wright et al., 2014).

In adults, Barratt (1994) proposes three overlapping subcomponents of impulsiveness: motor/behavioural impulsiveness (acting without thinking), cognitive/attentional impulsiveness (quick decisions), and non-planning impulsiveness (present orientation without thought of future outcome). Motor impulsivity occurs when the individual acts in a way that is motivated by the moment, thus giving rise to an inappropriate response (Archer & Bright, 2012). The term "attentional impulsiveness" refers to the inability to focus on a task and rushing thoughts, whereas non-planning impulsivity is described as acting without thinking and avoiding complex cognition (Carver & Johnson, 2018).

Response inhibition

Inhibitory processes are phasic response mechanisms triggered by an external stimulus to which one must not respond (Criaud & Boulinguez, 2013). In the early stages of life, people develop

executive functions that are shaped by experiences, learning, and genes. The prefrontal cortex (PFC) hosts the executive functions, such as response inhibition, working memory, planning, time processing, set-shifting, and selective and divided attention (Diamond, 2013). Impaired executive function results from a delay in the maturation of the PFC. Reynolds et al. (2019) suggest that impaired executive function increases the chance of young individuals engaging in risky and perhaps dangerous behaviour. Barkley (1997) proposed that the core symptoms of ADHD are associated with impairments in neurocognitive functions, as impaired response inhibition constitutes "behavioural inhibition". The Barkley model articulates four executive neuropsychological functions correlated with ADHD: working memory, self-regulation of affect–motivation–arousal, internalization of speech, and reconstitution (Barkley, 1997). Response inhibition represents behavioural control and the adaptation of responses to the surrounding environment when self-regulation and goal-directed action are required.

The connection between emotion and impulsivity

The UPPS-P impulsive behaviour model presents impulsive personality traits that include sensation-seeking, emotion-based rash action (positive and negative urgency), and deficits in conscientiousness (lack of premeditation and perseverance) (Cyders, Littlefield, Coffey, & Karyadi, 2014). Hence, in this model, impulsive behaviour can be triggered by both positive and negative urgency. Positive urgency occurs when one experiences extremely positive emotions, while negative urgency occurs when experiencing extremely negative ones. Deficits in conscientiousness include lack of premeditation (acting without thinking) and perseverance (failure to continue focusing on a task); ADHD is associated with both deficits (Lopez, Dauvilliers, Jaussent, Billieux, & Bayard, 2015; Nigg, Sibley, Thapar & Karalunas, 2020).

Researchers have found that sensation-seeking behaviours, including novelty-seeking, is a personality trait in adults with ADHD (Donfrancesco et al., 2015; Kerekes et al., 2013), sometimes affecting long-term goals. Adults with elevated levels of novelty-seeking behaviours tend to engage in new experiences in their environment without thinking about the negative consequences. Also,

novelty-seeking is associated with low self-directedness in ADHD-impulsivity (Gomez, van Doorn, Watson, Gomez, & Stavropoulos, 2017), affecting goal-directed behaviours due to a lack of impulse control.

Core symptom: Emotion dysregulation

A pattern or expression of emotion that interferes with achieving goals can be described as emotion dysregulation (Thompson, 2019). Maladaptive behavioural strategies, such as poor ability to manage emotional responses or keep them within an acceptable range, are positively correlated with psychopathology. Emotional dysregulation has been identified as deficient emotional self-regulation (often measured using the Difficulty in Emotion Regulation Scale; DERS), which is inextricably linked with ADHD (Russell, 2022).

ADHD was linked to emotional dysregulation until 1968 and was then excluded from the DSM-II diagnostic criteria. Nowadays, research shows that emotion dysregulation is a core component of ADHD and should not be excluded from the DSM-5-TR diagnostic criteria since such problems are prevalent in ADHD children and adults (Hirsch, Chavanon, Riechmann, & Christiansen, 2018). People with ADHD have independent symptoms of emotion dysregulation that affect their attainment of long-term goals because of their maladaptive emotional responses, emotional "impulsiveness" (anger, aggression, fast reaction urgency), being extraordinarily emotional, and being overwhelmed (Koole, 2011). In study 1 of this thesis, emotion dysregulation and ADHD-like traits were shown to be linked using self-report questionnaires.

This connection between emotional dysregulation and impulsivity in captured in the DERS, where impulse control difficulties comprise one of the sub-scales of the DERS - higher scores suggesting more significant problems with emotion regulation. This measures the ability to control urges and follow goals, with poor scores indicating that participants are experiencing negative affect, feeling overwhelmed and out of control when they are upset (Gratz & Roemer, 2004). So, when facing negative emotions, the ability to inhibit impulsive impulses and behave according to intended aims is

weakened. When impulsivity increases, the level of attention decreases, leading to more significant problems with emotion regulation. Groves, Kofler, Wells, Day, & Chan (2020) argue that the presence of hyperactive/impulsive symptoms also predicts emotion dysregulation when the influence of working memory is controlled.

Research on children suggests that impulsivity factors and regulating emotions can go hand in hand (van Stralen, 2016). In general, difficulties in controlling impulsive behaviours can be accompanied by difficulties in regulating emotions. Prioritizing emotion dysregulation when diagnosing ADHD could target the deficits in the ADHD population. However, the exact relationship between the two is unknown. In spite of the studies connecting emotional dysregulation and impulsivity, in study 1 of this thesis, impulsivity was found to predict emotion dysregulation scores, but only until scores on the AQ were added. So understanding the interrelationship between impulsive behaviours and emotional processing could contribute to the knowledge base and pave the way for achieving effective interventions when impulsive behaviours and/or emotional processing become problematic. If there is a connection, it may provide clues to the underlying neural dysfunction in ADHD. Researchers should investigate the various dimensions of emotion dysregulation to understand the neurobiology of ADHD and its symptoms fully. Considering different dimensions would be sufficient for successfully diagnosing and treating ADHD.

Measuring impulsivity

Behavioural assessments measuring impulsive behaviours can be divided into cognitive and motor impulsivity instruments (Esteves, Moreira, Sousa, & Leite-Almeida, 2021). In studies of emotional decision-making under conditions of complexity and uncertainty, ADHD patients consistently perform worse on the Iowa Gambling Task, a classical test of cognitive impulsivity, than healthy participants due to sensitivity to reward and/or punishment. A meta-analytic review highlighted significant impulsive decision-making in ADHD populations compared to non-ADHD populations (Patros et al., 2016). On the other hand, to measure motor impulsivity, researchers developed the go-no/go Task (GNGT) and the stop-signal Task (SST). In the Go/No-Go task, the

inhibitory impairments result in high numbers of commission and omission errors and shorter reaction times (Wright et al., 2014). The number of errors a subject makes on no-go trials (i.e., false alarms) is typically used as a behavioural indicator of inhibitory control (Criaud & Boulinguez, 2013). Subjects with ADHD make significantly more errors (higher commission error rate) compared to typically developing children, even when the requirements of the tasks are minimal (Wodka et al., 2007).

4.2.1 Current Study

This study aimed to see whether impulsiveness is related to emotion dysregulation and whether both of those are related to more general issues in a non-clinical population with varying levels of ADHD-like traits. Participants undertook two neuropsychological tasks: the Iowa gambling task, measuring cognitive impulsivity, and the Go/No-go task, measuring motor impulsivity, as well completing several scales in the form of an online questionnaire, measuring classical ADHD symptoms and emotion dysregulation. This study hypothesises that people with high levels of impulsivity (motor and cognitive) compared to participants will exhibit high levels of emotion dysregulation. Previous work has almost exclusively focused on children and emotionality has been assessed by observing behavioural expression. This study aims to change the emphasis to adults.

4.3 Methods

4.3.1 Participants

399 English-speaking participants (234 female, 162 males, and 3 others) undertook the Iowa gambling task and the Go/No-go task presented online. Participants were recruited using Prolific Academic, an online recruitment platform. The demographic characteristics of the participants are presented in Table 4.1. Participants were over 18 (M = 33.62, SD= 14.41) and 87.5% of the sample were White.

Data from 11 participants were not included in the analysis; 5 participants were due to poor data quality, and 6 participants had been diagnosed with ADHD. The Department of Psychology's Research Ethics Committee approved the procedures of this study.

Table 4.1. *Demographics of participants*

Characteristic	
Age, N (%)	*M*= 33.62, *SD*= 14.41
18-24	100 (25.1%)
25-34	95 (23.8%)
35-44	84 (21.1%)
45-54	55 (13.8%)
55-64	45(11.3%)
65-74	15 (3.8)
75+	5 (1.3)
Gender, N (%)	
Male	162 (40.6%)
Female	234 (58.6%)
Other	3 (.8%)
ASRS level, N	
Low level	226
High level	105
Moderate level	68
Diagnosed with ADHD	6
Ethnicity, N (%)	
White	349 (87.5%)
Black / African / Caribbean / Black British	11 (2.8%)
Mixed / Multiple ethnic groups	16 (4.0%)
Asian / Asian British	19 (4.8%)
Arab	1 (.3%)
Other	3 (.8%)

Note. N = 399

In addition to the 6 participants who had been diagnosed with ADHD, 64 participants were previously diagnosed with other major mental illnesses, and 21 participants had been diagnosed with ASD or dyslexia. Disclosure of mental illness reported in detail on Table 4.2.

Table 4.2. *Disclosure of mental illness*

	ASD	Dyslexia	Mental disorder	Medication

Yes	5 (1.3%)	11 (2.8%)	59 (14.8%)	20 (5.0%)
Prefer not to say	4 (1.0%)	1 (.3%)	5 (1.3%)	1 (.3%)
No	390 (97.7%)	387 (97.0%)	335 (84.0%)	378 (94.7%)
Total	399 (100 %)	399 (100 %)	399 (100 %)	399 (100 %)

4.3.2 Materials

To measure impulsiveness, participants undertook the Iowa gambling task and the Go-No/go task. The Adult ADHD Self-Report Scale (ASRS-v1.1) was used to measure ADHD-like traits and the Barratt Impulsiveness Scale was used as an independent measure of impulsiveness, to assess the extent to which performance on the neuropsychological tasks trulyreflected impulsiveness. Participants were also completed the Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004), which measures six facets of emotion regulation. Participants were not aware of the research purpose, so we invited them to take part in a research study about impulsive difficulties and emotional control.

4.3.2.1 Adult ADHD Self-Report Scale (ASRS-v1.1)

ASRS-v1.1 is a self-report, 18-questions scale developed by the World Health Organization. It covers the 18 DSM-IV-TR criteria and measures inattention and hyperactivity/ impulsivity symptoms. ASRS-v1.1 is designed to identify the signs of ADHD and score the frequency of symptoms (from 0 to 4) ("never," "rarely," "sometimes," "often," and "very often") (Kessler et al., 2004).

ASRS-v1.1 has two subscales: inattention (‘when you have a task that requires a lot of thought, how often do you avoid or delay getting started?’) and a hyperactivity/ impulsivity: (‘how often do you feel overly active and compelled to do things, like you were driven by a motor?’) and each subscale contains nine items. If the scores exceed 24, they indicate participants are highly likely to have ADHD in adulthood. Scores between 17 and 23 indicate the participants are likely to have ADHD, and not likely to have ADHD if they score 0-17. In this study, the internal consistency (Cronbach’s alpha) of the total ASRS scale was .89. The reliability of the inattention subscale was .85 and hyperactivity/ impulsivity subscale was .80.

4.3.2.2 The Barratt impulsiveness scale

Barratt Impulsiveness Scale (Barratt, 1995) is a 30 items self-report scale used to measure impulsiveness. Items are scored on a 4-point scale: (Rarely/Never = 1 Occasionally = 2 Often = 3 Almost Always/Always = 4). It is divided into three second-order factors (attentional, motor, and non-planning impulsiveness) and every section has its own score. Reverse scored questions are 2, 4, 19, 20, 21, 22, 23, 24, 26, 27, and 30. The scale has three sections; the attentional facet measures cognitive stability; ('I have "racing" thoughts'). The motor facet identifies impulsive decisions ('I "act" on impulse'). The planning facet pinpoints self-control and the cognitive aptitude for complexity (I am more interested in the present than in the future). In this study, the internal consistency for the total scale was .85.

4.3.2.3 Difficulties in Emotion Regulation Scale (DERS; Gratz and Roemer, 2004)

The DERS is a brief, 36-item self-report questionnaire designed to assess multiple aspects of emotional dysregulation such as non-acceptance of emotional responses, difficulties engaging in goal-directed behaviour, impulse control difficulties, lack of personal awareness, and inadequate access to emotion regulation strategies and lack of emotional clarity. Higher scores suggest more significant problems with emotion regulation. Participants have to indicate how often the statement applies to them ("almost never (0-10%)," "sometimes (11-35%)," "about half the time (36-65%)," "most of the time (66-90%)," "almost always (91-100%)"). One of the features of DERS it has high internal consistency (=.93) with Cronbach's >.80 for each subscale. It also has good test-retest reliability when tested after 4 to 8 weeks ($p < 0.1$) as well as adequate construct and predictive validity (Gratz and Roemer, 2004). In the present study, the DERS had high reliability (.95).

4.3.2.4 Cognitive Functions Tasks

4.3.2.4.1 The Iowa Gambling Task

The Iowa Gambling Task was developed by Bechara and his colleagues (1994) at the University of Iowa; it assesses real-life decision making. The Task was presented online via the experiment builder platform Gorilla. Participants see four virtual decks (A, B, C, or D) and each deck holds cards that either reward or penalise them (they need to choose one of 4 buttons with the mouse), using game money. It includes 100 cards from across the four decks. The advantageous decks are C & D since they present smaller wins of £50 and smaller losses (fees) of £50, while the disadvantageous decks are A & B that have large wins of £100 and losses of £250. Across the Task, the total high risk (A & B) reward is £10,000 and £12,500 fees, whereas the low risk has a reward of £5000 and fees of £2500 (Table 4.3.). So, participants can end up in a positive financial position by favouring the advantageous decks and unfavourable financial position by favouring the disadvantageous decks.

Table 4.3. *Decks on the Iowa Gambling Task.*

BECK	A	B	C	D
Wins	£100	£100	£50	£50
Fee	£250	£250	£50	£50
Total reward	£10,000	£10,000	£5000	£5000
Total fees	£12,500	£12,500	£2500	£2500
Total reward	£20,000		£10.000	
Total fees	£25.000		£5000	
Total of Decks	100 trials (50 trials have a fee)			

4.3.2.4.2 The Go-No/go Task

There are two repeated conditions of 40 trials, with 5-10 practice trials for each run. The first condition requires a 'Go' response to the letter P, and a 'No-Go' response to the letter R. The second condition requires the reverse. The commission error rate is the main measure in this Task. Making a "go" response on "no-go" high errors indicate a poor response inhibition (Table 4.4).

The stimulus was presented in the centre of the screen for 500 milliseconds, and the wait time after the stimulus was 1500 milliseconds. Participants are required to respond as quickly as possible by

pressing the spacebar. In the practice trials, participants give feedback when the response is correct or incorrect; show feedback (well done) for 200 milliseconds at the end of the practice trials. No feedback was given when the main task started, and no break was given between conditions. The task should take around 6 minutes to complete.

Table 4.4. *Go/No-go task*

Go/No-go task	GO	NO-GO	Total
Go/No-go (1) - Instructions and Practice 1	4	1	5
Go/No-go (2) - Instructions and Practice 2: Repeat	4	1	5
Go/No-Go (3) - P Condition (press the spacebar if you see P)	32	8	40
Go/No-Go (4) - Instructions and Practice 1	4	1	5
Go/No-Go (5) - Instructions and Practice 2: Repeat	4	1	5
Go/No-Go (6) - R Condition (press the spacebar if you see R)	32	8	40

4.3.3 Procedure

Participants were provided with study details and a link to the Gorilla website. Before accessing the tasks and questionnaire, all participants were asked to maximize the browser window, switch off phone/e-mail/music & anything else distracting, read the study information sheet, and give their informed consent to participate. After giving their consent, participants undertook the two tasks – the Iowa gambling task and the Go – No-go. After the tasks, they completed a series of questionnaires, including a measure of ADHD-like traits and emotion dysregulation. Participants were asked to disclose if they have a previous diagnosis of ADHD, dyslexia, ASD or any mental disorder or are currently experiencing such an illness and if so, whether they are taking any psychotropic medication. Completing the study took approximately 15 minutes. After completing the questionnaire, participants were debriefed about the purpose of the study. (see Figure 4.1.).

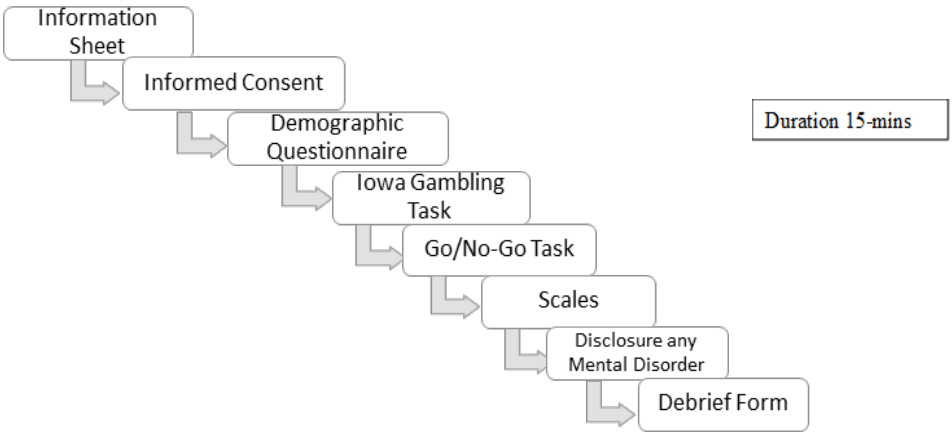

Figure 5.1. The procedures of the study

4.4 Data Analysis

Three hundred ninety-nine participants completed the study. For the purposes of analysis, participants were divided into a low ADHD-like trait group (Low ASRS group; scoring 29 or less in the overall ASRS score; N= 226), and a high ADHD-like trait group (High ASRS group; scoring 35 and more in the overall ADHD score; N= 105). (Table 4.5.).

Table 4.5. *ASRS Level*

	ASRS Level	
1	Mild	226 participants (127 females, 98 males, and 1 other)
2	Severe	105 participants (68 females, 35 males, and 2 others)

The cut off scores were based on a study conducted by Panagiotidi et al. (2017), exploring ADHD-like traits in 800 healthy participants. Participants had a mean score of 31.83, a score of 35 (the cut-off in the current study) was at the 75th percentile, and a score of 25 was at the 25th percentile. Data management and analysis were performed using the Statistical Package for the Social Sciences (SPSS).

Questionnaires Characteristics

ASRS scale data for the full 399 participants met the assumption of normality (skewness, .39 (*SE* =.12), kurtosis, .56 (*SE* = .24), as did the DERS scale data (skewness, .32 (*SE* = .12), kurtosis, -.44 (*SE* = .24)).

The IGT data was normally distributed; the low risk A & B (skewness, .057 (*SE* = .12), kurtosis, -.78 (*SE* = .24); the high risk C & D (skewness, -.057 (*SE* = .12), kurtosis, -.78 (*SE* = .24)). (C+D) - (A+B) (skewness, .057 (*SE* = .12), kurtosis, -.786 (*SE* = .24)). However, the Go/No-go task data the RT Go-No/go data was not (skewness, 1.93 (*SE* = .12), kurtosis, 4.87 (*SE* = .24)). Therefore, we decided to use nonparametric tests to analyses performance, and initially examined overall performance on the task.

Participants were recruited using the recruitment website Prolific Academic and consisted of any gender over the age of 18. An a priori sample size calculation was undertaken using G*power 3.1.9.4 (Faul et al., 2007) and Cohen's (1992) table. Prior studies suggested medium effect size was to be expected for the planned multiple regression. Power analysis suggests that with a medium effect size (0.15), for an alpha of 0.05 and a power of 0.8, a group size of 114 will be required to achieve a robust statistical outcome. In this study, a sample consisted of 399 participants. Therefore, the study was adequately powered.

Analysis - Iowa gambling task

The descriptive statistics and Kruskal-Wallis H tests of the "high risk" decks (A/B) and "low risk" decks (C/D) between different ASRS levels were investigated. Inhibitory control was measured by subtracting the total number of advantageous deck choices from the total disadvantageous decisions [(C + D) – (A + B)]. A positive score indicates a good decision-making strategy, while a negative score is evidence of a poor decision-making strategy. Also, we examined the reaction times across the 4 decks in the two ASRS groups

Analysis - Go-No/go task

Response inhibition was analysed by looking at the accuracy based on two types of errors - errors of omission and commission. Errors of omission were where the participant did not respond on go trial (percentage of Go trials erroneously followed by no keypress also called misses); errors of commission where they did respond on a no-go trial (percentage of No-Go trials erroneously followed by a keypress called false alarms). A measure for the speed of inhibition: Go reaction time: (Go RT; average reaction time on correct Go trials) was also used, with a high RT reflecting low response inhibition. Association among performance on both tasks were examined in relation to the ASRS, Barratt Impulsiveness, and DERS scores. A p-value of 0.05 is accepted as statistically significant.

4.5 Results

Age

The Kruskal-Wallis H test was used to examine whether questionnaires scores differed based on age. The difference was statistically significant for ASRS scores χ^2 (6) = 41.52, p <.001 and for the DERS scores χ^2 (6) = 53.07, p <.001. ASRS and DERS scores tended to be higher for the youngest and oldest age groups (Table 4.6).

Table 4.6. Characteristics of Age Group M (SD)

Age group	ASRS Score	DERS score	Frequency
18-24	34.26 (9.24)	106.06 (27.11)	100
25-34	28.74 (11.28)	101.21 (26.99)	95
35-44	27.70 (10.06)	90.90 (23.13)	84
45-54	27.78 (10.14)	89.71 (24.65)	55
55-64	26.52 (10.14)	82.57 (28.38)	46
65-74	21.67 (9.22)	69.20 (17.77)	15
75- over	31.60 (11.71)	104.40 (28.83)	5

M = mean, SD = standard deviation

Gender

A Mann-Whitney U test was run to determine if there were differences in the total ASRS and DERS, BIS scores between the males and females. The ASRS scores for females (Mdn =29.00) were statistically significantly higher than for males (Mdn = 28.00), U = 20730.000, z = 1.50, p < .131. The

DERS scores for females (Mdn =98.00) were statistically significantly higher than for males (Mdn = 89.00), $U = 19029.500$, $z = -.005$, $p < .996$. The BIS scores for females (Mdn =60.00) were statistically significantly lower than for males (Mdn = 61), $U = 22396.000$, $z = 2.99$, $p < .003$. The median for total gender (N= 400) in the ASRS was Mdn = 28.50, whereas for DERS it was Mdn = 95.00 and BIS Mdn = 61.00. (Table 4.7).

Table 4.7. *Gender Differences in different scales* & subscales M (SD)

Variable	Overall scales	M(SD)
Males		N=162
	ASRS	28.00
	DERS	89.00
	Barratt	61.00
Females		N=235
	ASRS	29.00
	DERS	98.00
	Barratt	60.00
Total Gender		N=400
	ASRS	28.50
	Barratt	61.00
	DERS	95.00

ASRS Scale Scores

The mean score in the overall ASRS for 399 participants was 29.27 (SD= 10.70), and the mean score in the inattention subscale was 16.16 (*SD*= 6.06), and the hyperactivity subscale 13.11 (*SD*= 5.72). There was a statistically significant positive correlation between the inattention and hyperactivity subscale (r (399)= .654**, p = 0.00). Also in the High and Low ASRS groups, both inattention and hyperactivity subscales were significantly positively correlated (r(105)=.297**, p=.002; r(226)=.303**, p=.000; respectively). Details of the scores for all the scales for the Low and High ASRS groups can be found in Table 4.6.

DERS Scale Score

The mean score in the DERS was 92.73 (*SD*= 26.35). For the DERS subscales, the mean score on the clarity subscale was 12.05(4.51), the aware subscale was 16.37(4.71), the impulsiveness subscale was 13.37(5.51), the non-acceptance subscale was 15.18(6.49), the goal subscale was 15.58(4.89), and the strategies subscale was 22.18(8.07). (see Table 4.8.)

Table 4.8. *ASRS Levels and different variables M (SD)*

	Low (226)	High (105)	N (399)
ASRS	22.03(6.10)	42.92(7.00)	29(10.70)
ASRS Inattention	12.32(3.76)	23.65(3.91)	16.16(6.05)
ASRS Hyperactivity	9.71(3.80)	19.28(4.75)	13.11(5.71)
DERS	80.74(20.9)	116.90(21.7)	92.73(26.35)
DERS Clarity	10.38(3.65)	15.75(4.27)	12.05(4.51)
DERS Aware	15.88(4.86)	17.82(4.67)	16.37(4.71)
DERS Impulsiveness	11.13(4.25)	17.81 (5.33)	13.37(5.51)
DERS Non-acceptance	13.04(5.58)	19.31 (6.41)	15.18(6.49)
DERS Goal	13.67(4.43)	19.14 (4.42)	15.58(4.89)
DERS Strategies	16.64(6.38)	27.06 (6.99)	20.18(8.07)

A Mann-Whitney U test was run to determine if there were differences in the total DERS scores between the High and Low ASRS groups. The DERS scores for high ASRS group (mean rank=252.01) were statistically significantly higher than for low ASRS group (mean rank= 126.04), $U = 20896.00$, $z = 11.14$, $p = .000$.

Tasks performances

Initially, the "high risk" decks (A/B) and "low risk" decks (C/D) were investigated in the Low and High ASRS groups. A Kruskal-Wallis H test was conducted to determine if there were differences in selecting "low risk" (C/D) and "high risk" decks (A/B) between the High and Low ASRS groups. Distributions of low risk and high risk deck choices were similar for the groups (Figure 4.2.). The mean rank of low risk (C/D) scores was higher for both groups than the mean rank of high risk (A/B) scores and the differences between the groups were not statistically significant, $\chi^2(1) = 1.38$, $p = .23$.

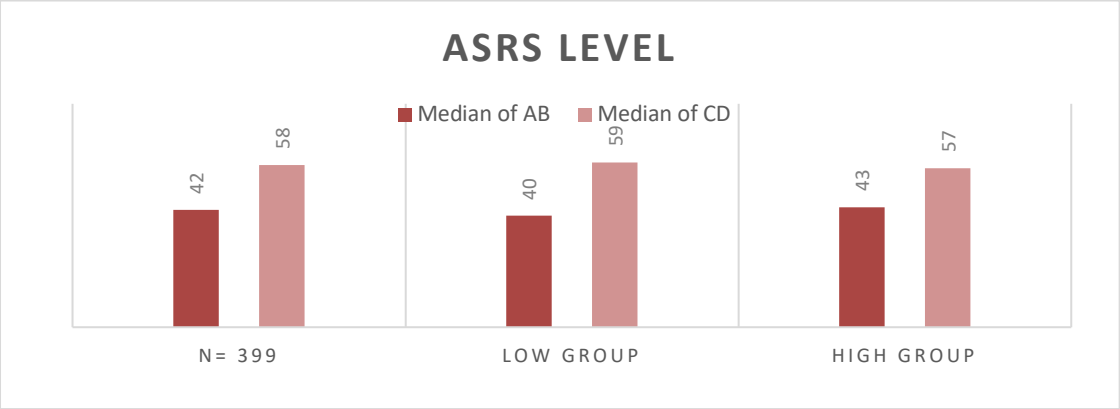

Figure 4.2. Bar Graph showing the ASRS score and median for the "high risk" (A/B)

Subtracting the total number of advantageous deck choices from the total disadvantageous decisions ([C + D] − [A + B]) is a standard measure of inhibitory control. A Kruskal-Wallis H test was conducted to determine if there were differences in this measure between the Low and High ASRS groups. The mean rank of [C + D] − [A + B]) scores for the High ASRS group was 14.00 and for the Low ASRS group was 19.00, but the differences were not statistically significant, χ^2 (1) = 1.38, p = .23.

There was a difference in the reaction times across the 4 decks in the two groups. The average reaction time for participants in the High ASRS group was faster than for participants in the Low ASRS group. A Friedman test was run to determine if there were differences in the ASRS group's reaction times across the four decks. Pairwise comparisons were performed (SPSS Statistics, 2012) with a Bonferroni correction for multiple comparisons. Reaction times for the four decks were statistically significantly different across the ASRS group, $\chi^2(3) = 210.90$, $p < .001$. For the Low ASRS group, the post hoc analysis revealed statistically significant differences in reaction times from deck A (*Mdn* = 1182.59) to deck B (*Mdn* = 1081.73) to deck C (*Mdn* = 871.63) and deck D (*Mdn* = 920.07); $\chi^2(3) = 130.95$, p =.000. For the High ASRS group, the post hoc analysis revealed statistically significant differences in reaction times from deck A (*Mdn* = 1001.77) to deck B (*Mdn* = 931.37) ($p <$ .001) to deck C (*Mdn* = 755.77) and deck D (*Mdn* = 823.01); ($\chi^2(3) = 85.01$, p =.001). (See Figure 4.3.).

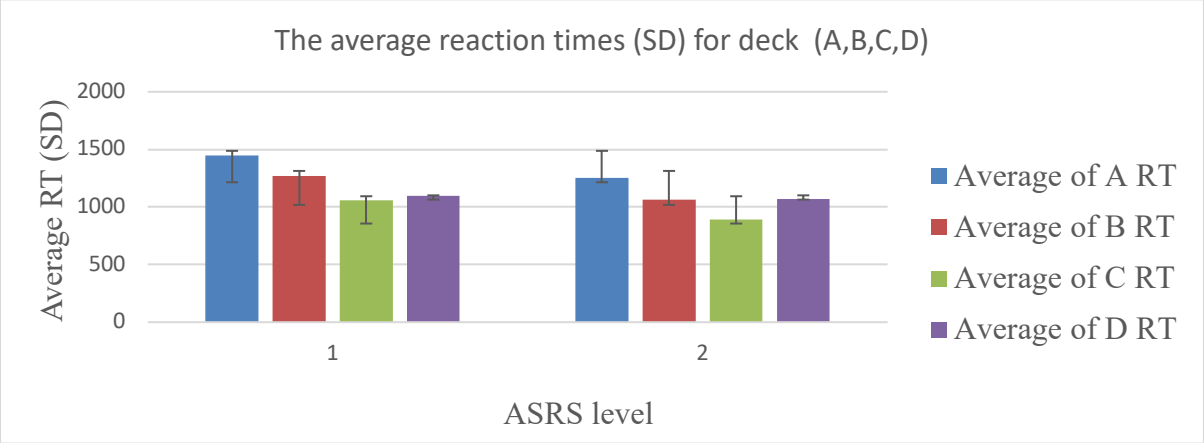

Figure 4.3. Bar Graph showing the average reaction times (RT) (standard error) for deck choices (A,B,C,D) in the Iowa gambling task for Low & High ASRS groups

Go-No/go Task

A Kruskal-Wallis test was conducted to determine differences in omission and commission error rates between the Low and High ASRS groups on the Go-No/go Task. Omission error rates were significantly different between the two groups, χ^2 (1) =7.46, p = .006 (see Figure 4.4.).

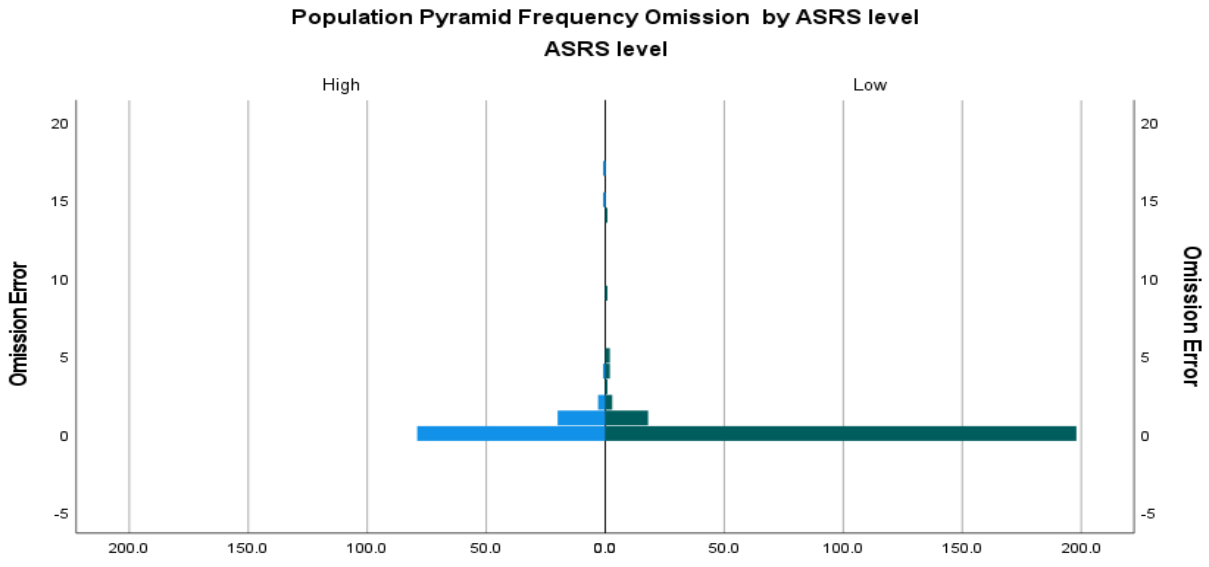

Figure 4.4. Graph showing the distribution of omission errors for Low & High ASRS groups

Also, the differences in commission error rate were significantly different between the two groups, χ^2 (1) =19.35, p = .001 (see Figure 4.5.).

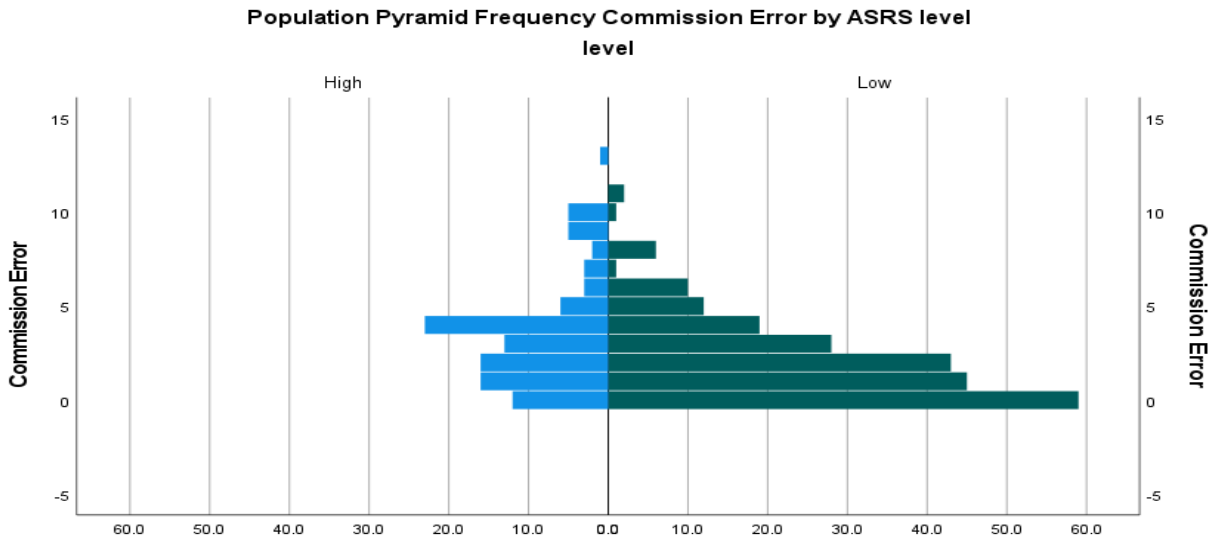

Figure 4.5. The graph showing the distribution of commission error for Low & High ASRS groups

In terms of Go reaction time (average reaction time on correct Go trials), in both the P & R conditions, (i.e. when P was the Go symbol, and when R was the Go symbol), the High ASRS group had shorter reaction times (average reaction time on both conditions P= 463.65 & R= 452.22) than the Low ASRS group (average reaction time in both conditions P = 505.95 & R = 486.34). A Mann-Whitney U test was run to determine if there were differences in the Go reaction time in the P & R conditions between the High and Low ASRS groups. The Go reaction time in the P & R conditions for High ASRS group were statistically significantly shorter than for Low ASRS group (Go reaction time in the P was U = 9191.50, z = -3.30, p = .001; Go reaction time in the R was U = 9041.50, z = -3.48, p = .000). (See Figure 4.6.).

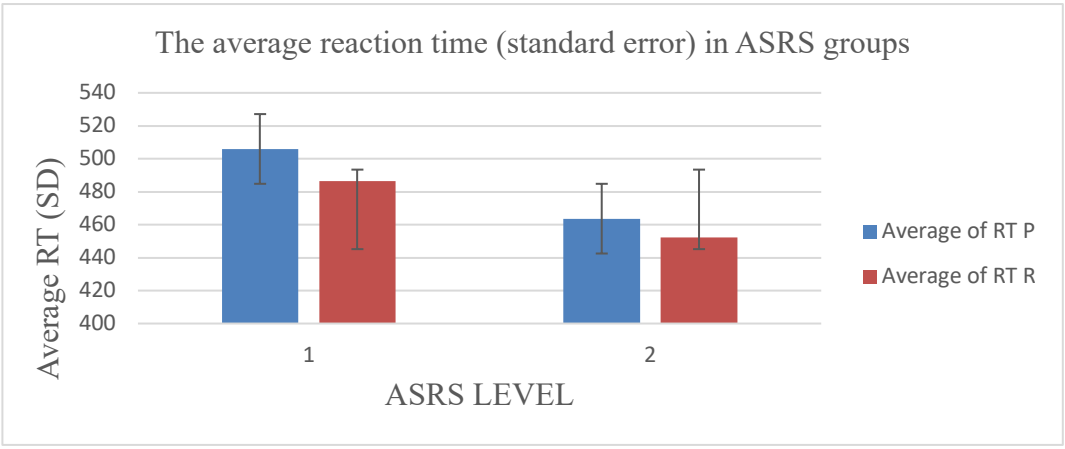

Figure 4.6. Bar Graph showing average reaction time (RT) in the Low & High

Binomial logistic regression

Binomial logistic regression was used to look at whether the Iowa gambling task scores or the Go-No/go task scores better predicted group membership of the High and Low ASRS groups. Linearity of the continuous variables with respect to the logit of the dependent variable was assessed via the Box-Tidwell (1962) procedure. A Bonferroni correction was applied using all 16 terms in the model, including the nine independent variables (the high risk (A/B), (RT) for deck choices (A, B, C, D), the errors of omission, commission, and Go reaction time in both the P & R conditions), the six interaction terms (for deck choices (A, B, C, D) and Go reaction time in both the P & R conditions and the intercept (called the "Constant") when $p < .00312$ (Tabachnick & Fidell, 2014). Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the dependent variable. There was one standardized residual with a value of 3.644 standard deviations, which was kept in the analysis; we do not have any significant outliers. The logistic regression model was statistically significant, $\chi2(9) = 31.13$, $p < .001$. The model explained 12.6% (Nagelkerke R2) of the variance in level and correctly classified 69.8% of cases. Sensitivity was 20.0 %, specificity was 92.9 %, positive predictive value was 56.75 %, and negative predictive value was 71.42 %. Commission error was the only independently statistically significant predictor (as shown in Table 4.9.).

Table 4.9. *Logistic Regression Predicting Likelihood of ASRS level based on IGT & GNG*

	B	SE	Wald	*df*	Sig.	Exp (B)	95% C.I. for Exp (B)	
							Lower	Upper
AB (IGT)	.001	.007	.033	1	.856	1.001	.988	1.015
A RT (IGT)	.000	.000	.470	1	.493	1.000	.999	1.000
B RT (IGT)	.000	.000	1.332	1	.248	1.000	.999	1.000
C RT (IGT)	.000	.000	.248	1	.618	1.000	.999	1.000
D RT (IGT)	.000	.000	2.014	1	.156	1.000	1.000	1.001
Omission (GNG)	.087	.076	1.314	1	.252	1.091	.940	1.265
Commission (GNG)	.162	.054	9.203	1	.002	1.176	1.059	1.306
R RT (GNG)	-.003	.003	1.209	1	.271	.997	.991	1.002
P RT (GNG)	.000	.002	.010	1	.922	1.000	.995	1.004
constant	.694	.924	.565	1	.452	2.003		

AB: "high risk" decks (A/B); (RT) for deck choices (A, B, C, D); errors of omission: percentage of Go trials erroneously followed by no keypress**;** errors of commission: percentage of No-Go trials erroneously followed by a keypress; Go reaction time in both the P & R conditions.

The DERS in relation to task performance and ASRS scores

Spearman's rank correlation was computed to assess the relationship between DERS scores and impulsivity affected by ADHD status. For the Low ASRS group, there was a negative correlation between overall DERS scores (and the clarity, goal and strategy subscales) and Go reaction time in the Go-No/go R and P conditions. As emotion dysregulation worsened (i.e. scores became greater), reaction times became shorter in the low ASRS group. The Low ASRS group had a high score in difficulties engaging in goal-directed behaviour, lack of emotional clarity and inadequate access to emotion regulation strategies, so their reaction times were slower.

For the high ASRS group, there was no relationship between overall DERS scores (or the subscales) and task performance. (Table 4.10).

Table 4.10. *Spearman's rank correlations for the Low ASRS group between scores on the DERS and reaction times on the Go-No/go task 28*

Low group N=226	Go RT R	Go RT P	Go RT RP
DERS	-.200**	-.142*	-.180**
DERS Clarity	-.221**	-.188**	-.218**

DERS Goal	-.170*	-.150*	-.172**
DERS Strategies	-.142*	-.094	-.127
DERS- Non-acceptance	-.130	-.053	-.095
DERS- Aware	-.112	-.092	-.105
DERS- Impulsiveness	-.121	-.101	-.117

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed).
DERS, Difficulties in Emotion Regulation Scale; ASRS, Adult ADHD Rating Scale; RT, Reaction Time; Go RT P Reaction Time with the P Go symbol; Go RT R Reaction Time with the Go R symbol

The Barratt score with the impulsivity measures

The overall Barratt scores and the subscales correlated significantly with the errors of commission in the Go/Nogo task. At the same time, they correlated negatively with Go reaction time and reaction times for deck choices (A, C, D). (Table 4.11). The significant correlations with the total Barratt score validated the tasks as measures of impulsivity.

Table 4.11. *Spearman's rank correlation for the BIS scores and tasks (N=331)*

N=331	BIS	BIS AF	BIS MF	BIS PF
Errors of Commission	-.257**	-.227**	-.168**	-.213**
Go RT R	-.132*	-.198**	.015	-.141*
Go RT P	-.164**	-.214**	-.027	-.164**
A RT	-.117*	-.127*	-.072	-.096
B RT	-.097	-.093	-.064	-.086
C RT	-.118*	-.138*	-.016	-.130*
D RT	-.085	-.133*	-.004	-.098

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed).
BIS, Barratt Impulsiveness Scale; RT, Reaction Time; Go RT P Reaction Time with the P Go symbol; Go RT R Reaction Time with the Go R symbol

4.6 Discussion

The present study was designed to determine the relationship between impulsiveness and emotion dysregulation among adults with varying levels of ADHD-like traits. It was hypothesised that there would be a difference between participants with high-levels of ADHD-like traits and those with low-levels of ADHD-like traits in terms of impulsivity; motor (action without thinking measured by Go-No/go Task), and cognitive (quick cognitive decision-making measure by Iowa Gambling Task), which would be linked to emotion dysregulation.

There are various aspects of impulsivity, including response inhibition (measured by Go/No-Go task or Stop-Signal Task), delay discounting (choices between immediate, smaller rewards and delayed larger rewards), risk-taking (assessed using Balloon Analogue Risk Task (BART) or Iowa Gambling Task (IGT)), response speed (Go/No-Go Tasks), and time perception (Time Production Task or Time Discrimination Task). Overall, all tasks measure impulsivity but each task emphasizes different aspects of impulsivity.

Impulsivity is a complex construct with various characteristics and there is no commonly accepted classification of impulsivity. In this study impulsivity is measured by looking at motor and cognitive aspects using the Go/No-Go task and Iowa Gambling Task (IGT) respectively. They are the most well-known types of tasks used to measure various components of impulsivity. However, non-planning is recognised as a feature of impulsivity. It is not often regarded as a wholly independent type of impulsivity, but rather one features within the wider concept of impulsivity.

Overall, we had 399 participants, so the requisite sample size was satisfied, allowing us to draw appropriate conclusions about the relationship between ADHD, IGT and the Go/Nogo task. In addition, BIS scores were correlated with the IGT and Go/Nogo tasks, and hence validated the tasks as measures of impulsivity.

In the Iowa Gambling Task, both Low and High ASRS groups had selected more "low risk" (C/D) over the "high risk" decks (A/B), but there were no significant differences between the Low and High ASRS groups in terms of their deck choices, or in the measure of inhibition based on the difference between advantageous and disadvantageous deck choices. In contrast, for the Go-No/go Task, the commission and omissions error rate were higher in the High ASRS group, so participants with higher levels of ADHD-like traits were less accurate. The difference between the High and Low ASRS groups on commission error rates, indicating poorer response inhibition (motor impulsivity); implying that the High group was willing to sacrifice accuracy for speed. Response speed in the High

ASRS group on both the P & R conditions was faster than in the Low ASRS group, suggesting that the group was trading off speed for accuracy.

This study confirms our hypotheses response inhibition is impaired in participants with high-levels of ADHD-like traits, in particular in relation to motor impulsivity. Several studies support the idea that impulsivity can be a result of deficits in motor control (Demers, McNevin, & Azar, 2013). There are similarities between this study's finding of a reduced ability to suppress motor responses (deficits response inhibition) and those indicated by (Mäntylä, Still, Gullberg, & Del Missier, 2012). As mentioned earlier, response inhibition is supposed to be the primary executive control deficit in ADHD (Aron & Poldrack, 2005; Doyle, 2006; Dekkers, Popma, van Rentergem, Bexkens, & Huizenga, 2016). As to why the deficit may have been selective for motor inhibition, research supports the idea that increasing cognitive load impacts response control in adults with ADHD. The Iowa gambling task may have had a lower level of cognitive load than the Go-No/go task. In the former, participants had to select one of four virtual decks (A, B, C, or D), while in the latter, the initial condition requires a 'Go' response to the letter P and a 'No-Go' response to the letter R and the second condition requires the reverse. The use of two simple stimuli in go/no-go tasks poses a low risk of introducing confounds with parallel cognitive functions such as attention, working memory, or response selection (Criaud & Boulinguez, 2013). As a result, it is possible that participants with higher levels of ADHD-related characteristics found the test to be more difficult.

The DERS scores and impulsivity related to the task where performance is affected by ADHD status were evident in the Low ASRS group. The low ADHD group strongly correlates negatively with Go reaction times in both conditions (P & R). Also, the DERS subscales scores (clarity, goal and strategy) were affected by the low ADHD group in the GO-No/go task (Go reaction times). However, the high ASRS group did not show any correlation between impulsivity (the elements of the tasks that were affected by ADHD/ASRS status and the DERS. That doesn't support the idea that ADHD impulsiveness is related to emotion dysregulation. At least when a task rather than a questionnaire

measure impulsiveness. The Barratt score correlated with both tasks (error of commission, Go reaction time and deck choices); it is validated as a measure of impulsivity.

This study will fill the gap in understanding impulsiveness and how the deficits in motor control or decision-making can result from impairment of the inhibition process in ADHD. If emotion dysregulation has the priority as the overactivity, impulsiveness, and inattentiveness symptoms when diagnosing ADHD. In that case, it will improve the patient's treatment outcome, and the benefit can last for a lifetime by informing practice and enhancing understanding of emotional self-regulation among the affected people.

4.7 Limitations and suggestions for future research

The clinical sample size was very modest, and patients who couldn't access the internet couldn't take part in the study. Furthermore, self-report questionnaires have some limitations, but the ASRS and DERS showed excellent internal consistency and were correlated once again. In addition, BIS scores validated the tasks we used as measures of impulsivity. Our experiment was conducted online rather than in a laboratory because of the Covid -19 restrictions, which may have had a detrimental impact on the performance. We do not test individuals who were unable to access or use the computer. COVID-19 may adversely impact the mental health of those with ADHD (Behrmann, Blaabjerg, Jordansen, & Jensen de López, 2022; McGrath, 2020). Covid -19 could increase some aspects of problem-solving ability and impulsive behaviour. Additionally, a lack of self-awareness can be biased in some groups, resulting in an inaccurate assessment of impulsivity and emotional dysfunction. Further studies should repeat our paradigms in the lab with the clinical population and compare it with the general population; it will be informative. There might be other factors related to ADHD, and emotional dysregulation that are not considered in this study should be investigated; since ADHD overlap with other mental disorders (Andersson et al., 2020).

4.8 Conclusion

Impulsiveness is a fundamental symptom of ADHD; it appears as the inability to inhibit motor responses to non-target stimuli or cognitive inhibition when engaging in decision-making. Impulsivity has several dimensions, including decreased inhibitory control, low tolerance for delays in rewards, quick decisions without considering consequences, and poor attentional capacity (Winstanley, Eagle, & Robbins, 2006). Response inhibition in ADHD, as measured by cognitive tasks, supports a deficit in the executive functions necessary for mature adult goal-directed behaviours in ADHD patients. The status of emotion dysregulation as a core symptom of ADHD remains controversial in the diagnosis of the disorder. Understanding the relationship between impulsive behaviours and emotion dysregulation could help people with impulsive behaviours problems develop self-control and decrease risk behaviours; if emotion dysregulation relates to impulsiveness, it may be possible to treat the latter by focusing on the former.

Chapter 5. General Discussion & Conclusion

5.1 Chapter Summary

This chapter reviews the findings of the three studies and the general discussion of the thesis. In addition, the study implications and how they will affect future research in the ADHD field have been discussed in this chapter. Finally, the limitations are also discussed.

5.2 General discussion

Attention Deficit Hyperactivity Disorder (ADHD) is a spectrum disorder with complex symptomatology, classically considered to be inattention, hyperactivity and impulsivity. One symptom exhibited by people with ADHD is emotional dysregulation, which although pervasive, is not a core symptom in the ADHD diagnosis. Indeed, it was disappointing to see that emotion dysregulation was not consider in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR) (American Psychiatric Association, 2022). That omission probably reflects that fact that relatively little is known about emotional dysregulation in ADHD, especially in adults, including its relationship to the classical symproms.

The relationship between ADHD & emotional dysregulation

The relationship between ADHD and emotional dysregulation is not novel. The negative consequences of emotional dysregulation in ADHD affect responses to various aspects of life in many different situations. The difficulties with emotional self-regulation experienced by adults with ADHD complicate their ability to maintain stable relationships with their peers, academic achievement, and occupational status. Some studies (Green & Rabiner, 2012) report that nearly 25% of students with ADHD did not complete high school, compared with 2% of students who do not have an ADHD diagnosis. Overreaction is common among adults with ADHD and can be triggered by over-sensitivity to emotional states and changes. It may be generated by difficulty in appropriately handling the problems they come across (Northover, Thapar, Langley & Van Goozen, 2015). In this thesis, we have tried to at least partially fill the gap in our understand about the relationship between emotional dysregulation and thre better understood symptoms of ADHD.

This thesis emphasises how crucial it is to define ADHD in a way that goes beyond simply highlighting inattention, hyperactivity, and impulsivity. Therefore, the importance of the thesis can be explained as follows:

Firstly, understanding the relationship between the classical core symptoms of ADHD and emotional dysregulation will theoretically help to treat more than one symptom by intervention with a more restricted focus. For example, depending on the linkages between symptoms, when a treatment plan focuses on emotion dysregulation as one symptom, it may help people with ADHD to better resist distractions, lower impulsivity, and improve their focus.

Secondly, the degree to which symptoms are correlated can provide clues about the nature of the underlying pathophysiology, which is essential to a drug discovery program. ADHD is exacerbated by cognitive demands, and is worsened by sex differences and co-occurring disorders (Albrecht, Uebel-von Sandersleben, Gevensleben, & Rothenberger, 2015); hence understanding the pathophysiology mechanism of ADHD is essential for drug development.

The main aim of the present thesis was to investigate the role of emotional dysregulation as a symptom in adults with ADHD-like traits. Hence, the questions to be addressed within the thesis are the relationship between the classic symptoms of ADHD, namely hyperactivity, impulsivity and inattentiveness, and emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits.

The self-report questionnaire we used in this thesis was the Adult ADHD Self-Report Scale (ASRS-v1.1), the Difficulties in Emotion Regulation Scale (DERS Gratz and Roemer, 2004), and the Barratt Impulsiveness Scale. In the first study, to understand the overlap between ADHD and ASD, the Autism-Spectrum Quotient (AQ) was added. There is no objective test for assessing the relationship between ADHD and emotional dysregulation, so besides the self-report questionnaire, task performance was used in the second and final study to supplement the self-report measures. In the second study, the sustained attention to response task (SART) was used and the go/no-go task (GNG) and Iowa Gambling Task (IGT) in the final study. The primary variable of interest for each task was commission errors (CE), which indicates an individual's ability to withhold a response correctly. In

addition, the omission errors (OE), an index of sustained attention, and mean reaction time, and intra-individual reaction times (variability).

5.3 Summary of findings

5.3.1 Study 1

The first study explores emotion dysregulation and al ADHD symptoms in a non-clinical population. More specifically, we looked at the relationship between (the core components of ADHD) inattention, hyperactivity /impulsivity, and emotional dysregulation in individuals with ADHD-like traits. We found there was a highly significant positive correlation between the DERS and both subscales of the ASRS (inattention and hyperactivity-impulsivity), suggesting that the symptoms of ADHD do indeed cluster together. The Autism Spectrum Quotient (AQ) was examined; the study supported the possibility of overlap between ASD and ADHD in that both disorders were associated with emotional dysregulation. Our finding supports the idea that emotional dysregulation is a crucial feature of ADHD and should be added to the diagnostic criteria.

The findings of this study are consistent with (Pinzone et al., 2019) where different types of temperament; lability, irritability and excessiveness of emotional responses were observed in people with ADHD. The aim of my thesis is to understand ADHD and its link to emotional dysregulation. The classical symptoms of ADHD in a non-clinical population were indeed associated with emotion dysregulation. Our finding supports the idea that it is sensible to consider emotional dysregulation as an additional core symptom. The findings of this study might be best explained by executive Function (EF) and Gross's emotion regulation model (1998), and both are connected to ADHD.

Researchers study clinical groups categorically; studying ADHD as a continuous disorder is meaningful before examining clinical groups. The dimensional approach supports studying ADHD-like traits in the general population since ADHD is distributed continuously with inattentive and hyperactive-impulsive symptoms (Panagiotidi, Overton, & Stafford, 2017). There is also some

potential support for the dimensional approach in more generally across neurodevelopmental disorders. Neurodevelopment is better understood in terms of many continuous dimensions pertaining to cognition, behaviour, or neurobiology - with graded levels ranging from typical to atypical functioning (Astle et al., 2022). Individuals may have increased degrees of difficulty across numerous dimensions, with the specific mix reflecting both the nature and complexity of their problems (Astle et al., 2022).

Further investigation of the link between the 'classical' ADHD symptoms and emotion dysregulation may be helpful in developing novel treatments for ADHD itself. However, self-report instruments do have their pitfalls. Consequently, in study 2 and study 3 we used online tasks to assess the classical symptoms of ADHD and assess the relationship between performance on those tasks and emotion dysregulation.

5.3.2 Study 2

In the second study, we looked mainly at distractibility and emotion dysregulation. To investigate the relationship between the classic symptom of inattention and emotion dysregulation, we developed a distractibility task (The Sustained Attention to Response Task; SART) and examined performance on that in a non-clinical population with varying levels of ADHD-like traits, and its relationship with emotion dysregulation. The ASRS and DERS self-report scales supported their correlation; however, the cognitive task (SART) did not. The outcome demonstrates that there was no statistically significant variance based on the ASRS groups, and the response times (RTs) on trials with distractions were faster than those without distractions. Additionally, accuracy in trials with and without distractors varied; accuracy was higher with distractors. Both groups' distractor costs for accuracy and reaction times were fairly close. Overall, the modified SART exam was unable to distract; strangely, performance was aided by the diversions. As a result, we were unable to reach any conclusions about the relationship between emotion dysregulation and task-based inattention.

5.3.3 Study 3

In the final study, we explored the relationship between the classical symptom of impulsiveness and emotion dysregulation in a non-clinical population with varying levels of ADHD-like traits**.** This study aimed to see whether impulsiveness measured by both cognitive impulsivity risky decision making (Iowa Gambling Task) and motor impulsivity (Go-No/go task) are linked to emotion dysregulation. For the Go-No/go task, both groups exhibited similar omission error rates. However, the omission and commission error rates differed more between the High and Low ASRS groups; and there was less accuracy. The High ASRS group outperformed the Low ASRS group in response times on both the P and R conditions, suggesting that the group was compromising accuracy for speed. For the Iowa Gambling Task, all participants selected low risk and there were no differences between the two groups when it came to choosing low risk. There was no statistically significant difference between groups for inhibitory control**.** Additionally, the low ADHD group's performance on the GO-No/go test (Go reaction times) were correlated with the DERS subscales scores for clarity, objective, and strategy. However, the high ASRS group did not exhibit any link between impulsivity (the task components influenced and the DERS). As a result, when tested by a task rather than a questionnaire, ADHD impulsivity is not connected to emotion dysregulation in the high group. Both tasks and the Barratt score were associated, making it a reliable indicator of impulsivity.

The relationship between the classical symptoms of ADHD emotion dysregulation in study 2 and 3 was not clear when we added the online tasks. However, some task-based evidence supports the relationship between ADHD and emotional dysregulation, for example Tottenham, Hare and Casey, (2011) using the Emotional Go/No-go task (Tottenham, Hare, & Casey, 2011). Furthermore, a Study by Schreiber, Grant, & Odlaug (2012) used self-report and cognitive paradigms from the Cambridge Neuropsychological Test Automated Battery (CANTABeclipse, version 3). They found subjects who reported high levels of emotion dysregulation also scored significantly higher on two self-report impulsivity measures (BIS attentional and non-planning impulsivity subscales) but not on impulsive

behaviours such as drug and alcohol use, gambling, stealing, buying, being out of control, deliberately setting fires, or sexual obsessions.

A systematic review showed that adults with ADHD may have a cognitive profile characterized by deficits in all attention modalities, processing speed, executive function (mainly working memory and inhibition with emphasis on reward delay and interference control), verbal memory, reading skills, social cognition, and arithmetic abilities (Onandia-Hinchado et al., 2021). Interventions involving cognitive training in ADHD may harnesses the brain's intrinsic neuroplastic abilities by concentrating on neural system function across mental disorders, thereby improving cognitive processes involved in emotion regulation, clinical symptoms, and adaptive community functioning (Keshavan et al., 2014). We did not find relationship between emotion dysregulation and task-based inattention, this could happen due to several limitations that we have discussed in each chapter.

5.4 Discussion of research findings

Overall, our finding fills the gap in understanding the connection between ADHD and emotional dysregulation. Study 1 suggested that the classical symptoms of ADHD were indeed associated with emotion dysregulation. However, that was in a non-clinical group. Researchers study clinical groups categorically; studying ADHD as a continuous disorder is meaningful before examining the clinical group. The dimensional approach supports studying ADHD-like traits in the general population since ADHD is distributed continuously with inattentive and hyperactive-impulsive symptoms (Panagiotidi, Overton, & Stafford, 2017). The ASRS is a valid scale measuring ADHD-like traits in healthy people. The relationship was not there in your small clinical sample, but that as probably due to the sample size.

However, some evidence supports the relationship between ADHD and emotional dysregulation using the behavioural paradigm of Emotional Go/No-go tasks (Tottenham, Hare, & Casey, 2011). A Study by Schreiber, Grant, & Odlaug (2012), used self-report and cognitive

paradigms from the Cambridge Neuropsychological Test Automated Battery (CANTABeclipse, version 3). They found Subjects who reported high levels of emotion dysregulation also scored significantly higher on two self-report impulsivity measures (BIS attentional and non-planning impulsivity subscales) but not on impulsive behaviours such as drug and alcohol use, gambling, stealing, buying, being out of control, deliberately setting fires, or sexual obsessions.

The results indicate that the self-report scale supports the correlation, but we did not find confirmatory evidence from cognitive tasks. The reasons for that could be explained as the following self-report questionnaires are subjective and vulnerable to biases. Additionally, in some populations, a lack of self-awareness might lead to a biased evaluation of ADHD symptoms and emotional disorders. Cognitive assessments were conducted online, and the major disadvantage of an online examination is that we cannot observe the participant as we do in the lab. Another limitation of our studies is collecting the data during COVID-19, which may lead to increased AHDH symptoms, especially isolation during the pandemic, and remote learning makes the study more challenging.

We need to evaluate people in their actual environment since having too much control over individuals is harmful in a laboratory. Future research may replicate the second study using carefully controlled laboratory experiments. For example, in the distractor paradigm, eye movement monitoring could be used to examine fixation, blink, and saccade frequency and how they are related to distractibility. Researchers also could add additional forms of distractions (no distractions, visual distractions, auditory distractions, or a combination of them).

Study 1 suggested that the classical symptoms of ADHD were indeed associated with emotion dysregulation but the relationship in study 2 and 3 was not clear when we added the online tasks. It is critical to understand how the findings in the thesis fit into psychological theories of ADHD and emotion regulation. The major theories are executive Function (EF), behavioral inhibition, sustained attention, Gross emotion regulation model (1998).

Conceptualizing emotion dysregulation and ADHD involves understand executive function (EF) theory. According to EF theory, ADHD is related to an executive function deficit. People with ADHD report problems with inhibition, impulsive control, regulation of behaviour, attention, novel-seeking, in other words a set of functions ascribed to the prefrontal cortex (known to perform executive functions) and that contribute to emotion dysregulation. Understanding the mechanisms of executive function could help to manage the ADHD symptoms and emotional dysregulation. One executive function could explain the impairment in the ability to suppress behavior in different situations is the deficit in behavioral inhibition, which is and linked to ADHD and emotional problems leading to problem with inhibiting emotional expressions, suppressing impulsive reactions or enhancing positive emotions.

The emotion regulation model of Gross (1998) could help to understand the relationship between ADHD's core symptoms and emotion dysregulation. People with ADHD report problems with five key emotion regulation strategies proposed by Gross: situation selection, situation modification, attentional deployment, cognitive change, and response modification. Emotional dysregulation contributes to emotional impulsivity, emotional lability, emotional instability, and increased ADHD symptoms. Both classical ADHD symptoms and emotion dysregulation are thought to add challenges throughout the lifespan, resulting in increased emotional arousal and difficulty successfully managing and regulating one's emotions.

It is also possible that managing emotional intensity in people ADHD could contribute positively to manage autism spectrum disorder when they are overlap. People with neurodevelopmental disorders find emotion regulation challenging, hence identifying the problem could help them control negative emotions when triggered and modulate the emotional responses to suit the situation.

5.5 Limitations and future directions

We divided the participants into groups based on the overall ASRS scores: so, the participants in the first study for the low group was =115 and for the high group was = 112. In second study, the "low" ASRS group was = 160 and "high" ASRS group was = 143. For the study 3, the low ADHD-like trait group was= 226, and a high ADHD-like trait was = 105. However, the number of participants with a clinical diagnosis was small. In the future, it might be useful to examine the relationships we investigated here with large clinical sample.

The results for study 2 and 3 using self-report scales supports a relationship between the classical symptoms of ADHD and emotion dysregulation, but we did not find confirmatory evidence from cognitive tasks. The reasons for that could be explained aby the fact that self-report questionnaires are subjective and vulnerable to biases. However, the self- reports we used are standardized and had high reliability and internal consistency. In study 2 and 3 we supplemented the self-reports with cognitive assessments methods to gain a fully comprehensive understanding the relationship between ADHD and emotional dysregulation. Cognitive assessments were conducted online, and the major disadvantage of an online examination is that we cannot observe the participant as we do in the laboratory. So, we able to control for distractors and were not able to capture any behavior that may explain a particular response. Another limitation of our studies is that we collected data during COVID-19, which may have been a time of increased ADHD symptoms, especially due to isolation during the pandemic, as remote learning makes the study more challenging. Also, affective experience during COVID-19 may have influenced our finding.

Although the results showed no differences between the ADHD groups in study 2 and 3, future research may replicate the second and third studies using carefully controlled laboratory experiments. For example, in the distractor paradigm, eye movement monitoring could be used to examine fixation, blink, and saccade frequency and how they are related to distractibility. Researchers also could add additional forms of distractions (no distractions, visual distractions, auditory distractions, or a combination of them). ADHD is complex disorder so future research might benefit from exploring other factors that relate to emotional experience in adults with ADHD.

5.6 Research implications

Emotion dysregulations are considered transdiagnostic (Sloan et al.,2017) so researchers could focus on understanding the common underlying mechanisms for emotional issues in different psychopathologies and directly address the issue of an emotion dysregulation treatment plan. Providing a combination of different interventions for people with ADHD could help to manage the classical symptoms alongside the emotional issues. But researchers should maintain realistic expectations about the treatments to avoid the ADHD interventions being so challenging that it prevents people from engaging with the intervention. For example, the access to resource maybe not be available to everyone, stigma about disorder may increase feelings of shame, isolation, and self-doubt.Also, future research might look how are the emotional issues in adults with ADHD differs between the sexes, and if they do differ, what is the appropriate treatment method?

5.7 Clinical implications

There are several features of the results that have clinical implications for treatment plans to target the symptoms of ADHD: inattention, hyperactivity, impulsivity, and emotion dysregulation. First, the self-report findings of this thesis support the idea that there is a relationship between the core ADHD symptoms and emotion dysregulation, and that emotional symptoms should be considered to be a core feature of ADHD. Addressing the emotional problem of people with ADHD is important to improve quality of life. Second, psychoeducation is very important and should support the families, caregivers, and people with ADHD. Since there is high chance of emotional issues in ADHD, risky behaviours and substance abuse, relationship difficulties, and comorbidity; the psychoeducation should be considered to promote overall well-being and support treatment adherence.

Third, our results will enhance self-management by helping patients to understand how ADHD leads to intense emotion. Self-help and resources that detail evidence-based treatments as coping strategies should be available to everyone. People spend years on NHS waiting lists so psychoeducation, self-help guides, evidence-based practices should be easy to access for them. Finally,

clinics should be aware that emotional instability means that group therapy may not be effective as individual sessions, especially since rejection sensitive dysphoria (RSD) is linked to ADHD.

5.8 Non-pharmacological therapies for ADHD

There are different appropriate treatment plans for emotional dysregulation in individuals with ADHD; Dialectical behavioural therapy (DBT), Cognitive Behavioral Therapy (CBT), Mindfulness-Based Interventions and exercise. Importantly every person should have a treatment plan that is based on the specific needs and includes a person's strengths and weaknesses. The different approaches should be used to complement each other and not as replacements for other active interventions especially medication.

Dialectical behavioural therapy (DBT) for ADHD

Insofar as emotion dysregulation is connected with other ADHD symptoms, treating that may have more widespread benefits. DBT is an emotion regulation strategy that helps to manage ADHD symptoms by learning mindfulness, distress tolerance, emotional regulation, and interpersonal effectiveness. It is an evidence-based treatment developed by Marsha Linehan (Linehan, 2014). Understanding the role of emotional dysregulation in ADHD will help improve the intervention by adapting emotion regulation strategies (Bodalski, Knouse, & Kovalev, 2019).

There are six strategies for controlling emotions; it has been proposed that reappraisal, problem-solving, and acceptance are protective factors against the development of psychopathology, whereas the risk factors for disordered psychology are suppression, avoidance, and rumination. Understanding the various regulatory mechanisms that might be more closely associated with specific psychopathologies can enhance current treatments and provide opportunities for novel approaches to each disorder (Aldao Nolen-Hoeksema, Schweizer, 2010).

It is essential to understand the degree and variance of ADHD and the factors of emotional dysregulation to understand the whole complex picture unique to every person with ADHD. When evaluating the patterns of responding to emotion over time, people with ADHD are more likely to experience difficulties controlling their emotional responses due to poor emotion regulation skills. So,

the treatment should include emotion regulation skills because of the long-term effects of controlling emotion and physiological arousal. For future ADHD research, we need to understand the maladaptive responses adults with ADHD use to overcome any problematic events. Also, what emotion regulation skills processes are thought to be the core strategies use in the management of ADHD symptoms.

Cognitive Behavioral Therapy (CBT)

The combination of medication and cognitive-behavioural interventions can help people with ADHD address dysfunctional thinking and beliefs by modifying them, thus improving the core symptoms of ADHD. In recent meta-analyses, Young, Moghaddam, and Tickle (2020) and Lambez, Harwood-Gross, Golumbic, and Rassovsky (2020) identified how cognitive behavioural therapy (CBT), as one option, can effectively treat people with ADHD. Lambez et al. (2020) looked at 18 published studies that focused on neurofeedback, CBT, cognitive training, and physical exercises over the period 1980–2017 to understand the effects of non-pharmacological treatments (cognitive interventions) on cognitive difficulties in ADHD. All the studies showed a moderate to large effect size. Physical activity was the most effective interms of effect size, followed by CBT, neuro and biofeedback, and mental training, respectively. Moreover, Lambez et al. (2020) found different interventions with medication improved the outcomes of ADHD treatment and that cognitive function improved with alternative interventions alone.

Hodgson, Hutchinson, and Denson's (2014) meta-analytic review recommends behaviour modification and neuro-feedback for children with ADHD as medication and evidence-based psychological treatments help manage the core symptoms, hyperactivity and impulsivity. Furthermore, support is necessary not just for those diagnosed, but also for caregivers – parents, other family members, or teachers – to assure better outcomes of ADHD treatment (Harpin,

Safren, Sprich, Chulvick, and Otto (2014) developed a cognitive-behavioural model of ADHD in adults. The conceptual basis for the model is that ADHD entails neuropsychological deficits associated

with the prefrontal cortex, leading to executive deficits, emotion dysregulation, impulsivity, and attention. As well as impairments in attention, inhibition, and self-regulation, they note that neuropsychological impairments cause the core symptoms of ADHD and chronic cognitive and behavioural impairments.

As a result, Safren et al. (2014) point out that people with ADHD will have problems in school or at work and will struggle with time management, procrastination, and being easily distracted. Moreover, in terms of their social lives, they will suffer from social rejection, difficulty sustaining peer relationships, avoidance, and managing their emotions (Harpin, 2005). Regular experience of failures or underperformance by those with ADHD will boost feelings of emotional discomfort and affect beliefs and emotions about themselves, others, and the future. Negative cognitions will reinforce these (Safren et al., 2014). A history of failures will increase the core symptoms of ADHD, i.e., inattention, hyperactivity and impulsivity, and emotion dysregulation. These can result in using compensatory strategies, such as adaptation, paying attention, organisation, external support, or avoidance. ADHD will increase functional impairment and affect thoughts, emotions, physiology, and behaviour, leading to suffering from mood disturbances such as depression, anxiety, and sadness (Safren et al., 2014). There is a reinforcing deficits cycle, with the sequences of deficits resulting in repeated use of compensatory strategies.

Cognitive–behavioural patterns lead to enhanced neuropsychological impairments. However, psychosocial interventions can help people with ADHD use structured skill-building treatments and cope more effectively, mitigating maladaptive coping patterns to prevent any functional impairments as well as to stop negative thought cycles. Safren et al. (2014) argue a role for CBT as a means of examining the causes and consequences of ADHD disorder through the functional analysis of behaviour and understanding how dysfunctional cognitions and beliefs reinforce and maintain unwanted behaviour and thought. The general principle of CBT is that it is not the situation that causes distress, but our interpretation of the situation (Beck Institute, 2021). Not reinforcing the deficits cycle

by using CBT and increasing self-awareness, goal setting, and organisation will reduce the sense of failure and underachievement and relieve the severity of core symptoms (Safren et al., 2014).

Mindfulness-Based Interventions

Mindfulness involves *paying attention on purpose moment by moment with non-judgmental, (Full Catastrophe Living, – Jon Kabat-Zinn) and* includes meditation, breathing exercises, and yoga. Mindful emotion regulation refers to the ability to be attentively aware at all times, regardless of the apparent valence or intensity of any emotion experienced; it does not entail emotional suppression or any deliberate attempts to reappraise or manipulate it in any way (Chambers, Gullone, & Allen, 2009). There is evidence that mindfulness-based interventions (MBIs) are effective in managing ADHD symptoms and emotion dysregulation (Poissant et al. 2019). Mindfulness practice is linked with improved emotional recovery, positive emotional responses, decreased negative emotional responses, behavioural avoidance, and emotion dysregulation (Roemer, Williston, & Rollins, 2015).

One program of mindfulness, Mindfulness-Based Stress Reduction (MBSR), was originally developed in the late 1970's by Jon Kabat-Zinn and colleagues at the University of Massachusetts Medical Centre. MBSR involves a group of people meeting for 8 weeks of sessions and its cover different stressors arising from a variety of life events. MBSR has resulted in significant improvements in mental health (Kenne Sarenmalm et al. 2017). Mindfulness-based stress reduction is considered to lower emotional reactivity and improve emotional control in individuals with social anxiety disorder (SAD) (Goldin et al. 2013). These findings suggest that MBSR effective in lessening psychological symptoms. ADHD co-occurs with other disorders, and the symptoms are varied. MBSR was not developed to treat ADHD symptoms, although it might help with stress reduction, attention retention, self-compassion, emotional control, impulsive behaviours, and emotional reactivity.

Exercise

Exercise such as aerobic exercise has been shown to have a positive effect in depression and anxiety (Smith, & Merwin, 2021; Singh et al, 2023). Physical activity (PA), exercise, and aerobic fitness improve well-being, brain function, promote self-regulation and mental health resilience (Belcher et al., 2021). It has an influence on psychological states, physiological states and mood states (Mikkelsen et al., 2017). There is mounting evidence that a single exercise session can result in rapid improvements in ADHD symptoms and cognitive abilities (Mehren et al., 2020). Regular physical activity is *proven to help* improve mood, motivation, mindfulness, executive function skills as memory, concentration reduce anxiety, build confidence, and enhance overall well-being.

Physical activities or exercise therapies may assist reduce symptoms of inattention, hyperactivity/impulsivity, and interpersonal relationships to improve students' adaptability in learning. This method can significantly enhance the perceptual and cognitive functioning of children with ADHD (Chan, Jang, Ho, 2022). Also, people who experience emotion dysregulation have a difficulty with emotional well-being and an inability to cope with negative thoughts and feelings that affect goal-directed behaviour. Exercise has various favorable benefits on how people perceive and control their emotions, which leads to traits associated with high levels of emotion regulation.

As a result, exercise will *prevent and manage* symptoms of ADHD and co-occurring conditions as anxiety (Cerrillo-Urbina et al., 2015; Christiansen et al., 2019). A recent systematic review concluded that exercise was related with moderate gains in executive function areas in children and adolescents with neurodevelopmental problems (Varigonda, Edgcomb, & Zima, 2021).

Inactive lifestyle is associated with different mental health problems. Lack of engagement in physical activity is more prevalent in people with ADHD since they have problem with functional skills, including setting specific goals, creating a routine, motivation, and sustaining activities. Health provider should address the barriers to physical activity in ADHD, such as executive dysfunction, described as forgetfulness, difficulty with sustained focus, and time management), poor self-esteem, and lack of motivation (Ogrodnik, Karsan, Malamis, 2023). A meta-analytic review of the effects of

physical exercise interventions on cognition in people with ASD and ADHD demonstrated an overall small to medium positive effect of exercise on cognition, suggesting the usefulness of exercise therapies in boosting specific elements of cognitive function in persons with ASD and/or ADHD (Tan, Pooley, & Speelman, 2016). Furthermore, the meta-analysis shows that exercise interventions have specific beneficial effects on inhibitory control and memory functions in people with ADHD (Tan, Pooley, & Speelman, 2016). Furthermore, in a systematic review and meta-analysis of non-pharmacological therapies for cognitive impairments in ADHD, physical exercise had the largest average impact size (= 0.93) (Lambez et al., 2020). So, the treatment plan for ADHD should highlight the lifestyle changes and increase the likelihood of adherence to a regular exercise routine.

For the next required studies most studies have examined ADHD and emotional responses using observation, EEG/ERP or startle responses, rather than looking directly at the physiological reactivity (heart rate and skin conductance) that underlies and/or accompanies emotional responses. On possibility for the future is to examine physiological reactivity to pleasant, unpleasant and neutral images in a non-clinical population of adults with a range of levels of ADHD-like symptoms, to explore the relationship between ADHD-like traits and physiological responses, which underpin emotional responses, to pleasant, unpleasant and neutral images in adults.

The basic elements of the study are as follows: once consent has been obtained, participants will be seated in front of monitor and will be exposed to a series of images taken from the International Affective Picture System (IAPS). Participants will be told that pictures differing in emotional content will be displayed on a screen in front of them. Images will be selected according to standardised ratings (Lang et al., 2005), and will be either pleasant, unpleasant or neutral in valence, with pleasant and unpleasant images matched as far as possible for arousal (see attached examples of the unpleasant images – 7380; 9300). Choice will be guided by selections that have proved to be effective in other studies (e.g. Ribeiro et al., 2007). Each image will be preceded by preparatory slide showing the number of the next photograph to be presented (baseline period). To maintain attention, participants will be asked to rate the images in terms of valence and arousal after each image (which

will allow us to compare the ratings of our participants with the standard ratings). At the outset, participants will be coupled up to a Biograph Infiniti 5 physiological recording system to record heart rate (the variability of which is an index of parasympathetic activity) and skin conductance (a measure of sympathetic activity).

The experiment will need to be conducted in two phases. There needs to be an initial pilot phase to determine value for some of the display parameters. In particular, we need to find out what the 'settling' (reset) period is for the physiological parameters after exposure to an image. That will determine the inter-stimulus interval (baseline period) and thus the number of stimuli to which participants are to be exposed. Given the nature of the participants (i.e. some will have attentional difficulties), we aim to limit our experimental session to two blocks of 15 min. Our initial exposure parameters will be: exposure time, 5 s (as in Ribeiro et al., 2007); interstimulus time, 25 s; 30 images in each 15 min block (10 pleasant, 10 unpleasant and 10 neutral) presented randomly. Phase two of the experiment will then use the display parameter values determined in the pilot to run the full study. In the full study, once the participants have finished the experimental section of the study, they will be administered the Adult ADHD Self-Report Scale (ASRS; Kessler et al., 2005), the Emotional Processing Scale (Baker et al., 2009; a 25-item self-report questionnaire designed to identify emotional processing styles and deficits, which we will use to explore in relationship between self-reported indices of emotional processing and physiological measures in the same individual), and all participants will be fully debriefed.

Participants will be recruited from the University – participants will be of any gender and over the age of 18. A priori power analysis suggests that with a medium effect size (.25), for an alpha of 0.05 and a power of 0.8, a group size of 28 will be required to achieve a robust statistical outcome with a 2 way mixed measures ANOVA (e.g. Hi/Lo ASRS [between]; pleasant, neutral unpleasant images [within]) looking at skin conductance responses.

5.9 Conclusion

This thesis aimed to understand emotional dysregulation in ADHD; is it a core feature of ADHD in adults and what is its relationship to other symptoms. Three studies with different methods investigated this issue. The first study with self-report mesures found support for the relationship between ADHD and emotion dysregulation, suggesting that the symptoms of ADHD are linked in some way. However, the second and third study using cognitive tasks to assess inattention (distractibility) and impulsivity found little evidence to link emotion dysregulation with these classical ADHD symptoms. The confliciting results cast a focus on methodology and it is suggested that the next experimental studies addressing the question of the relationship between the classical symptoms of ADHD and emotion dysregulation take place under controlled condition in the laboratory.

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A Appendix

A. Demographic sheet

Please indicate your age:

- 18 – 24
- 25 – 34
- 35 – 44
- 45 – 54
- 55- 64
- 65 – 74
- 75 years or older

Ethnic origin: Please specify your ethnicity:		
White • English / Welsh / Scottish / Northern Irish / British • Irish • Gypsy or Irish Traveller • Any other White background	Mixed / Multiple ethnic groups • White and Black Caribbean • White and Black African • White and Asian • Any other Mixed / Multiple ethnic background	Asian / Asian British • Indian • Pakistani • Bangladeshi • Chinese • Any other Asian background
Black / African / Caribbean / Black British • African • Caribbean • Any other Black / African / Caribbean background	Other ethnic group • Arab • Any other ethnic group • Prefer not to say	Other

Gender:

- Male
- Female
- Other

English language competence level:

- Beginner
- Intermediate
- Fluent non-native speaker
- Native speaker

Are you taking any psychotropic medication

- Yes
- No
- Prefer not to say

I have previously been diagnosed with ADHD.

- Yes
- No
- Prefer not to say

I have previously been diagnosed with Autism.

- Yes
- No
- Prefer not to say

I have previously been diagnosed with Dyslexia.

- Yes
- No
- Prefer not to say

I have previously been diagnosed with a mental disorder that I have been told might account for the types of experiences above, or I believe that I may be experiencing such a disorder. This might include Schizophrenia or other Psychotic Disorder, or something in the class of disorders included under the headings of Mood Disorder, Anxiety Disorder, Dissociative Disorder, or Personality Disorder.

- Yes
- No
- Prefer not to say

B Appendix B. Adult ADHD Self-Report Scale (ASRS-v1.1)

Please answer the questions below, rating yourself on each of the criteria shown using the scale on the right side of the page. As you answer each question, place an X in the box that best describes how you have felt and conducted yourself over the past 6 months. Please give this completed checklist to your healthcare professional to discuss during today's appointment.

	Never	Rarely	Sometimes	often	Very Often
1- How often do you have trouble wrapping up the final details of a project, once the challenging parts have been done?					
2- How often do you have difficulty getting things in order when you have to do a task that requires organization?					
3- How often do you have problems remembering appointments or obligations?					
4- When you have a task that requires a lot of thought, how often do you avoid or delay getting started?					
5- How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?					
6- How often do you feel overly active and compelled to do things, like you were driven by a motor?					
7- How often do you make careless mistakes when you have to work on a boring or difficult project?					
8- How often do you have difficulty keeping your attention when you are doing boring or repetitive work?					
9- How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?					
10- How often do you misplace or have difficulty finding things at home or at work?					
11- How often are you distracted by activity or noise around you?					
12- How often do you leave your seat in meetings or other situations in which you are expected to remain seated?					
13- How often do you feel restless or fidgety?					
14- How often do you have difficulty unwinding and relaxing when you have time to yourself?					
15- How often do you find yourself talking too much when you are in social situations?					
16- When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to,					

before they can finish them themselves?					
17- How often do you have difficulty waiting your turn in situations when turn taking is required?					
18- How often do you interrupt others when they are busy?					

C Appendix C. Difficulties in Emotion Regulation Scale

Please indicate how often the following statements apply to you by writing the appropriate number from the scale below on the line beside each item.

1----------2----------3----------4----------5

Almost never Sometimes About half the time Most of the time Almost always

(0-10%) (11-35%) (36-65%) (66-90%) (91-100%)

1) I am clear about my feelings.

2) I pay attention to how I feel.

3) I experience my emotions as overwhelming and out of control.

4) I have no idea how I am feeling.

5) I have difficulty making sense out of my feelings.

6) I am attentive to my feelings.

7) I know exactly how I am feeling.

8) I care about what I am feeling.

9) I am confused about how I feel.

10) When I'm upset, I acknowledge my emotions.

11) When I'm upset, I become angry with myself for feeling that way.

12) When I'm upset, I become embarrassed for feeling that way.

13) When I'm upset, I have difficulty getting work done.

14) When I'm upset, I become out of control.

15) When I'm upset, I believe that I will remain that way for a long time.

16) When I'm upset, I believe that I will end up feeling very depressed.

17) When I'm upset, I believe that my feelings are valid and important.

18) When I'm upset, I have difficulty focusing on other things.

19) When I'm upset, I feel out of control.

20) When I'm upset, I can still get things done.

21) When I'm upset, I feel ashamed at myself for feeling that way.

22) When I'm upset, I know that I can find a way to eventually feel better.

23) When I'm upset, I feel like I am weak.

24) When I'm upset, I feel like I can remain in control of my behaviors.

25) When I’m upset, I feel guilty for feeling that way.

26) When I’m upset, I have difficulty concentrating.

27) When I’m upset, I have difficulty controlling my behaviors.

28) When I’m upset, I believe there is nothing I can do to make myself feel better.

29) When I’m upset, I become irritated at myself for feeling that way.

30) When I’m upset, I start to feel very bad about myself.

31) When I’m upset, I believe that wallowing in it is all I can do.

32) When I’m upset, I lose control over my behavior.

33) When I’m upset, I have difficulty thinking aboutanything else.

34) When I’m upset I take time to figure out what I’m really feeling.

35) When I’m upset, it takes me a long time to feel better.

36) When I’m upset, my emotions feel overwhelming.

D Appendix D. The Barratt Impulsiveness Scale (BIS)

Read each statement and circle the appropriate number on the right side of this page. Do not spend too much time on any statement. Answer quickly and honestly.

Scores: 1 Rarely/Never - 2 Occasionally - 3 Often - 4 Almost Always/Always

Attentional Facet

1. I don't "pay attention.
2. I concentrate easily.
3. I "squirm" at plays or lectures.
4. I am a steady thinker.
5. I am restless at the theater or lectures.
6. I have "racing" thoughts.
7. I change hobbies.
8. I often have extraneous thoughts when thinking.

Motor Facet

9. I do things without thinking.
10. I make up my mind quickly.
11. I am happy-go-lucky.
12. I "act" on impulse.
13. I act on the spur of the moment.
14. I buy things on impulse.
15. I spend or charge more than I earn.
16. I change jobs.
17. I change residences.
18. I can think only about one thing at a time.
19. I am future oriented.

Planning Facet

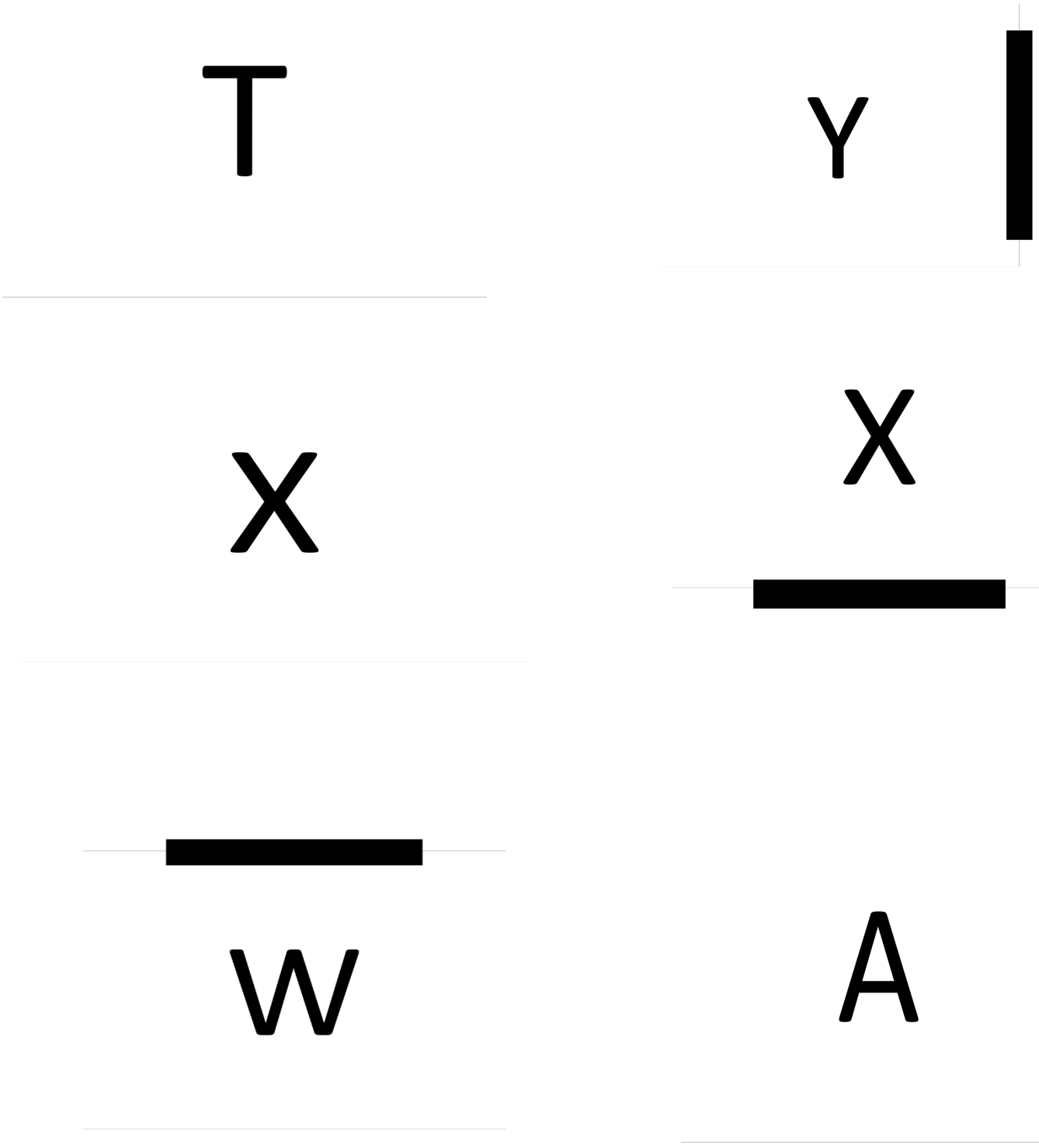
20. I plan tasks carefully.
21. I plan trips well ahead of time.
22. I am self-controlled.
23. I am a careful thinker.
24. I plan for job security.
25. I say things without thinking.
26. I save regularly.
27. I like to think about complex problems.
28. I am easily bored when solving thought problems.
29. I am more interested in the present than in the future.
30. I like puzzles.

E Appendix E. Autism-Spectrum Quotient (AQ)

	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
I prefer to do things with others rather than on my own.				
I prefer to do things the same way over and over again.				
If I try to imagine something, I find it very easy to create a picture in my mind.				
I frequently get so strongly absorbed in one thing that I lose sight of other things.				
I often notice small sounds when others do not.				
I usually notice car number plates or similar strings of information.				
Other people frequently tell me that what I've said is impolite, even though I think it is polite.				
When I'm reading a story, I can easily imagine what the characters might look like.				
I am fascinated by dates.				
In a social group, I can easily keep track of several different people's conversations.				
I find social situations easy.				
I tend to notice details that others do not.				
I would rather go to a library than to a party.				
I find making up stories easy.				
I find myself drawn more strongly to people than to things.				
I tend to have very strong interests, which I get upset about if I can't pursue.				
I enjoy social chitchat.				
When I talk, it isn't always easy for others to get a word in edgewise.				
I am fascinated by numbers.				
When I'm reading a story, I find it difficult to work out the characters' intentions.				
I don't particularly enjoy reading fiction.				
I find it hard to make new friends.				
I notice patterns in things all the time.				
I would rather go to the theater than to a museum.				
It does not upset me if my daily routine is disturbed.				
I frequently find that I don't know how to keep a conversation going.				
I find it easy to 'read between the lines' when someone is talking to me.				
I usually concentrate more on the whole picture, rather than on the small details.				

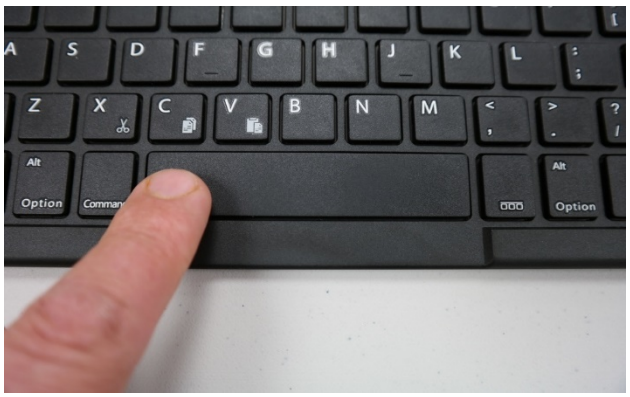
I am not very good at remembering phone numbers.				
I don't usually notice small changes in a situation or a person's appearance.				
I know how to tell if someone listening to me is getting bored.				
I find it easy to do more than one thing at once.				
When I talk on the phone, I'm not sure when it's my turn to speak.				
I enjoy doing things spontaneously.				
I enjoy doing things alone.				
I find it easy to work out what someone is thinking or feeling just by looking at their face.				
If there is an interruption, I can switch back to what I was doing very quickly.				
I am good at social chitchat.				
People often tell me that I keep going on and on about the same thing.				
When I was young, I used to enjoy playing games involving pretending with other children.				
I like to collect information about categories of things (e.g., types of cars, birds, trains, plants).				
I find it difficult to imagine what it would be like to be someone else.				
I like to carefully plan any activities I participate in.				
I enjoy social occasions.				
I find it difficult to work out people's intentions.				
New situations make me anxious.				
I enjoy meeting new people.				
I am a good diplomat.				
I am not very good at remembering people's date of birth.				
I find it very easy to play games with children that involve pretending.				

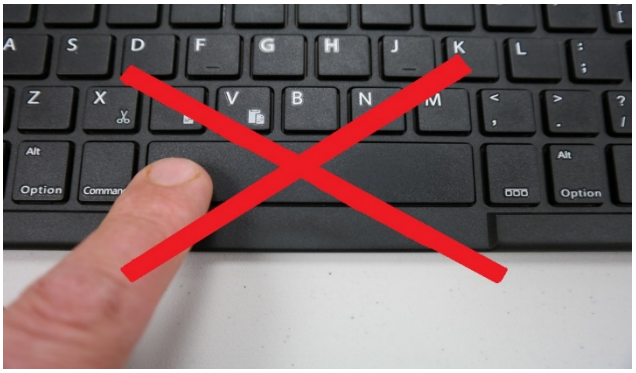
F Appendix F. The Sustained Attention to Response Task (SART)

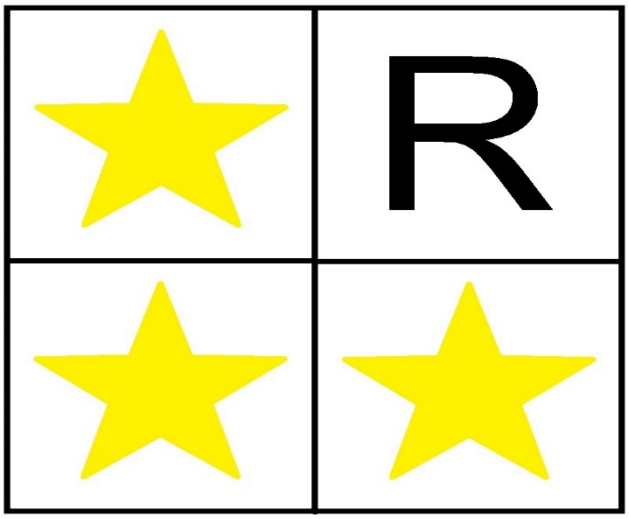


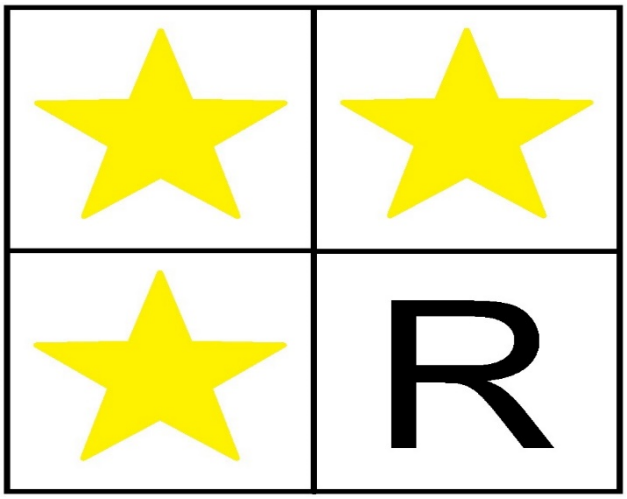
"Gorilla Experiment Builder." *Gorilla*, https://app.gorilla.sc/admin/home.

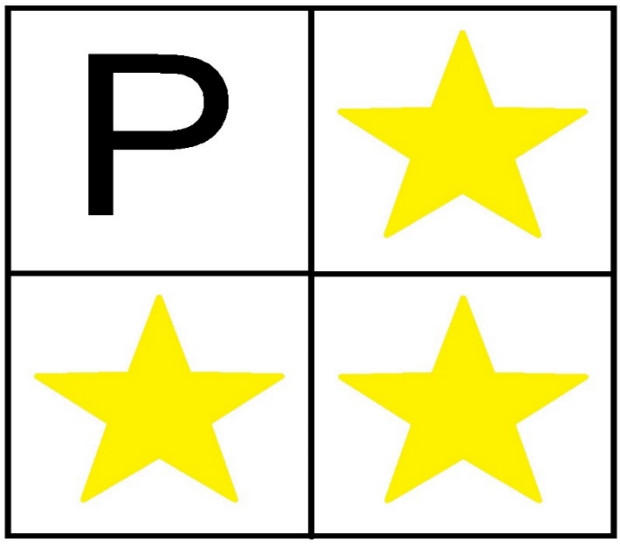
G Appendix G. Go-No/go task

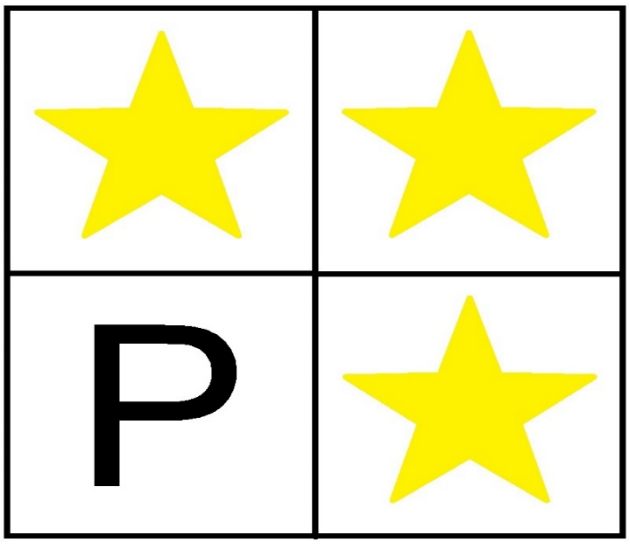












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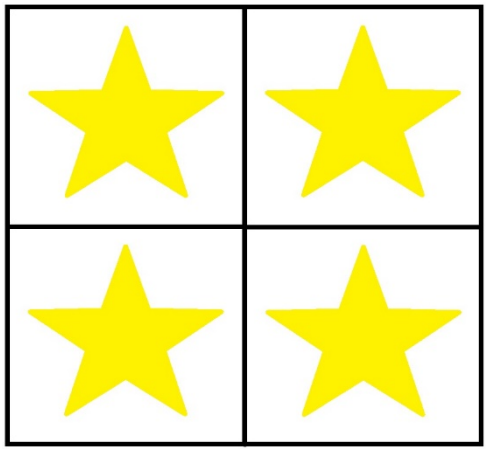


Remember!

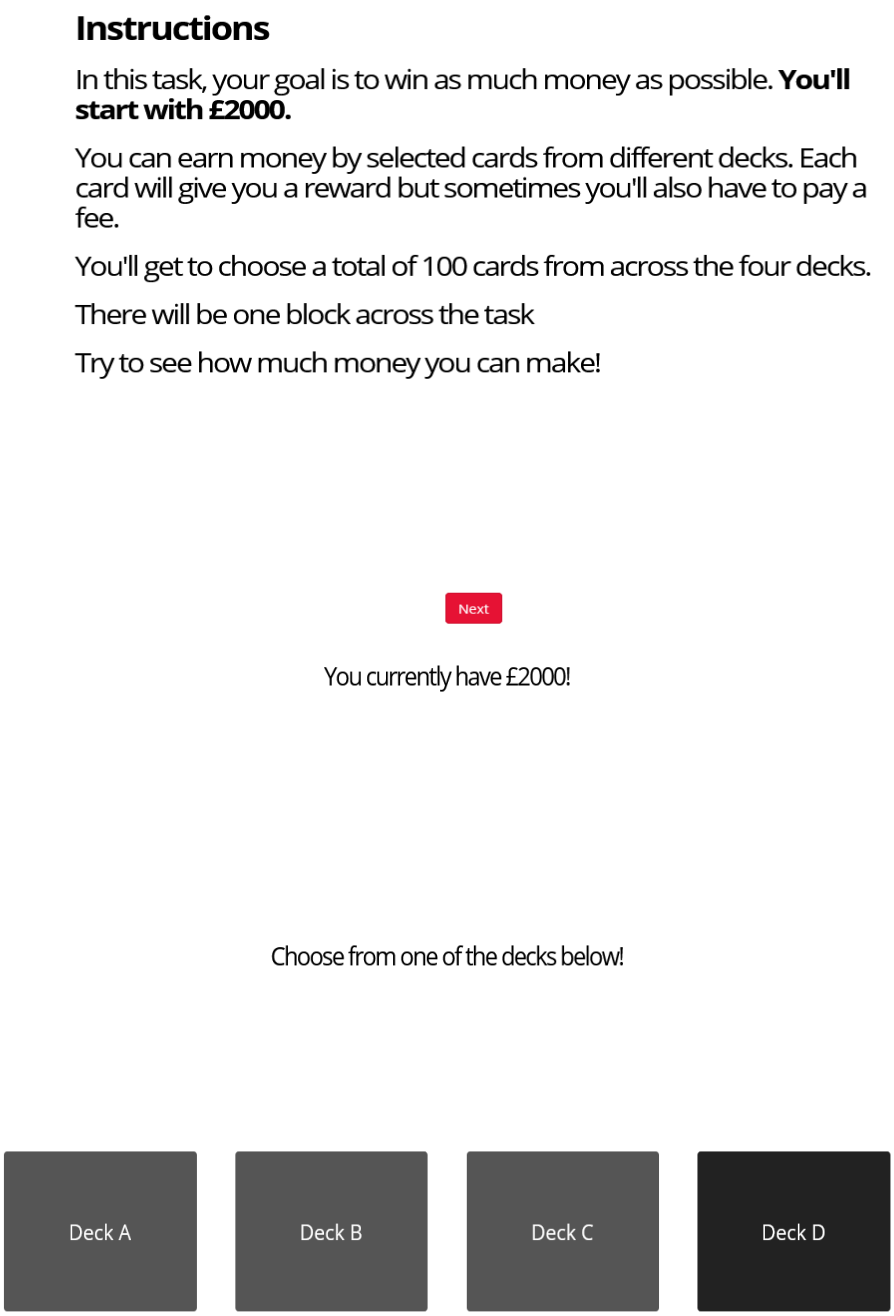
Press the **Spacebar** if you see **P**

Don't press anything if you see **R** !

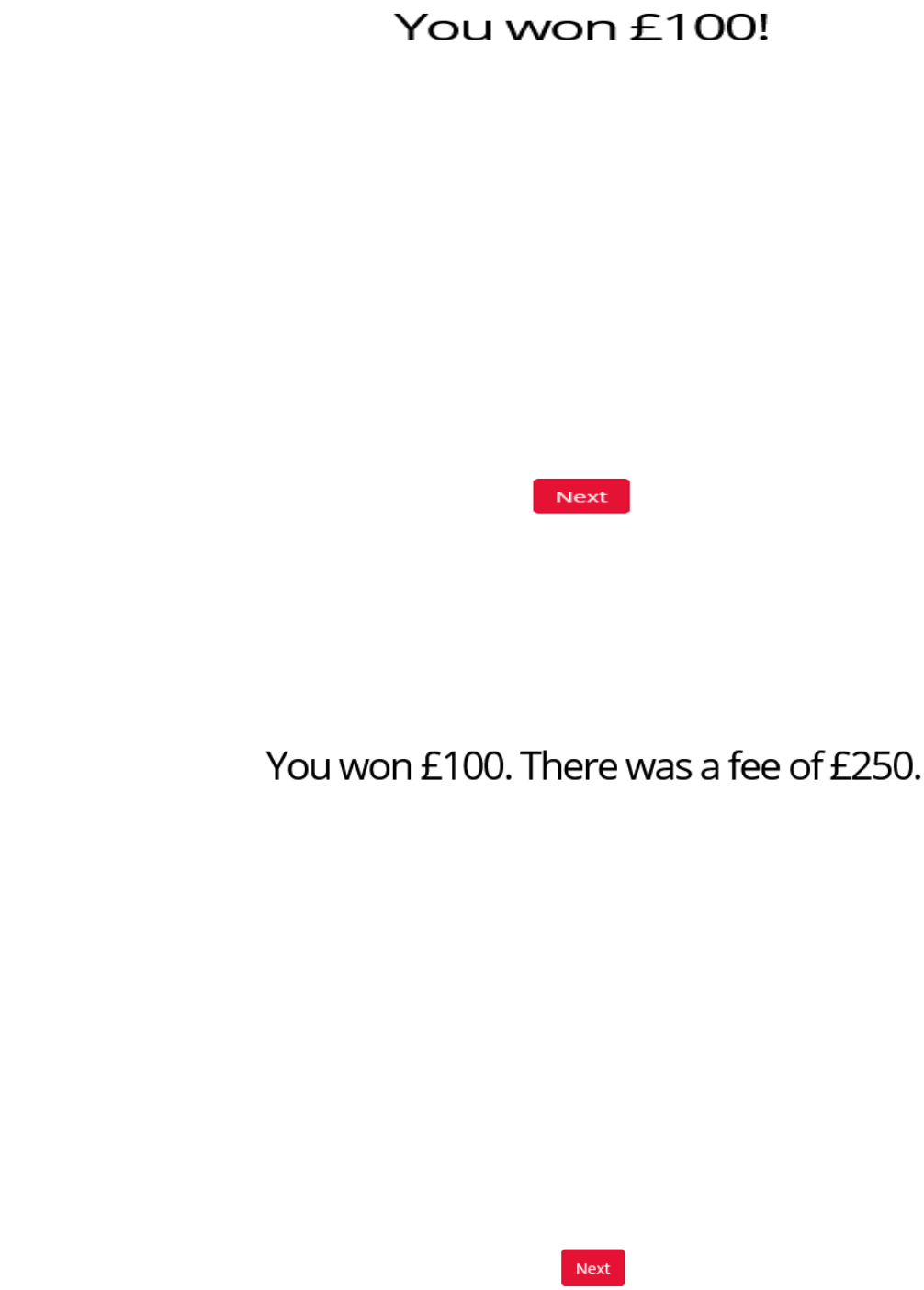
Press Space

"Gorilla Experiment Builder." *Gorilla*, https://app.gorilla.sc/admin/home.

H Appendix H. Iowa Gambling Task



"Gorilla Experiment Builder." *Gorilla*, https://app.gorilla.sc/admin/home.



"Gorilla Experiment Builder." *Gorilla*, https://app.gorilla.sc/admin/home.

I Appendix I. Study 1 Ethical Approval

The University Of Sheffield.

Downloaded: 22/10/2022
Approved: 01/04/2019

Siham Albesisi
Registration number: 180102206
Psychology
Programme: psychology

Dear Siham

PROJECT TITLE: explore the relationship between ADHD-like traits and difficulties in emotion regulation
APPLICATION: Reference Number 025413

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 01/04/2019 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 025413 (form submission date: 27/03/2019); (expected project end date: 01/06/2019).
- Participant information sheet 1057625 version 1 (08/03/2019).
- Participant information sheet 1058753 version 1 (27/03/2019).
- Participant consent form 1057626 version 1 (08/03/2019).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Jilly Gibson-Miller
Ethics Administrator
School of Education

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy:https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

J Appendix J. Study 2 Ethical Approval

The University Of Sheffield.

Downloaded: 22/10/2022
Approved: 12/05/2020

Siham Albesisi
Registration number: 180102206
Psychology
Programme: Psychology

Dear Siham

PROJECT TITLE: Emotion dysregulation and ADHD-like traits
APPLICATION: Reference Number 034332

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 12/05/2020 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 034332 (form submission date: 08/05/2020); (expected project end date: 30/09/2020).
- Participant information sheet 1078435 version 1 (24/04/2020).
- Participant information sheet 1079138 version 2 (08/05/2020).
- Participant consent form 1078436 version 1 (24/04/2020).
- Participant consent form 1079136 version 2 (08/05/2020).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Thomas Webb
Ethics Administrator
Psychology

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy:https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.

K Appendix K. Study 3 Ethical Approval

The University Of Sheffield.

Downloaded: 22/10/2022
Approved: 18/02/2021

Siham Albesisi
Registration number: 180102206
Psychology
Programme: psychology

Dear Siham

PROJECT TITLE: Impulsiveness and emotion regulation
APPLICATION: Reference Number 038208

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 18/02/2021 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 038208 (form submission date: 17/02/2021); (expected project end date: 05/05/2021).
- Participant information sheet 1086993 version 2 (17/02/2021).
- Participant consent form 1086994 version 2 (17/02/2021).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Department Of Psychology Research Ethics Committee
Ethics Administrator
Psychology

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy:https://www.sheffield.ac.uk/research-services/ethics-integrity/policy
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.