University of Southampton

Faculty of Environmental and Life Sciences

School of Psychology

Exploring the Impact of Early Life Experiences on the Development of Inhibitory Control and Impulsiveness Using the Dimensional Model of Adversity.

by

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Abstract

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This doctoral thesis holds together two interrelated works in the field of early childhood development. Parenting is a foundational element of a young child's developmental environment, impacting the development of early self-regulatory skills. Through a previous meta-analysis, Karreman et al. (2006) found that parenting correlated with inhibitory control (IC) development but acknowledged this relationship warranted further study. A systematic literature review was used to address the question 'how does positive parenting impact the development of inhibitory control in early development?'. Aspects of positive parenting were found to significantly predict increased IC both cross-sectionally and over time, with effect sizes ranging from small to moderate, and evidence for bidirectional effects was also found. Having found hopeful evidence highlighting key practices that support positive self-regulatory development in early life, it is important to consider what happens in the absence of these positive experiences.

Early life trauma experiences have been demonstrated to correlate with negative life outcomes across several domains, potentially mediated by the development of poor inhibitory control. In the present study the researcher aimed to explore the relationship between early life trauma, using the dimensional model of adversity (McLaughlin et al., 2014), adolescent impulsivity and inhibitory control, and substance use. Seventy-two participants aged 16 to 19 in mainstream education completed a series of self-report measures covering early life experience, perceived impulsivity, and current drug and alcohol use. Following this, they completed three experimental measures of inhibitory control, including one novel measure of associative inhibition. Experiences of threat and deprivation were found to differently impact development. Deprivation significantly predicted greater impulsivity, and threat significantly predicted difficulties with associative inhibition. Greater experience of trauma during development was found to predict increased adolescent substance abuse, explained by variance in threat experience but not deprivation. These results support the use of the dimensional model of adversity when considering the impact of early life experiences on development, challenging the traditionally held cumulative ACEs model. They also highlight areas for timely educational psychology support and intervention and present a framework for understanding young people's developmental context when supporting presenting needs. Held together, the two research chapters highlight a shift in how we should view children's early experiences and present several avenues for targeted support and allocation of resources.

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Research Thesis: Declaration of Authorship

Print name: Thomas Oliver Hoppé

Title of thesis: Exploring the Impact of Early Life Experiences on the Development of Inhibitory Control and Impulsiveness Using the Dimensional Model of Adversity.

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission

Signature: ..... Date: 23.07.2024

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Definitions and Abbreviations

α ..... Cronbach's Alpha reliability statistic.

ACE ..... Adverse Childhood Experience

ACPT-P ..... Auditory Continuous Performance Test for Preschoolers

ADHD ..... Attention Deficit Hyperactivity Disorder

ANOVA ..... Analysis of Variance; statistical test to measure differences between more than two groups.

ANCOVA ..... Analysis of Covariance

ASD ..... Autism Spectrum Disorder

ASSIST-Lite ..... Alcohol, Smoking, and Substance Involvement Screening Tool – Lite

β ..... Standardised regression coefficient.

BIS-11 ..... Barratt Impulsiveness Scale, eleventh edition

CASP ..... Critical Appraisal Skills Programme

DCCS ..... Dimensional Change Card Sort

EC ..... Effortful Control

EEF ..... Education Endowment Foundation

EF ..... Executive Function

EHCP ..... Education, Health, and Care Plan

EP ..... Educational Psychologist

ERIC ..... Education Resources Information Centre

F ..... F-Value; variation between sample means/variation with samples.

FASD ..... Foetal Alcohol Spectrum Disorder

IC ..... Inhibitory Control

IQ ..... Intelligence Quotient

LAB-TAB ..... Laboratory Temperament Assessment Battery

LCA ..... Latent Change Analysis

M ..... Mean

MDMA ..... Methyl-Dioxymethamphetamine

NB ..... Nota Bene (note well); used to indicate a piece of important information to the reader.

NEET..... Not in Education, Employment, or Training

NR/UTC ..... Not Reported or Unable to Calculate

NSPCC ..... National Centre for the Prevention of Cruelty to Children

OCD ..... Obsessive Compulsive Disorder

p..... Denotes significance value.

PSDQ..... Parenting Styles and Dimensions Questionnaire

r..... Denotes Pearson's correlation.

RCA ..... Residualised Change Analysis

SASB..... Structural Analysis of Social Behaviour

SD ..... Standard Deviation

SE..... Standard Error

SEN ..... Special Educational Needs

SES..... Socio-Economic Status

SSRT..... Stop-Signal Reaction Time

t..... T-Statistic, used to determine difference between two groups.

T(n) ..... Specific timepoint in longitudinal research, e.g., T1, timepoint 1

WEIRD ..... Western, Educated, Industrialised, Rich, and Democratic

Chapter 1: Introduction

1.1 Drawing together two fields of research.

This thesis sits within two fields of research: the study of children's early developmental experiences, and the study of self-regulatory cognitive processes. More detailed and nuanced explanations of these fields can be found in both succeeding chapters, and the following supplies a brief overview to aid the reading of this body of research. The cognitive process of interest is inhibitory control, including its development across childhood (chapter two), and into adolescence (chapter three). Inhibitory control nests within executive functioning, which itself is considered a part of our self-regulation (Chae, 2022; Corno, 1986; Inzlicht et al., 2021). Broadly, inhibitory control is our capacity to stop (inhibit, resist, supress, etc.) a dominant response in favour of a sub-dominant response (Diamond, 2013; Yu & Hsu, 2019). There are two main sub-domains of inhibitory control: behavioural inhibition, and cognitive inhibition (Bari & Robins, 2013). Put simply, behavioural inhibition is the stopping of actions while cognitive inhibition is the stopping, or redirecting, of thoughts and attention. In the third chapter, we will explore a further nuance within inhibitory control: associative and non-associative inhibition. Briefly, associative inhibition occurs when the presence of a stimulus or context weakens the relationship between a cue and a response. Non-associative inhibition refers to more general stopping of prepotent (dominant) behaviours without specific context or cued association (Brudan et al., 2024; Sosa, 2024).

Impulsiveness, or impulsivity, is often considered to be partially contingent on failures of inhibition. Impulsivity also includes further components such as failures of attention, failures of planning, novelty seeking, and decreased sensitivity to negative consequences (Barratt, 1994; Fino et al., 2014; Moeller & Dougherty, 2002; Nigg, 2016). Impulsivity as a construct is not without controversy, with opinions ranging from outright rejection of its use through to proposing a universal "i" akin to the controversial concept of universal "g" used to describe general intelligence (Huang et al., 2024; Spearman, 1904; Strickland & Johnson, 2021). As with many concepts in psychology, a more nuanced position is proper. The term impulsivity captures a useful collection of behaviours and traits that can be helpful to consider in research, but its generalisability is hampered by the heterogeneity often found in attempts to capture universal truths about individual development. In the third chapter we will be exploring further the relationship between inhibitory control and impulsivity, considering the above nuances and theoretical underpinnings. In this research we used a self-report measure of impulsivity (Barratt Impulsiveness Scale 11), capturing individuals' own views of their impulsive traits. In contrast,

we used experimental measures of inhibitory control to try to dispassionately capture participants' relative capacity for inhibition.

My systematic literature review draws together recent research in the fields of positive parenting and inhibitory control development, building on an earlier review published in 2006 which explored the impact of parenting on broader self-regulatory and executive functioning development (Karreman et al., 2006). The decision to constrain the present review to positive parenting and inhibitory control was made to enable rich and nuanced discussion of positive parenting factors and to completement my empirical research, which explores *"what can happen when it goes wrong"*, with a more hopeful review of *"what can happen when it goes right"*. To conclude we will make recommendations for future support and investment in early intervention services. There is scope for future research that considers the impacts of negative parenting factors, dovetailing with the review presented in chapter two of this thesis.

In my empirical research, we explored the impact of early trauma experiences on the development of inhibitory control, using the dimensional model of trauma, explored in greater detail in the third chapter (McLaughlin et al., 2014). In brief, the dimensional model is a novel framework through which we can view trauma experiences in psychology research, in which trauma is divided into deprivation experiences (such as poverty, institutional deprivation, cognitive deprivation etc.) and threat experiences (such as physical and sexual abuse). The longer held framework of cumulative risk (ACEs) can still be useful in exploring children's general experiences of early adversity. However, the dimensional model acknowledges the growing body of research showing diverging developmental pathways following deprivation vs. threat experiences. While we did not find all the expected outcomes, there were noteworthy results highlighting differences in impulsive trait development and substance use following deprivation and threat. The expected and unexpected results, and the implications thereof, are discussed in the third chapter.

There are two primary areas where my empirical research makes a novel contribution to the field of study. The first is through the validation of novel measures. This research made use of the Threat, Deprivation, and Unpredictability questionnaire, a recently developed measure of dimensional trauma (McLaughlin et al., 2014). This measure has not yet been used extensively and is unvalidated for use with an adolescent sample. Through this research we found this measure to show excellent reliability, and strong factor loadings for each of the subdomains[1].

[1] Cognitive, emotional, and physical deprivation (in the home); cognitive, emotional and physical deprivation (in the community); threat in the home; threat in the community; threat due to identity; experience of major life events (such as natural disaster).

This measure, and the dimensional model of trauma, are useful frameworks for future research in this area and should be considered by researchers. This research also made use of a novel measure of associative inhibition through extinction; this measure was developed by Dr Steven Glautier, and comparable procedures have been used with adult samples. Through this research we explored the validity of using this approach to measure associative inhibition in an adolescent sample, finding promising results and some suggestions for future research.

The second area of novel contribution comes from the use of the dimensional model of trauma in this context. My empirical research is, to the best of my knowledge, the first to explore differences in inhibitory control development following early experiences of trauma specifically using the dimensional model of trauma. Acknowledging limitations discussed in the third chapter, this research adds nuance to the understanding of how trauma experiences lead to difficulties with self-regulatory development in adolescence. There are also several avenues for future research that would serve to expand and confirm the results we found.

1.2 Rationale and driving motivations.

I have a long-held desire to engage with work that supports and 'betters' the experiences of those who have been mistreated. A core motivating event for me was in my first teaching practice, during which I saw the transformational effects of warm, trauma informed support for a 10-year-old boy in my class who had experiences of early maltreatment and was, at the time, under local authority care. I chose to position my thesis research within the field of adverse childhood experiences to add to the understanding of how to best support and advocate for those who have been mistreated in their early development. Through my developing educational psychology practice, I have seen the value of early family support and the central importance of the home environment in the difficulties many children face. My literature review has given me an opportunity to robustly advocate for family intervention and early support to bolster the positive developmental trajectories that follow positive parenting experiences.

1.3 Defining my research paradigm.

When approaching a piece of psychological research, it is important to understand the assumptions made by the author, their core beliefs about the nature of reality and how one might come to know about it, and the role of their values and beliefs in the knowledge-generating process (Rehman & Alharthi, 2016). My personal research paradigm is most accurately captured by that of post-positivism, with some notable nuances discussed below.

1.3.1 Ontology and Epistemology - "What is true and how can we know?"

The ontology that this thesis sits within is critical realism, the consideration that there is an objective truth that stands independent of perspective (Scotland, 2012; Young & Ryan, 2020). However, I also hold true that we cannot claim to have a full and complete understanding of that truth through experimentation and testing alone, with social reality being inherently difficult to access (Bisel & Adame, 2017). Next to this, I also believe that others, and I myself, hold constructed perspectives that are important to recognise and consider, in so much as they inform our understanding of how an individual engages with the world around them. These perspectives do not necessarily constitute objective truth, and it can be simultaneously true that an individual's situation, and their perception of it, do not line up. Thus, knowledge sits independent of the knower, but is inherently influenced by the one seeking to know it (Sharpe & Bhaskar, 1975). In the context of this research, this view has informed the use of both experimental and self-report data, allowing the individuals' perceptions to be captured while also looking to measure objective information about their current skills and capacities that further refine our understanding of existing concepts. Through psychology research we primarily test the hypotheses and conclusions of those who come before us in an effort to refine our understanding of what is true (Young & Ryan, 2020).

1.3.2 Methodology - "How can I find out?"

My methodological assumptions are based on that of post-positivist experimentation, adhering to the 'scientific method' and looking to make precise measurements that inform our understanding of underlying phenomena, testing and refining the existing understanding and assumptions within the field. To this end, I sought to generate quantitative, experimental data using standardised tests and closed-ended Likert scale questionnaires. It was also important for me to acknowledge participants' context in my research, considering not only the substantive nature of the data collected, but also the context within which the collection occurred. Participants may have been influenced in how freely they answered the questions depending on, for example, my presence as a researcher, or their expectations coming into the process. Their capacity to engage with the experiments may also have been impacted by situational factors. While every attempt was made to help participants feel at ease, it should be acknowledged that taking part in research can induce anxiety or other pre-occupying emotions which may influence participants' inhibitory capacity. The steps taken to standardise participants' experience, and potential considerations for future research are explored in the third chapter.

1.3.3 Axiology - "Why do I care?"

Research conclusions hold value and utility, and how we generate those conclusions ought to be considered in context of researchers' individual values and beliefs. It is not possible or desirable to remove the contextual understanding of individuals from the 'knowledge' we have gained about them. Whilst the collective knowledge built by psychology research is ever shifting and refining, the conclusions drawn are, nonetheless, valuable in their implications for policy, ascribing support, and understanding the nature of how individuals interact with one another and the world around them (Scotland, 2012). It was also important for me that participants felt that through my research I was learning *with them* rather than *doing to them* (Ryan, 2006, pg. 12-26). This meant that the data collected ought to be as objective as possible, whilst also holding the wellbeing and inherent value of the individuals in mind. The challenges of reconciling rigorous psychological research with a desire to support those I worked with are discussed below.

1.4 Ethical considerations

Prior to completing this research, ethical approval was granted by the University of Southampton Ethics Committee and the Research Governance Office. All participants were over the age of 16, and therefore able to consent for themselves. However, careful consideration was given to the decision not to seek added consent from parents/caregivers (Hunter & Pierscionek, 2007; NSPCC, n.d.). Understanding a child's competence and capacity to give informed consent applies more stringently to those under 16, but the conclusions drawn by Hunter and Pierscionek apply to my reasoning also. They present two circumstances in which seeking individual consent alone supersedes seeking parental consent. The first scenario applies when significant personal benefit is expected for the participant with relatively minor risk. The second applies when the research may generate *greater societal benefit* whilst presenting minor risk to the participant, yet *with the potential to raise parental objection* (Hunter & Pierscionek, 2007).

This second scenario applies more readily to my research. The findings and implications raise significant challenges to the application of education and social care funding/support and add to the growing literature championing the advocacy of children and young people who have been mistreated. However, as can be reasonably inferred, parents may be reluctant to consent to their children disclosing their own mistreatment. There was also potential harm that could occur should parents be informed of their child's participation, most notably if the participant is still living through the situations disclosed as part of the research (National Academies Press, 2014). Holding in mind the expected societal benefit of the research with the expected reticence

and potential for harm from participants' guardians, the decision was taken to not seek parental consent, nor were parents/guardians specifically informed. To best support participants to give informed and considered consent, no deception was used, and the information given to participants prior to taking part clearly disclosed the potential risks involved, most notably the potential for transient discomfort (Newman & Kaloupek, 2009). It is important for children and young people of all ages to feel like active participants in the work that is done with them (not *to them*), and the skills I have built through my practice as a trainee educational psychologist helped me to ensure participants felt heard, included, and comfortable throughout the research process (Lyons & Thomas, 2024).

A further element of this research that called for significant ethical consideration was how to proceed following any disclosure of information that indicated current and ongoing harm to the participants, either at their own impetus (current substance use) or at the hands of others. There were two guiding principles in my decision making, those of beneficence and nonmaleficence. Participants autonomously chose to take part in my research, with full information about the nature of questions they would be asked, and the anonymity of study involvement may have been a significant deciding factor to take part. Withdrawing anonymity may put participants at risk of harm, as they may fear retribution from the perpetrators of disclosed trauma (Newman & Kaloupek, 2009).

The principle of nonmaleficence guided me to keeping strict anonymity, limiting the potential for my research having a directly harmful impact. To best offer support for participants whilst protecting their anonymity, participants were provided with a list of available resources that they could independently and anonymously engage with. These included locally available support through charities and nationally available support such as Childline. From a safeguarding perspective, it was important for me to reflect that the participants were not making a trusted disclosure to me, they were making an anonymous contribution to research. From a practical perspective, the participants were anonymous prior to any disclosure being made, making specific offers of support impossible. While, as the researcher, it may have been possible to infer which participant had given which answers, all collected data was stored with a participant number rather than name (and this number is not stored with their consent). Engagement with support services needs to be an informed and consenting process for the participants and offering support without disclosure married the desire to be of benefit to the participants and address ongoing harm, with the need to minimise added risk from research participation.

1.5 Reflective comments

The process of constructing this thesis has been one of great challenge and personal reflection. I have long relied on my base of academic writing skills and capacity to quickly synthesise information to find relative success in my undergraduate, and masters level study. However, completing a doctoral thesis has been a humbling experience as I have found myself outside my comfort zone and capacity, needing to rely on the experience and support of others in ways that I am not used to – or comfortable with. An aspect of the process that I have found particularly challenging is holding two competing workloads and headspaces. Completing my thesis research and write up alongside an increasingly independent traded and statutory caseload through my professional placement has challenged my working memory and task-switching capacity. It has also challenged my resilience and underlying motivation to press on.

An aspect of the thesis process that I found particularly challenging was confronting the pervasive difficulty in psychology and education research to gain an adequate sample. I found it increasingly discouraging and exasperating being met with responses ranging from complete indifference to active rejection from schools and colleges as I sought to recruit for my research. I am indebted to those who, through existing professional relationships, were able to secure support from the education settings that took part in my research. It has been insightful to reflect on capacity in education, both at the level of individual members of staff and in the ethos of whole education settings. Schools and colleges are desperate for additional support, equipping, and help to support the children and young people in their care. However, due to the enormity of demands placed on them and the lack of resources to meet these demands, education settings lack the capacity to engage with projects such as doctoral thesis research. I bear no grudge to the education settings that declined to participate, as I have seen through this research and my professional practice that education settings are at their maximum capacity.

In formulating the research questions and methodology for this research I created several challenges for myself. The scope of my initial plans was far-reaching and broadly unrealistic in the context of an educational psychology doctorate. The process of refining my ideas and operationalising them into something that could be achieved with the time given was difficult. I thoroughly enjoyed the hands on, in person, rich data collection experiences that I had through this thesis. However, requiring an hour or more per participant created undue strain on my own capacity, and limited the eventual sample obtained.

Through all these challenges, however, I can see the skills that I have been developing and the knowledge that I will take into my professional practice going forward. I have built more robust strategies and approaches to managing workload demands and personal stress. I have

learned to be vulnerable and rely on the support and encouragement of others, something that has never come comfortably for me. Finally, and of perhaps the greatest importance, working first hand with the young people who took part in my research has continued to stoke my desire to engage with work that advocates for, champions, and builds up those who have been mistreated, marginalised, and hurt by others. As I enter the EP profession, I sincerely hope that my work achieves this, even in small part.

1.6 Dissemination plan

The following two chapters stand independent of one another as publishable articles of research. Several potential journals were held in mind when preparing the final manuscript and following successful completion of this doctoral thesis the two papers contained within chapters two and three may be individually prepared to seek publication. Further to potential peer-reviewed journal publication, several points of dissemination have been agreed with the participating education settings. So that the findings and implications of this research can have an immediate beneficial impact on the target population, participating education settings have been offered staff professional development training to explore the implications of my research for their practice. The aim of this staff training will primarily be to promote a trauma informed understanding of the difficulties and needs the young people in their care have. I also aim to encourage staff to reflect on their own practice, fostering an environment that promotes secure, person-centred support for all children regardless of their developmental experiences.

Many of the findings and implications of my research also hold valuable insight for educational psychology professionals. I have already negotiated an opportunity to present my thesis research to a local authority educational psychology service in the south of England, and it is my intention to seek further opportunities to share my research with colleagues and psychology professionals. Further to this, and perhaps as importantly, this research has impacted my own understanding and practice and I will hold the implications found closely as I seek to advocate for those I support. As psychologists, it should be a lifelong endeavour to engage with current research and developments in best practice. It is my sincere hope that my thesis has a positive impact on the lives of children and young people, and those who serve them.

Chapter 2 Systematic Literature Review

2.1 Title

How Does Positive Parenting Impact the Development of Inhibitory Control in Early Development?

2.2 Abstract

Parenting is one of the most foundational elements of a young child's developmental environment. Through a previous meta-analysis, Karreman et al. (2006) found that parenting correlated with inhibitory control (IC) development but acknowledged this relationship warranted further study. This review aims to address the need for further study and review the almost 20 years of research that has taken place since their analysis by exploring the impact of positive parenting characteristics on the development of IC in pre-school aged children. Studies were selected for inclusion if they measured positive parenting and IC for children aged 2-5 (+/- 6 months), were published after 2005, and did not rely solely on self-report data. In total, ten studies were included in this review with a total of 3900 participants and their primary caregivers. A range of IC measures were used for assessment, with most studies employing versions of the "go/no-go" or "Stroop" tasks. All ten included studies were assessed to be of adequate quality for inclusion. Synthesis of these studies found that positive experiences of parenting, characterised by warm, responsive regard and structured scaffolding, have a significant impact on the development of inhibitory control in early childhood. Aspects of positive parenting significantly predicted increased IC both cross-sectionally and over time, with effect sizes ranging from small (.110) to moderate (.390), and evidence for bidirectional effects was also found. The results of this review have implications for targeted parenting support and raise important questions about allocation of statutory resources in early development.

2.3 Introduction

2.3.1 What is Inhibitory Control?

Self-regulation, the ability to direct our emotions, cognitive skills, and behaviours towards goals, is often considered an overarching construct within which we find cognitive processes, affective processes, and metacognition (Chae, 2022; Corno, 1986; Halfon et al., 2018; Inzlicht et al., 2021). Executive functions (EF) include our capacity to shift our attention between different tasks and stimuli, inhibitory control, planning, organisation, and working memory capacity (Benson et al., 2013; Lucas et al., 2013; Semrud-Clikeman et al., 2013). Untangling existing research is challenging, as some psychologists define self-regulation as a component part of EF, rather than the other way around (Benson et al., 2013; Rhodes et al., 2016; Taha, 2017). Effortful control (EC) can be described as the 'muscle' that we need to strain to inhibit responses. EC is our ability to deliberately supress a dominant response, or deliberately activate a sub-dominant response, to pursue a goal (Chae, 2022; Duckworth et al., 2013; Lin et al., 2019). A distinction often drawn between EC and EF is the temperamental component of each. EF can be considered a 'cold' cognitive process without affective components, whereas EC is often considered a 'hot' process that can be understood in terms of emotional and affective responses (Chae, 2022). The 'hot' or affective systems tend to emerge in earlier development and research in younger samples tends to focus on EC rather than EF.

Inhibitory control (IC) is the cognitive process through which we inhibit, or resist, a dominant response in favour of a sub-dominant response to perform goal-directed actions, override emotional responses, or engage in socially preferable behaviour (Diamond, 2013; Yu & Hsu, 2019). The concept of *inhibition* is more broadly used to describe a range of psychological and neurological processes. For this review, the term *inhibitory control* can be understood to include response inhibition and attentional inhibition (Bari & Robins, 2013; Tiego et al., 2018). Inhibitory control nests within the broader constructs of executive function, effortful control, and self-regulation.

Inhibitory control and effortful control are often conflated in research, with both referring to our capacity to voluntarily resist a dominant urge. Studies included in the present review include measures of inhibitory control (including affective and non-affective inhibition), delay inhibition (inhibiting a dominant response with the prospect of reward), effortful control, and conflict effortful control (inhibiting a dominant response while executing a conflicting response without obvious reward). It is possible to further categorise these processes in early

childhood as forming part of a child's *temperament*. Child temperament, of which IC is a component, has been shown across longitudinal research to correlate with adult personality traits and adaptive development (Saudino & Gagne, 2016). To provide some clarity on the above; inhibitory control can broadly be considered a component part of our core executive functions needed to supress pre-potent (dominant) responses and actions (Bari & Robins, 2013).

2.3.2 Why is Early Inhibitory Control Important?

There is evidence that early difficulty with inhibitory control associates with several negative outcomes in development and school readiness such as impulsive behaviour, cognitive difficulties, unstable temperament, externalising problems, internalising problems, and difficulty developing positive relationships with peers (Gagne & Saudino, 2009; Saudino & Gagne, 2016; Ciairano et al., 2007). Children who have poor IC have been found to display more externalising behaviours (behavioural problems that occur in interaction with the social environment) and aggression when they enter early education. However, the relationship between poor IC and externalising problems is not significant for very young children where impulsive and uncontrolled behaviours are developmentally appropriate (Nikstat & Riemann, 2020; Utendale & Hastings, 2011).

Early IC also correlates with several cognitive and academic factors, both directly and indirectly influencing skills needed for successful academic learning (Allan et al., 2014). Early IC has been found to correlate with the acquisition of maths skills and, to a lesser extent, literacy skills. Through these, and more general learning-related difficulties, IC can have a significant impact on general educational trajectories with poor IC leading to lower attainment in later years (Allan et al., 2014). There is also significant evidence of longer-term difficulties arising from poor IC in childhood, including correlations with impulsive and negative risk-taking behaviours in adolescence and adulthood.

There are many correlations between the development of early executive function skills, particularly inhibitory control, and the development of social capacity. Children with better IC are more likely to be rated highly on social-skills in early education and may display reduced internalising behaviours - behavioural problems that focus in on oneself such as anxiety and withdrawal (Nikstat & Riemann, 2020; Rhodes et al., 2009). They may also demonstrate more competent use of IC related skills in social interactions such as handling others' perspectives and inhibiting aggressive or non-cooperative behaviours (Ciairano et al., 2007). Inhibitory

control also correlates with social competence, popularity, shyness, and sympathy, contingent on emotion regulation. The capacity to regulate our emotional responses and our inhibitory capacity are highly related processes for tasks that require emotional understanding and control, such that both indicate voluntary temperamental control, and they undergo rapid interrelated development in early childhood. Carlson and Wang (2007) found that, while increased IC predicts improvements in emotion regulation to a point, there is a "sweet spot" followed by a drop in emotion regulation capacity for the highest IC scores. Those with low IC (lacking control) are more likely to struggle with externalising problems and those with high IC (over controlled) are more likely to struggle with internalising problems. Those with high levels of IC may struggle in social settings due to increased shyness, sensitivity to threat, negatively biased perceptions, social withdrawal, and a proclivity towards anxiety (Gray, 1970; Thorell et al., 2004).

2.3.3 The Emergence of Inhibitory Control in Early Life.

The development of IC is most significant during the first years of life, emerging between the ages of one and two and undergoing rapid development between the ages of two and five (Roskam et al., 2014). Executive function skills, including IC, continue to develop across childhood and IC may reach maturation as early as 12, with other estimates ranging to later adolescence (Fosco et al., 2019; Saudino & Gagne, 2016). As discussed above, the observed relationships between early IC and negative cognitive/behavioural outcomes become stronger over time. In very early childhood, behaviours that would be considered externalising in school-age children, such as aggression, may be developmentally appropriate and part of a normal developmental process (Utendale & Hastings, 2011).

Inhibitory control has been shown to be subject to genetic influences, with estimates ranging from 38% to 60% of the variance in IC explained by genetic factors at the age of two (Saudino & Gagne, 2016). This relationship, observed in mono-zygotic twins over time, becomes non-significant by the age of three as an increasing amount of variance is explained by shared environmental factors including parenting experience. Gagne and Saudino (2016) conclude that IC performance *continuity* can be attributed to genetic factors, and IC performance *change* can be attributed to environmental factors. Previous research conducted with twins has found effortful control (analogous with IC) to be up to 79% heritable (Smith et al., 2013).

2.3.4 Parenting factors.

Changes in IC over time are largely attributable to environmental factors, with the most significant being primary caregiver relationship. Significant research evidence has demonstrated that parenting influences, both positive and negative, have an impact on the development of early EF skills including IC. In a systematic review of literature published in 2006, Karreman and colleagues found that the way parents discipline, set limits for, respond to, and express warmth to their children relates to emergent self-regulation capacity. Self-regulation, defined as compliance, inhibition, and emotion regulation was found to have several associations with their identified parenting categories (positive control, negative control, and responsiveness). Positive control, including clear guidance, low power-assertion, instructional behaviour, and moderated limit-setting, positively correlated with self-regulated behaviours. Negative control, comprising coercive and power-assertive control, intrusiveness, over-control, and over-involvement, negatively correlated with self-regulated behaviours. In their meta-analysis the authors did not find a significant relationship between responsiveness and self-regulation (Karreman et al., 2006).

The emphasis of parenting shifts between care and nurture in very early parenting, to meet needs for guidance, secure boundaries, limit setting, and shared exploration of new learning (Verhoeven et al., 2007). Parenting also shifts in relation to stressors and aspects of the parent's own character and context. Verhoeven and colleagues report that parents who score highly on agreeableness, extraversion, openness, and conscientiousness are more likely to score highly on measures of positive parenting characteristics such as positive affect, nurturing, and adaptive parenting (Verhoeven et al., 2007). The converse is true, and parents who themselves lack self-control or struggle with EF skills are more likely to exert psychological control and physical punishment on their children, amounting to harsh and "negative" parenting with can lead to reduced child autonomy and self-regulation capacity (Maughan & Cicchetti, 2002; Moilanen et al., 2010). The social context, such as marital satisfaction and socio-economic status (SES), plays a significant role in the development of parenting behaviours. Parents with low SES are more likely to report high levels of harsh parenting, and financial pressures can undermine a parent's capacity for adaptive and responsive parenting (McLoyd, 1990). Additionally, the characteristics of the child can play a role in determining how parents parent. One such example is that mothers of children with higher IC have been reported to exhibit higher levels of positive support (Verhoeven et al., 2007). The bidirectional effects of

parenting on children's IC and children's IC on parenting will be explored further in the present review.

2.4 Rationale and Objectives

The present review is intended to complement the meta-analysis of 42 studies completed by Karreman et al. in 2006. They explored three categories of parenting; positive control, negative control, and responsiveness, finding that only positive control (weighted mean $r = .008$, $p < .005$) and negative control (weighted mean $r = -.14$, $p < .001$) were significantly associated with self-regulation in a pre-school sample (Karreman et al., 2006). They did not find any significant relationships between parental responsiveness and self-regulation (weighted mean $r = .03$, not significant), concluding that this may be due to ceiling effects. That is, that all parents measured exhibited "good enough" parental responsiveness, consequently squashing the observed effects. In the present review these relationships will be further explored through novel research published since 2005. Karreman and colleagues highlight in their review that IC was a lesser researched construct compared to other aspects of self-regulation and, as such, will be the focus of the present review.

Following their initial review (search completed in 2004) several longitudinal studies of parenting and IC development have been published. Karreman et al. (2006) noted that only cross-sectional research was included in their review, limiting the conclusions that can be drawn about the direction of effects. They also critiqued the use of quite broad parenting categories in their review, with the need for additional nuance. The focus of this review is solely on positive parenting and will hopefully capture more nuanced relationships between different aspects of positive parenting and IC development. A further limitation reported by Karreman et al. (2006) was the lack of socio-cultural and financial variation in their analysed studies. The present review aims to explore any arising moderating or mediating factors in the relationship between parenting styles and IC development, guided by the presenting data. A meta-analysis was not completed in the present study due to limited comparable effect size data which prevented creation of summed variables and forest plots.

2.5 Methods

2.5.1 Research questions

This review was conducted with the aim of exploring how positive parenting experiences in early childhood impact the development of inhibitory control, with a view to better understand how some young people develop challenges with IC as they enter school. The following research questions were considered:

- How do different aspects of positive parenting influence the development of early inhibitory control skills?
- What other factors influence the development of early inhibitory control skills, and how do these interact with positive parenting?
- What evidence is there for a bidirectional relationship between children's inhibitory control development and parents' capacity for positive parenting?

2.5.2 Information sources

Consistent with Karreman et al. (2006), records for this review were sought from the American Psychological Association's database PsychInfo, and the Education Resources Information Centre (ERIC). Additionally, records were sought from Scopus, which captures research across life, social, physical and health sciences. Journals that are included in the Scopus database are annually assessed for quality such that they meet the minimum requirements of peer review. Scopus was included to broaden the available research for this review. Consistent with Karreman et al. (2006), we did not seek literature from databases of doctoral theses such as ProQuest as all included studies must be published in a peer-reviewed journal.

2.5.3 Search strategy

Scoping searches were conducted in January 2024 and final searches were undertaken in February 2024 using a search strategy derived from Karreman et al. (2006), with several notable changes. To answer the more specific question proposed in this review, searches were constrained to "inhibitory control" measures, rather than broader measures of self-regulation. We also chose to include participants who had any educational diagnosis such as attention deficit hyperactivity disorder (ADHD), in contrast to the original study. This decision was taken to broaden the likely available research, and any observations made regarding diagnoses could form part of discussion. Karreman et al. (2006) excluded non-western research due to expected

cross-cultural differences in parenting. Research from other cultures was considered for inclusion in the present review. However, scoping searches did not reveal any non-western research that met the inclusion criteria.

Table 1: Search strategy with yielded records.

Database	Search Strategy	Records yielded
PsychInfo	*Searching within key words.* S1: (Parent* OR "parental behavio#r" OR mother* OR father* OR maternal OR paternal OR "parent-child" OR "child-rearing")[1] S2: "IC" S3: S1 AND S2	675
ERIC	*Searching within key words.* S1: (Parent* OR "parental behavio#r" OR mother* OR father* OR maternal OR paternal OR "parent-child" OR "child-rearing") S2: "IC" S3: S1 AND S2	155
SCOPUS	*Searching within key words.* S1: (Parent* OR "parental behavio#r" OR mother* OR father* OR maternal OR paternal OR "parent-child" OR "child-rearing") S2: "IC" S3: S1 AND S2	116

[1]Parenting terms derived from Karreman et al., 2006 simplified through truncation and wildcard syntax.

Table 2: Inclusion and exclusion criteria

Study Item	Inclusion Criteria	Exclusion Criteria
Type of research	Peer-reviewed, published papers.	Book chapters, systematic reviews, theses, dissertations
Participants	Aged between 2 and 5 at the time point where IC and parenting measures were taken (+/- 6 months). NB papers screened based on reported age range.	Younger than 18 months old or older than 5.5 years old at the point of relevant data collection (longitudinal studies with further data collection time points were considered).
Language	Paper accessible in English	Paper not accessible in English
Date	Published 2005 onwards	Published before 2005
Measures	Experimental/observed measures of IC and parenting quality	Exclusively self-report/parent report measures.

2.5.4 Exclusion of self-report studies

Studies relying solely on self-reported measures were not included due to the questionable reliability of self-report data in this field (Morsbach & Prinz, 2006). Parents may be reluctant to admit perceived deficiencies in their behaviour or the quality of their skills, with previous research suggesting that parents mentally "edit" their responses to withhold shortcomings, motivated by social desirability. Self-report data also suffers from challenges arising from memory and interpretation. For example, recalling a "frequent event" requires accurate recall of every instance, and a shared conceptualisation of the word "frequent". Zahidi (2018) explored the correlation between self-report and observed parenting measures for several parenting constructs, finding no significant correlations between the two methods. Self-report measures *have* been demonstrated to correlate with observed data for some parenting constructs, and for positive parenting constructs issues of social desirability may be less potent (Arney, 2004). The best quality research may come when multiple methods of data collection are used, namely self-report data alongside observation or other report (Morsbach & Prinz, 2006). This notwithstanding, observational data provides a more consistently objective measure of parenting behaviours and as such the studies included in this review were constrained to those that included at least one observed or experimentally tested measure of parenting and IC.

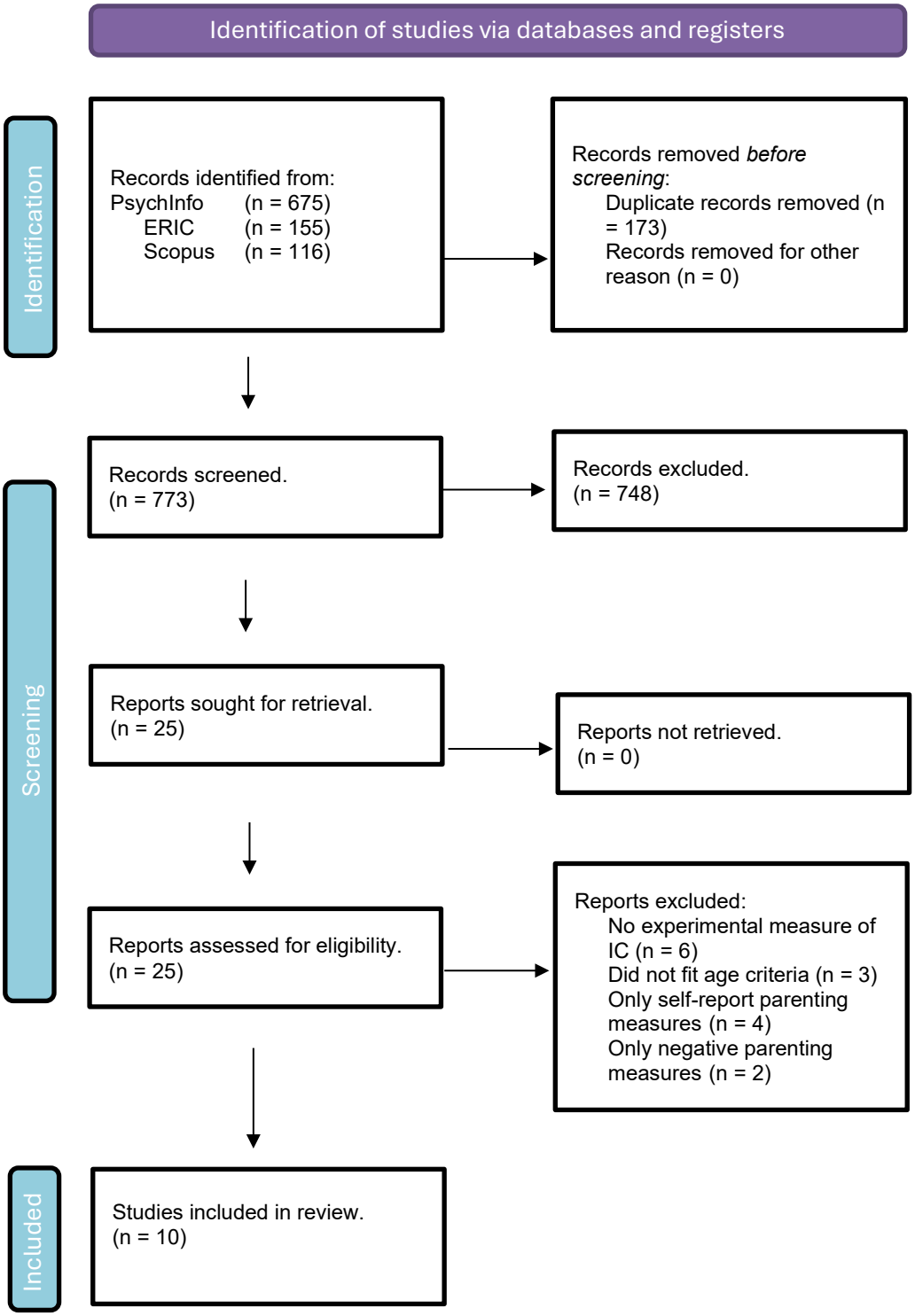
2.5.5 Selection process

The proposed search yielded 946 records which were imported into EndNote reference manager and 173 duplicates removed using automatic detection. Duplicate records were manually accepted for deletion to avoid false positives. Records were initially screened by title and a further 748 records were removed. Following this initial title screening, 66 records were sought for abstract screening. Following abstract screening, 25 papers were successfully retrieved for full text review. The screening process was completed independently by me as the sole researcher and discussed through academic supervision. Concerns relating to bias arising from single researcher screening will be discussed towards the end of this review. Of the 25 papers sought for full text review, 10 were selected for inclusion (see Figure 1 for PRISMA flow diagram depicting this process).

2.5.6 Quality assessment

Quality assessment was completed using the Critical Appraisal Skills Programme (CASP) checklist for cohort studies. This assessment framework was selected as it allows for an efficient, but thorough judgement of research quality without relying on scores or cut-off values. The CASP checklist provides 12 questions which probe the validity of study results, the nature of the study results, and the utility of the results. Each question is supplemented with "hints" to consider your subjective judgement of each paper. All papers were retained following quality assessment, with noteworthy omissions or concerns discussed later (see appendix A for full detail of quality assessment).

Figure 1: PRISMA 2020 flow diagram of the systematic search process (Page et al., 2021).



2.6 Results

2.6.1 Study characteristics

A full summary of study characteristics, IC measures, parenting measures, and key findings extracted can be found in appendix B. Included studies were published between 2013 and 2019 and were conducted in the United States of America (6), Canada (3), and the Netherlands (1). The total sample at the start of each study was 3900 (male = 1940) participants aged 19 months to 65 months with their primary caregivers[2]. Longitudinal studies reported varying levels of attrition and samples were smaller for subsequent time points. Individual study samples ranged from 42 to 1292 participants. Primary caregivers ranged from 28.6 to 35.5 years old and were mostly mothers, with fewer than 5% of reported caregivers being the father. Participants were predominantly Caucasian (58% to 100%) with the notable exception of Merz et al. (2017) who report a predominantly Hispanic (71%) and African American (28%) sample. Six of the included studies employed a longitudinal design, with the remaining studies sampling data at one time point using a cross-sectional design.

2.6.2 Conceptualising study variables

Parenting constructs differentially impact aspects of IC development, and prior research has stressed the need to address different parenting processes as distinct contributors to the development of executive functions (Fay-Stammbach et al., 2014; Yu & Hsu, 2019). The following briefly summarise the parenting constructs and methods of inhibitory control measurement used in the reviewed studies.

2.6.2.1 Parental responsiveness and sensitivity

Parental sensitivity and parental responsiveness are closely related constructs that respectively capture the quantity of parental response to child signals, and the quality of that response. Half of the included studies reported a measure of parental responsiveness or sensitivity, either as their primary measure of positive parenting or as part of an amalgamated score (specific measures can be seen in appendix B). Responsiveness and sensitivity may be considered umbrella terms that capture several other measured constructs of parenting,

[2] This total sample takes into account the samples of Amicarelli et al. (2018) and Smith et al. (2013) which appear to be the same and as such have only been included once.

including a combination of warm acceptance, sensitive and appropriate response to child signals, and attuned language input. A responsive, or sensitive parent, can meet the needs of a child appropriately in response to their verbal and non-verbal cues and creates an environment in which they can develop and meet their needs independently, promoting autonomy (Anikiej-Wiczenbach & Kaźmierczak, 2021; Blair et al. 2014; Merz et al. 2016; Wade et al., 2018).

2.6.2.2 Linguistic input and positive collaboration

Attuned, developmentally appropriate, language use comprising linguistic input, responsive language use, and pragmatic communicative function, is important in early life (Wade et al., 2018; Yu & Hsu, 2014). Pragmatic communicative function captures the context of communication as well as the function of conversation turns, considering non-verbal and inferred communication. High-quality collaborative communication has previously been found to predict social understanding and theory of mind development (Ensor and Hughes, 2008; Sung and Hsu, 2014). Linguistic input in early childhood can also be understood in terms of emotional content. Children build an independent understanding of emotional experience through the scaffolded emotional language of attuned caregivers in rich discussions (Kahle et al., 2016). Holding conversations about emotions with young children forms the basis of their own internal working models, and therefore how they experience emotions.

2.6.2.3 Parental warmth and positive affect

Children require supportive parents who can offer guidance and structured management, as well as affirming support for their own independent ideas and autonomy (Cipriano-Essel et al., 2013; Smith et al., 2013). The nature of this support is significant, and parents can differ in the warmth or hostility of their supportive behaviours. As found in research prior to this review, a child who receives low control or unstructured guidance, and low warmth, may find self-regulatory skills development more challenging than a child who receives high control/guidance with high warmth (Baumrind, 1971). High control that lacks warmth will also create difficulties in early self-regulatory development. Parenting that is characterised by assertions of power predicts difficulties in self-regulation as it undermines the development of autonomy and independent effortful control (Smith et al., 2013). Finally, parenting that is high in warmth but lacks control and structured guidance will likewise create a challenging environment for a child to develop self-regulatory skills as they lack the safety that comes from clear boundaries and a secure base (Cipriano-Essel et al., 2013). Warmth and positive affect towards children are not necessarily stable over time and as children become older and more

autonomous, the observed levels of outward positive affect such as hugging, and verbal affection decrease (Blair et al., 2014). This does not necessarily indicate a decline in the quality or warmth of parenting experience, but instead captures a natural decrease in close dependence in the parent-child relationship.

2.6.2.4 Parental scaffolding

Scaffolding is analogous to a temporary support structure that remains in place for as long as it is required and useful (EEF, n.d.). Coined in the 1970s, scaffolding in psychology is a metaphor for the social interaction processes that allow a child to achieve something they would not be capable of without considered support (Wood et al., 1976). Effective scaffolding takes place in the moment, serving to co-regulate a child's attention and cognitive processing of a task as it happens, without limiting their independent efforts and thinking (Bibok et al., 2009; Kahle et al., 2017). Furthermore, effective parental scaffolding during critical periods of development may predict children's self-regulation, social relationships, and capacity to express frustration in later childhood (Mazursky-Horowitz et al., 2019). In the context of reviewed research, positive experiences of scaffolding include gentle guidance, reasoning, and teaching during an activity.

2.6.3 Measures of inhibitory control

2.6.3.1 Variations of the "go/no-go" task

The go/no-go task is an established measure of IC credited to Alexander Luria in the 1940s. Participants respond to a primed "go" stimulus and withhold from responding to a primed "no-go" stimulus. Errors of commission occur when the participant incorrectly responds to the "no-go" stimulus and errors of omission occur when the participant fails to respond to the "go" stimulus. Total commission errors are typically described as a valid measure of IC performance, whereas omission errors relate to inattention.

In this review, Mileva-Seitz et al. (2015) made use of an auditory go/no-go task called the Auditory Continuous Performance Test for Preschoolers (ACPT-P). Participants responded to "go" stimulus (dog bark) by pressing a computer key as quickly as possible. The "no-go", to which participants must withhold their response, was the sound of a church bell. Swingler et al. (2018) used a visual go/no-go task presented on a computer screen. Participants had to respond to pictures of any animal (go stimulus) apart from pictures of dogs (no-go stimulus). In both studies, the primary statistic of interest was the number of commission errors made by

participants indicating the degree to which they successfully inhibited the pre-potent response to react to "go" stimulus.

2.6.3.2 The "gift delay-wrap" task

This measure was originally developed by Kochanska et al. (2000) as a measure of delay inhibition. Referred to in their original study simply as "wrapped gift" (pg. 223), this task involves an experimenter wrapping a gift while the child sits with their back to them. The child is instructed not to peek for the duration of the wrapping (60 seconds). In the present review, Merz et al. (2017) scored children based on their responses during 15 second blocks. Children were awarded one point if they left their seat to look, two if they turned their body in their seat, three if they looked over their shoulder, and four if they did not peek. Scores for each 15 second block were averaged to give a score for the task. Following this, the gift was left in the room for two minutes while the experimenter went to "retrieve a bow". The child was instructed not to touch or open the gift. They were again awarded scores based on their capacity to resist looking at the gift, averaged as above to create a score of IC. A summed score of IC was created by adding these scores together along with latency to peek (Merz et al., 2017).

2.6.3.3 Modified Stroop-like tasks

The "classic" Stroop task presents participants with colour words, presented in a different colour (e.g., blue). Participants are asked to name the print colour, rather than reading the word, requiring participants to inhibit responses to cognitive interference while responding appropriately to the target stimulus (MacLeod, 1991; Scarpina & Tagini, 2017). There has been significant literature and research produced since the Stroop tasks inception in the 1930s, and interested readers should consult MacLeod (1991) for a detailed review of the measure's development and underlying psychological processes. In the current review, six different variations of the Stroop task were used: 'day/night', 'bear/dragon', 'happy/sad', 'mean/good puppet', 'grass/snow', and 'animal Stroop' (Cipriano-Essel et al., 2013; Kahle et al., 2017; Merz et al., 2017; Wade et al., 2018; Yu & Hsu, 2019).

For 'happy/sad' and 'day/night', participants were shown cards with cartoon representations of two dichotomous stimuli (e.g., sun for day or moon for night) and were required to say the opposite to what they saw (e.g., "day" when presented with a picture of a moon). For some studies, the impact of emotional affect was considered using the happy/sad and day/night, which are procedurally identical but differ on their emotional salience. The happy/sad task presents pictures of a happy face and a sad face, with children instructed to say

"sad" when they see the happy face, and vice-versa. The grass/snow variant differs in that the participants respond non-verbally to a verbal stimulus, pointing to a green card when the experimenter said "snow" and a white card when they said "grass" (Wade et al., 2018). The 'bear/dragon' and 'mean/good puppet' variants involved participants doing what the nice character tells them to do, such as touch their nose, but not to do what the mean character says. The mean/good puppet variant is an adapted bear/dragon task with human-like characters (Wade et al., 2018; Yu & Hsu, 2019). The animal Stroop task requires participants to name an animal based on its head, which does not match its body, as quickly as possible (e.g., a dog with an elephant's head). Participants were scored based on a coded rating system where an immediate correct response scored three points, a rapid self-correction scored two points, a slow self-correction scored one point, and an incorrect response scored no points (Yu & Hsu, 2019). These measures show good convergent validity and as such, for studies that used more than one Stroop task variant, they were typically combined into a composite IC measure. Correlations reported:

- 'Grass/snow' correlates with 'bear/dragon' ($r = .280$, $p < .001$; Wade et al., 2018).
- 'Animal Stroop' correlates with 'mean/good puppet' ($r = .450$, $p < .01$; Yu & Hsu, 2019)
- 'Day/night' correlates with 'happy/sad' ($r = .570$, $p < .01$; Kahle et al., 2017).

Cipriano-Essel et al. (2013) additionally used a task simply called 'shapes' in which the child had to name a picture of a fruit that was embedded in a picture of a larger, different, fruit. This measures a similar process to the Stroop task as children are required to inhibit their response to the extraneous stimulus (big fruit) while correctly naming the target stimulus (small fruit). They found that 'shapes' significantly correlated with 'day/night' and as such presented a standardised, summed score as a composite measure of IC. Merz et al. (2017) additionally used a task called the Dimensional Change Card Sort (DCCS; Zelazo, 2006) which also measures participants' ability to inhibit conflicting responses. Children were presented with two boxes, one decorated with a red rabbit and one with a blue boat. They were then presented with cards that were either red (R) or blue (B), and either a rabbit (r) or a boat (b) (four possible cards: Rr, Rb, Br, Bb). Children were first asked to sort by colour, and then after several trials they were told to sort by shape. IC was measured by number of correct post-switch trials. They found the DCCS to significantly correlate with bear/dragon and as such presented a standardised, summed score as a composite measure of IC (Merz et al., 2017).

2.6.3.4 Sub-tests of the Laboratory Temperament Assessment Battery (LAB-TAB)

The LAB-TAB is a collection of sub-tests that explore aspects of children's early temperament and is reported to have good convergent validity with parent and experimenter ratings of child temperament (Goldsmith et al., 1993). The included studies made use of sub-tests from the pre-school battery including 'tower of patience' and 'snack delay' (Amicarelli et al., 2018; Smith et al., 2013). In 'tower of patience' the experimenter and the child take it in turns to place a block onto a tower, with the experimenter waiting incrementally longer before taking their turn. In 'snack delay' the experimenter places a chocolate under a cup and tells the child that they must wait until a bell is rung before they can eat the chocolate. The time between showing the chocolate and ringing the bell is incrementally increased. IC is measured as a count of children placing a block out of turn (not waiting) or eating a chocolate before the bell was rung. Both are analogous to measures of delay-inhibition such as the gift-wrap task used by Merz et al. (2017). An average score across both measures was used as an aggregate IC measure (Amicarelli et al., 2018; Smith et al., 2013).

Amicarelli et al. (2018) use two further sub-tests at their second time point: 'gift bag' and 'Simon says'. In gift bag, an experimenter leaves a gift bag in the room with the child and instructs them not to open it until they return with their parent after three minutes. IC was measured by total instances of touching the bag, opening the bag, etc. as well as the latency from starting the test to each 'IC failure', with shorter times indicating poor IC. As well as this latency score, multiple observer ratings of IC were recorded. The 'Simon says' task involved the experimenter playing a pre-recorded video of a different adult playing the traditional game. Actions when the adult did not say "Simon says" were summed with failures to complete actions when the model did say "Simon says". Scores from both tasks were standardised and averaged creating a total IC score.

2.6.3.5 Novel measure of executive function

Blair et al. (2014) made use of a newly validated assessment battery that measures children's inhibitory control, working memory, and attention shifting. Validation of the executive function battery was published in 2012 (Willoughby et al., 2012). They suggest that IC, working memory and attention shifting all form part of a unidimensional latent variable, here referred to simply as executive function. Reporting this measure of executive function as a concordant measure of inhibitory control allows for comparison with the other studies in this review. Their novel battery included seven tasks, of which four specifically measure IC. The IC measures used were

'silly sounds Stroop' (derived from 'Day/Night' task), 'spatial conflict' (Simon task variant), 'spatial conflict arrows' (identical to 'spatial conflict' with altered stimuli), and 'animal go/no-go', which is a standard go/no-go procedure as described above.

The first Simon task variant involves participants physically touching a picture of a car with their left hand and a picture of a boat with their right hand. Pictures are initially presented laterally, and then after 22 items they are *sometimes* presented contra-laterally. Inhibitory control was measured by correct responses to contra-laterally presented items (Willoughby et al., 2012). In the second Simon task variant the format is the same, but the pictures are of a left facing arrow and a right facing arrow. For both Simon task variants, participants are required to inhibit a prepotent response (location on the page) established in the first 22 items (Willoughby et al., 2012).

2.6.4 Reported findings

For a statistical summary of reported findings please see table 3 below.

2.6.4.1 Parental responsiveness and sensitivity

Increased parental responsiveness in early development was found to have a significant, but small, effect on inhibitory control development over time in two longitudinal studies. Children who experienced more responsive parenting between the ages of three, and four and a half showed greater inhibitory control development at least six months later (Blair et al., 2014; Merz et al., 2017). The magnitude of these effects was small, with effect sizes ranging from .110 to .190, but met the threshold for significance ($p < .05$). Blair et al. (2014) reported that this relationship was slightly attenuated by family income-to-need (a measure of financial shortfall) but remained significant. Notably, Wade et al. (2018) did not find a significant relationship between responsive behaviour and inhibitory control development in younger children (T1 18 months, T2 3 years) suggesting this relationship may emerge later in development. Blair et al. (2014) and Merz et al. (2017) also found evidence for the hypothesised bidirectional effect, and T1 inhibitory control predicted T2 parental responsiveness. These effect sizes were also small, ranging from .130 to .190, and Blair et al. (2014) report only marginal significance after controlling for income-to-need ($p = .08$).

The relationship between increased parental sensitivity and IC, explored in one study, is less clear. Blair et al. (2014) found no significant relationship between sensitivity at T1 and IC at T2, whereas Mileva-Seitz et al. (2015) found a significant relationship only for boys. The effect

reported by Mileva-Seitz et al. (2015) is larger at .260, with increased parental sensitivity at age three predicting increased IC for boys 16 months later. Amicarelli et al. (2018) report effects for their amalgamated measure of positive parenting, which includes sensitivity, supportive presence, and positive affect. They report a significant longitudinal effect of positive parenting between the ages of three (T1), and five and a half (T2), for boys only. Smith et al. (2013), using the same parenting measures, found a significant correlation between parenting and inhibitory control but did not measure this relationship over time. There is some limited evidence for a bidirectional effect of IC on parental sensitivity, with Blair et al. (2014) reporting a significant small effect (.150) of IC at T1 on sensitivity two years later.

2.6.4.2 Linguistic input and positive collaboration

Some significant effects were found linking higher quality linguistic input in early life to increases in inhibitory control development in three studies. Wade et al. (2018) found that greater quality linguistic input at 18 months (T1) predicted IC development at the age of three (T3). This effect was small at .190 but met the criteria for statistical significance ($p < 0.01$). The relationship between linguistic input and IC development may be moderated by emotional salience. Kahle et al. (2017) found that emotional explanations and emotional language use at three and a half years old (T1) significantly predicted IC development six months later for emotionally salient (hot) IC tasks. These effects were considerably larger, ranging from .270 to .390, and suggest that emotional language more strongly predicts IC when required to inhibit emotional responses. Yu and Hsu (2019), by contrast, did not find any significant correlations between collaborative communication and IC. Exploring this relationship cross-sectionally, they did however find that non-collaborative communication strongly correlated ($r = -.500$, $p < .01$) with reduced IC for girls only.

2.6.4.3 Warmth and positive affect

In two cross-sectional studies, increased parental warmth and positive affect were found to significantly predict increased IC performance. Swingler et al. (2018) report that maternal emotional support has a moderate effect of .230 on IC performance for all participants. The relationship reported by Cipriano-Essel et al. (2013) is more nuanced, and warm autonomy support was found to significantly predict (.200) IC only for those who were high in temperamental negativity. Children with high temperamental negativity performed more poorly on measures of IC than those with low temperamental negativity, but this deficit was erased for those who received warm autonomy support (Cipriano-Essel et al., 2013). The results of Smith

et al. (2013) and Amicarelli et al. (2018), as above, may lend support for the relationship between positive affect and IC development.

2.6.4.4 Scaffolding

Kahle et al. (2017) explored the importance of emotional salience in the development of IC over time. As reported, they found a significant effect of emotional language use on emotionally salient IC tasks. The inverse is also true, and they found that increased parental scaffolding, which is considered to be emotionally neutral, at three and a half years old (T1) significantly predicted 'cold' IC six months later. This effect was moderate at .260 ($p < .01$) and supports the notion that different aspects of parenting predict different components of IC development (Fay-Stammbach et al., 2014). The results of Smith et al. (2013) and Amicarelli et al. (2018) may also lend support for the effect of scaffolding on IC development. They both included 'supportive presence', analogous to scaffolding, in their amalgamated measure, finding significant effects as reported above.

2.6.5 Summary of Results

Positive parenting, comprised of parental responsiveness, sensitivity, linguistic input and collaborative communication, warmth and positive affect, and scaffolding, significantly predicts inhibitory control development during the critical period of executive function development in early childhood. Several studies also report robust, longitudinal evidence that this relationship is bidirectional and IC during early childhood significantly predicts parents' individual differences in parenting. There seems to be an underlying sex difference in the development of IC during pre-school years, with boys demonstrating lower initial levels of IC and more sensitive interactions with positive parenting experiences. As Mileva-Seitz et al. (2015) phrased it in the title of their paper, boys are more *"sensitive to sensitivity"*. Another nuance in the relationship between parenting and IC development is the impact of emotional salience. Several studies reported different effects for tests of 'hot' and 'cold' IC, finding that emotional language use and warm affect during development predict IC performance on emotionally salient tasks, whereas more 'cold' processes such as parental scaffolding predicted performance on tasks that did not have an emotional component.

Table 3: Summary of Reported Findings

		Findings	Effect Size - β	SE	Sig.
Responsiveness & Sensitivity	Blair et al. (2014)	Parental responsiveness, but not sensitivity, at T1 (36 months) predicted changes in inhibitory control at T2 (60 months), attenuated by family income.	.190	NR/UTC	p < .05
			.190	NR/UTC	p = .08
		Inhibitory control, at T1 predicted parental responsiveness at T2 with marginal significance[1], and significantly predicted sensitivity at T2.	.150	NR/UTC	p < .05
	Merz et al. (2017)	Parental responsiveness at T1 (4.45 years) significantly predicted T2 (~5 years) inhibitory control.	.110	NR/UTC	p < .05
		Inhibitory control at T1 significantly predicted parental responsiveness at T2.	.130	NR/UTC	p < .05
	Mileva-Seitz et al. (2015)	Increased parental sensitivity at T2 (36 months) significantly predicted inhibitory control (reduced commission errors) at T3 (52 months) *for boys only.*	.260[2]	NR/UTC	p = .05
Linguistic Input	Kahle et al. (2017)	Changes in *accuracy* on the 'happy/sad' task (emotionally salient) between T1 (3.5 years) and T2 (4.06 years were significantly predicted by maternal emotion explanations.	.390	NR/UTC	p = .01
		Changes in *latency* on the 'Happy/Sad' task between T1 and T2 were significantly predicted by maternal emotion language.	.270	NR/UTC	p = .04
		Changes in *latency* on the 'Day/Night' task (emotionally neutral) between T1 and T2 were significantly predicted by maternal scaffolding.	.260	NR/UTC	p = .01
	Wade et al. (2018)	Maternal linguistic input, but not responsive behaviour, at T2 (18 months) significantly predicted inhibitory control at T3 (3 years).	.190	NR/UTC	p < .01
	Yu & Hsu, 2019	Maternal collaborative communication did not significantly correlate with inhibitory control.	r = .150		/
Positive Affect	Swingler et al. (2018)	Maternal emotional support significantly predicted IC for all participants at one time point.	.230	.17	p = .01

	Cipriano-Essel et al. (2013)	Warm autonomy support, but not warm guidance, significantly predicted inhibitory control. This relationship was attenuated by child temperament and was only significant for those high in temperamental negativity.	.200	.107	$p < .05$
Scaffolding	Kahle et al. (2017)	Changes in *latency* on the 'Day/Night' task (emotionally neutral) between T1 and T2 were significantly predicted by maternal scaffolding.	.260	NR/UTC	$p = .01$
Amalgamated Positive Parenting	Amicarelli et al. (2018)	Positive parenting at T1 (3.02 years) significantly predicted inhibitory control at T2 (5.44 years) *for boys only.*	.670[3]	.340[3]	$p = .04$
	Smith et al. (2013)	Positive parenting significantly correlated with inhibitory control for all participants.	$r = .160$		$p < .01$

SE - Standard Error

NR/UTC – not reported and unable to calculate from available data.

[1] Blair et al. (2014) report 'significant' relationship, however p value falls below typical standard for significance.

[2] In this instance, inhibitory control was measured through reduction in commission errors ($\beta = -.260$), inverse result reported above for clarity.

[3] Unstandardised coefficient and error reported, Amicarelli et al. (2018) do not report standard deviations to allow for computation of standardised coefficient.

2.7 Discussion

This review set out to further examine the relationship between parenting and self-regulation in preschool children, developing and extending the findings of Karreman et al. (2006) with a specific focus on positive parenting and inhibitory control. The results of this review highlight several key relationships in early childhood cognitive development. Consistent with the wider research, parenting was found to be a significant driving factor behind the development of inhibitory control in the first five years of a child's life. In contrast with Karreman et al. (2006) the results of this review suggest that inhibitory control is significantly correlated with parenting, over and above the influence of shared environmental factors in the home such as SES. The size of these reported significant effects ranged from small to medium (.110 to .390) suggesting that parenting has a significant effect on IC development but is not the only contributing factor. This is corroborated by research that suggests IC is significantly heritable, and while some change in IC can be accounted for through nurturing factors such as parenting, a significant baseline is attributable to genetic and shared environmental factors (Gagne & Saudino, 2009). Other environmental factors correlate with IC including maternal education and family income and several studies controlled for these when assessing the relationship between parenting and IC development. It is also important to note that children who are pre-school age are not solely influenced by their home environment. One interesting finding reported by Mileva-Seitz et al. (2015) is that children who attended daycare (nursery) settings performed better on measures of IC than those who were exclusively raised in the home.

Karreman et al. (2006) used three categories of parenting for their review: positive control, negative control, and responsiveness; they reflected that more nuanced understanding may be found through exploring finer parenting categories. The studies included in this review explored several more nuanced aspects of positive parenting including parental responsiveness, sensitivity, positive affect, emotional language, warmth, collaboration, and effective scaffolding. These aspects of positive parenting were found to differently impact the development of IC. Affective components of parenting were found to more strongly correlate with IC tasks that require emotional regulation or inhibition of emotionally salient stimuli such as the 'happy/sad' Stroop task. Emotional language use and warmth in early development support children to inhibit responses more effectively in emotionally salient tasks and environments and may support skills development in social situations where emotional salience plays a significant role.

More affectively 'cold' parenting such as scaffolding and collaborative communication were found to correlate more strongly with non-emotional IC tasks. The direct comparison is the

'day/night' and 'happy/sad' tasks which are structurally identical apart from their emotional salience. Kahle et al. (2006) found significant longitudinal effects of maternal emotion language use on emotionally salient IC ('happy/sad'), and significant longitudinal effects of maternal scaffolding on emotionally neutral IC ('day/night'). Children require skilled IC across emotionally salient and non-salient environments and these findings highlight the nuanced relationship between parenting and self-regulation skills development. Children need parents who are able to provide structured and scaffolded parenting that promotes autonomy, and qualitatively warm parenting that promotes positive affect and emotional understanding. This finding builds on the conclusions drawn by Karreman et al. (2006), who concluded that parental control can be both positively and negatively associated with children's self-regulatory development dependent on the affective quality of that control. Parenting that exerts control through limit-setting, warm guidance, instructional behaviour, and low levels of power assertion can lead to improvements in self-regulation over time. However, over controlling parenting that lacks warmth can undermine the early development of autonomy and independent self-regulation.

Several additional factors were found to impact IC development in the reported studies. Most significant was the reported gender differences in IC development during the first years of life. Several studies reported lower levels of IC in boys than girls both cross-sectionally, and longitudinally. Gender was included as a covariate in some studies and there were reported differences in how parenting impacts on IC development for boys and girls, with boys showing greater rates of IC change with increased sensitivity. There is some evidence that the early deficits in IC observed in boys can be mitigated through positive parenting experiences (Amicarelli et al., 2018). While boys seem to be more sensitive to positive parenting in general, there is some evidence that girls' IC is more stable over time regardless of positive parenting and is instead likely to be impacted by negative parenting experiences (Yu & Hsu, 2019).

2.7.1 Strengths and Limitations

There were several limitations to the scope of this review. Having intended to broaden the scope to include non-western research, initial scoping searches did not find any research that met the inclusion criteria. This perhaps represents a limitation in the extant literature but may also reflect the inclusion criteria that all papers be published in English. Future research in this area should seek to explore cross-cultural differences in the relationship between parenting and IC more specifically. Consistent with Karreman et al., grey literature (dissertations and theses) was not included in this review. While the peer review process of publication can infer a level of quality, some insight may have been missed by excluding the grey literature and this should be sought in future reviews. As this review sought to explore only aspects of positive parenting, the

included studies were limited in comparison to the previous review. However, the results found suggest significant and interesting conclusions that are supported by multiple studies with large samples. The text screening and analysis were completed by me as the sole researcher, which presents some concerns for bias. This was mitigated through regular academic supervision to discuss potential inclusions and contentious results. However, future study to validate the results of this review and explore the implications would be valuable.

Notwithstanding these limitations, this review presents compelling evidence for the nuanced impact of parenting constructs on IC development. The total sample of 3900 participants is comparable to the 3799 families' data included in Karreman et al. (2006), giving statistical weight to the results found. This review also included six longitudinal studies allowing for more confident inference of directional effects between parenting and IC development.

2.7.2 Implications

The results of this review demonstrate the need for parenting support in the critical first years of a child's life. As IC is highly predictive of outcomes in short term development such as school readiness and early socialisation, as well as longer term health, mental health, social, and educational outcomes; intervening to support children at the source will be critical. The bidirectional nature of the relationship between parenting and IC development also suggests that a relatively small amount of input for parents at critical periods would likely lead to a virtuous cycle whereby improved parenting practices lead to greater IC gains, which in turn lead to improved parenting practices reciprocally. The trajectory for a child who perhaps has a lower base level of IC, most notable among boys, could be very different depending on the nature of parenting they receive. This trajectory will also have generational impacts, as parents who themselves struggle with IC are less likely to engage with positive parenting behaviours, proliferating their children's IC difficulties (Mazursky-Horowitz et al., 2019).

Holding the longer-term impacts of poor IC in mind, intervening early with comprehensive parenting support and education focused on increasing responsive, sensitive, warm, and appropriately scaffolded parenting may improve outcomes for children throughout their educational journey and into young adulthood. From a practical perspective, investing in early parenting support will likely pay dividends in reduced social burden and cost by reducing substance abuse, anti-social behaviour, and poor health outcomes in later life. It will also set children up to enter school equipped to learn and build secure, enduring social relationships. This also presents an area of work that should be a priority for educational psychology professionals, who are well placed to design, deliver, and support early parenting interventions. These findings should also serve to inform a richer understanding of how children form and maintain difficulties with self-regulation in schools and may inform psychological advice in

statutory assessment proceedings. The results of this review should inform educational psychologists' consultations, particularly when concerning children in early years settings or pre-school. Educational psychologists should seek to better understand the home context and empower parents to understand how their parenting strategies may or may not be supporting their child's inhibitory control development. The results of this review should also be disseminated to school staff, particularly in early years settings, so that staff feel informed and able to support parents and model effective care strategies.

2.7.3 Conclusion

Inhibitory control plays a central role in the development of many academic and social outcomes for young children, preparing them for independent learning and social interaction and providing the foundation to more complex executive functions. The environment a young child is brought up in, not least the nature of parenting they receive, significantly impacts their IC development. Parents who are responsive and sensitive to cues, providing warm, structured support to their children provide an environment in which children can develop strong IC skills. As children's IC skills improve, their parents' own capacity to provide such a responsive environment will also improve. These bidirectional effects highlight the critical need for effective early support for parents from educational psychology professionals and through funding and policy changes so that children, and their parents, can experience positive change that improves longitudinal outcomes for children and families.

Chapter 3 Empirical Paper

3.1 Title

How Do Experiences of Threat and Deprivation in Early Life Impact the Development of Inhibitory Control and Impulsive Behaviours in Adolescence?

3.2 Abstract

Early life trauma experiences have been demonstrated to correlate with negative life outcomes across several health, social, and emotional domains. This relationship is potentially mediated by the development of poor inhibitory control. Using the dimensional model of adversity, the researcher aimed to explore the relationship between early life trauma, adolescent impulsivity and inhibitory control, and substance use. Seventy-two participants (aged 16 to 19) in mainstream education completed a series of self-report measures covering early life experience, perceived impulsivity, and current drug and alcohol use. Following this, they completed three experimental measures of inhibitory control, including one novel measure of associative inhibition. Experiences of threat and deprivation were found to differently impact development. Deprivation significantly predicted greater impulsivity, and threat significantly predicted difficulties with associative inhibition. Greater experience of trauma during development was found to predict increased adolescent substance abuse, explained by variance in threat experience but not deprivation. These results support the use of the dimensional model of adversity when considering the impact of early life experiences on development, challenging the traditionally held cumulative ACEs model. They also highlight areas for timely educational psychology support and intervention and present a framework for understanding young people's developmental context when supporting presenting needs.

3.3 Introduction

3.3.1 Early Trauma Experiences

Early trauma experiences, sometimes referred to as adverse childhood experiences (ACEs), correlate highly with many negative life outcomes including the development of psychopathology in childhood and into adolescence (Green et al., 2010). Early trauma experiences such as physical, emotional, or sexual abuse and physical or emotional neglect are highly prevalent in the general population, with a recent large-scale meta-analysis finding more than 60% of adults globally have experienced at least one ACE in their lifetime. Perhaps more

starkly, the same paper found that 16.1% of adults have experienced four or more ACEs, linked with significantly increased likelihood of negative life outcomes (Madigan et al., 2023). A large, ongoing cohort study into the impact of early life adversity has so far found negative outcomes attributable to trauma experience across most domains of life outcomes including; increased risk of injury, poor mental health, negative maternal health outcomes such as unintended pregnancy and complications, risk of infectious diseases with specific risk of sexually transmitted disease, increased prevalence of chronic diseases such as cancer, increased prevalence of risky behaviours such as substance use, and negative educational and occupational outcomes (CDC-Kaiser; Felitti et al., 1998).

There are two predominant theoretical understandings of how childhood trauma experiences impact individual development, and how this ought to be measured experimentally. The traditional view is one of cumulative ACEs, whereby one ACE would be expected to have a lesser impact than two, and so forth (Turney, 2020). The term ACEs was initially coined by Felitti et al. (1998) in their study of causes of death in adulthood following childhood abuse and family dysfunction. In this seminal research they report a graded relationship between the quantity and severity of unique ACEs in early life and the likelihood of significant health risks in adulthood. The underlying mechanism proposed to explain how disparate trauma experiences influence development is through disruptions to the stress-response system (Evans et al., 2013). An alternative model, proposed by McLaughlin and Sheridan, is a dimensional understanding of early trauma experiences. They propose that experiences of trauma map onto two dimensions, threat and deprivation, and that trauma in these two domains may have different impacts on development, and on the neural development that underpins later difficulties (McLaughlin and Sheridan, 2014; 2016). A challenge faced in this field is the frequent co-occurrence of early trauma experiences, muddying the water when considering the different impact of deprivation and threat (Dong et al., 2004).

There is research evidence suggesting different developmental impacts of deprivation and threat. For example, while both threat and deprivation negatively impact executive functioning, the association is stronger for deprivation (Johnson et al., 2021). Deprivation has strong, well researched implications for cognitive development. Perhaps the most widely acknowledged study exploring severe early deprivation is that conducted by Rutter with Romanian adoptees. This seminal research found significant delays in cognitive development as a direct result of institutional deprivation. Rutter posited that the impact of psychological deprivation, lacking appropriate cognitive stimulation and interaction, would be more impactful than material deprivation (Rutter, 1998). Following up with the same cohort in 2017, severe early deprivation was found to lead to long term difficulties into early adulthood. Those who had experienced more than six months of institutional deprivation had higher rates of educational

diagnoses such as autism spectrum disorder (ASD) and inattentive and overactive behaviours (Sonuga-Barke et al., 2017). They were also found to have lower educational attainment, greater levels of unemployment, and greater use of mental health services in early adulthood. Notably, these effects were observed despite over 20 years of positive support and nurture in adoptive families, highlighting the critical early developmental period. Furthermore, these individuals were found to have persistent adverse neuropsychological development, specifically relating to their early experiences of institutional deprivation, and correlating with symptoms of attention deficit hyperactivity disorder (ADHD). It is worth noting, however, that the prevalence of attention difficulties in the deprived sample studied here may be explained by interactions with prospective (future oriented, action planning) memory and general intelligence (Golm et al., 2020). Earlier studies on this cohort have linked deprivation related symptoms of ADHD with deficits in executive functioning (Colvert et al., 2008). While institutional deprivation is a specific subtype of neglect, other studies on more 'conventional' types of maltreatment confirmed its association with executive functioning deficits (Letkiewicz et al., 2021; Wretham & Woolgar, 2017).

Whereas the impacts of deprivation can be characterised as under-stimulation, experiences of threat can be characterised as over-stimulation. Threat-type trauma impacts the development of our physiological stress response, leading to hyperarousal, hypervigilance to threat (even when not present), and difficulties with attentional inhibition and emotion regulation resulting from adaptive changes to the prefrontal cortex (Herzog et al., 2018; McCrory et al., 2017; Van Der Kolk, 1994; 2003). Threat responses can typically be considered adaptive (helpful), driving our attention and action to keep us safe. However, when an individual is exposed to persistent threat, these adaptive processes can develop into maladaptive (unhelpful) traits once an individual is no longer in the threatening context (McCrory et al., 2017; Perry et al., 1995). Coping mechanisms and behaviours can become over specified, meeting a need in a threat environment (such as drinking to numb over-active stress responses), but come at the detriment of adaptive strategies in non-threatening situations (Wadsworth, 2015). It has also been found that coping motives associate with greater drug use (cannabis) among teenagers who have experienced significant threat-type trauma (physical and sexual abuse), suggesting that substance use may be used to cope following experiences of threat (Adams et al., 2021). The difficulties following early trauma experiences discussed thus far may be contingent on altered executive functioning development, including deficits of inhibitory control, and impulsive behaviours, as well as functional adaptations and coping strategies.

3.3.2 Inhibitory Control and Impulsivity

Executive functioning deficits such as reduced inhibitory control and increased impulsivity in adolescence have been shown to lead to a range of negative developmental outcomes including anti-social behaviour, self-harm and suicidal ideation, aggression, risky sexual behaviour, gambling, disordered eating, employment instability, incarceration, marital problems, and poor adult mental health, among others (Carvalho et al., 2018; Herba et al., 2006; Moeller & Dougherty, 2002). Inhibitory control and impulsivity are also widely considered to be underlying mechanisms in several educational and mental-health diagnoses including ADHD, obsessive compulsive disorder (OCD), depression, and ASD, which are more prevalent among those who have experienced early trauma. Diagnosis of ADHD, considered to be contingent on both failures of inhibitory control and impulsivity, has been steadily increasing in the UK over the past 20 years and is highly correlated with risk taking behaviours such as substance use (Breaux et al., 2020; Herba et al., 2006; Kousha et al., 2011; McKechnie et al., 2023). While ADHD diagnosis is predictive of substance use, the relationship between substance abuse and impulsivity is likely bi-directional, with impulsivity as both a risk-factor and a consequence of substance abuse. Consumption of substances such as alcohol, cocaine, and MDMA[3] have been found to predict increases in impulsivity through several mechanisms including diminished serotonin function and failures of planning, behavioural inhibition, and working memory (Moeller & Dougherty, 2002). Substance abuse, correlating with both impulsivity and early life trauma experiences, serves as a useful vignette to explore the potential mediating effects of inhibitory control and impulsivity between early life experience and adult outcomes. Of the many outcomes associated with executive functioning deficits, we chose to measure substance abuse for several reasons. Previous research has found impulsivity to be a risk factor for drug experimentation and consequent problematic drug use and difficulty abstaining (de Wit, 2009). An additional practical factor is the ready availability of drugs and alcohol screeners and the relatively low emotional impact of recalling recent substance use when compared to other outcome variables such as risky sexual behaviour, disordered eating, or mental health difficulties. Substance use presented a practical and theoretically useful facsimile for general risk-taking behaviours resulting from poor inhibitory control and impulsivity.

The term inhibition is used to describe several different processes by which we withhold, resist, or redirect prepotent responses. While there have been many and various attempts to classify these processes, it is still considered contentious to definitively define inhibition

[3] Methyl-dioxymethamphetamine

(Werner et al., 2022). There are several sub-domains of inhibition described across the extant literature, and many terms are used interchangeably for comparable constructs (Tiego et al., 2018). Bari and Robins sought to describe the interrelated constructs of inhibition, subdividing the overarching construct of inhibitory control into behavioural and cognitive inhibition (Bari and Robins, 2013).

Cognitive inhibition pertains to the stopping of thoughts, memories, emotions, and perceptions, either intentionally or not, that do not meet our current goal. For example, when engaged with a task that requires focused attention, we need to inhibit thoughts that compete for that attention. Behavioural inhibition, according to Bari and Robins, can be subdivided into response inhibition (successfully stopping an action in response to a changing stimulus), deferred gratification (waiting for a future reward), and reversal learning (adjusting behaviour in response to a reversal in previously learned relationships) which may be contingent on response inhibition (Bari and Robins, 2013; Izquierdo et al., 2017; Verbruggen & Logan, 2008). Inhibitory control may also be subdivided more simply into response inhibition and attentional inhibition, which seem to map well onto behavioural and cognitive inhibition as described above (Tiego et al., 2018). Inhibitory control forms part of our core executive functions and forms part of the combined processes that enable us to enact choice over our behaviour (Diamond, 2013).

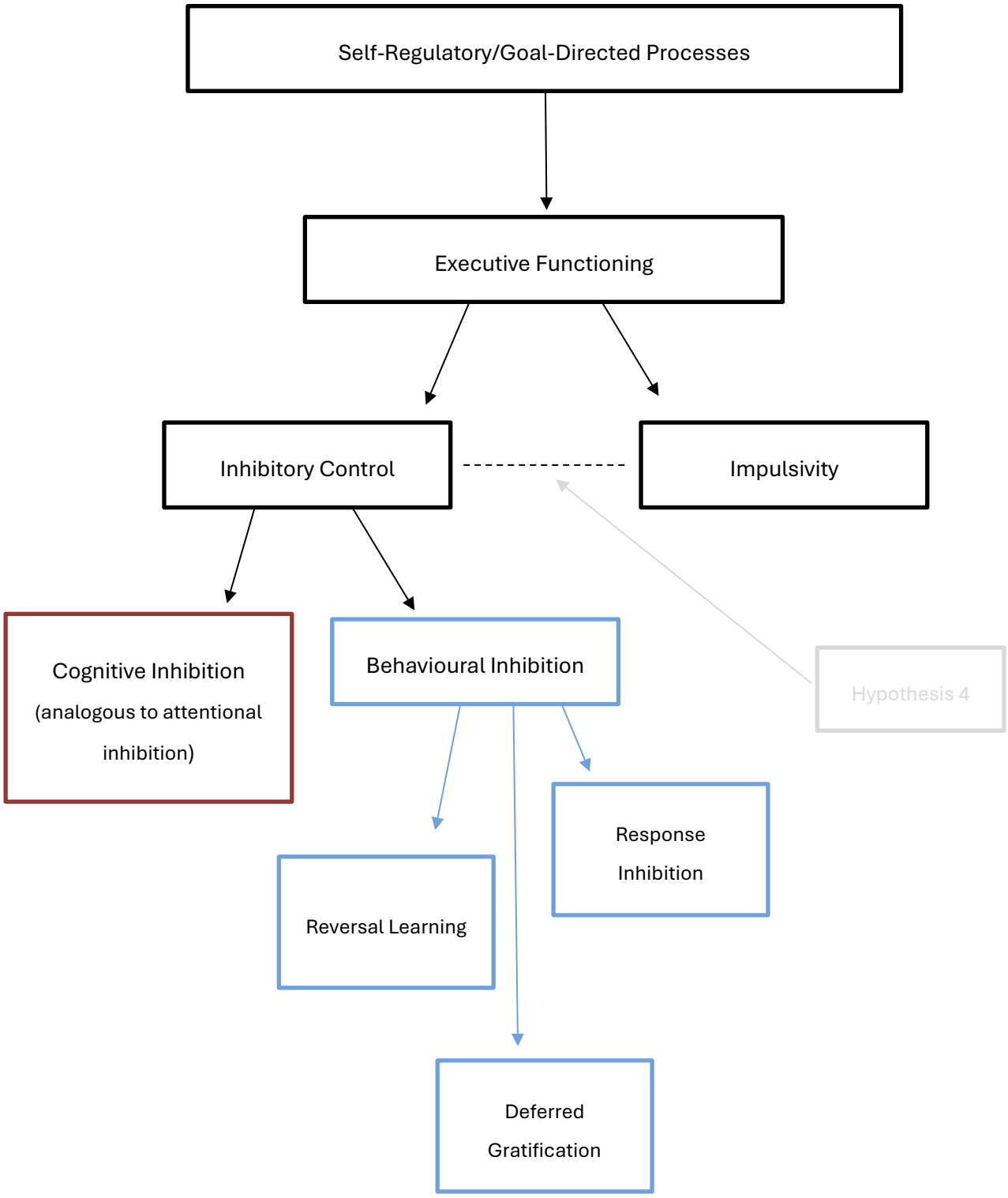
Inhibitory control can also be understood in the context of associative learning. Associative learning is the process by which we learn about our environments and build associations between stimuli. Through repeated presentation of an unconditioned stimulus following a conditioned stimulus, the conditioned stimulus can come to be associated with the unconditioned stimulus (Brudan et al., 2024; Sosa, 2024). For example, a child may learn to associate the music of an ice cream van (conditioned stimulus) with ice cream (unconditioned stimulus), leading to an appetitive conditioned responses which may include overt excitement every time they hear the music. Associative inhibition, a component of associative learning, comprises conditioned inhibition and negative occasion-setting (Brudan et al., 2024). If another stimulus is presented alongside the conditioned stimulus and the conditioned response no longer takes place, that additional stimulus can become inhibitory. For example, if the child experiences music and ice-cream pairings on some occasions, but on cloudy days they get no ice-cream when the music plays, the clouds may become a conditioned inhibitor (Brudan et al., 2024) and suppress the appetitive conditioned responses that the music would normally produce. Inhibition in this context is said to be associative, that is, it relates to specific cue/outcome relationships. Inhibition can also be non-associative, not based on specific learned associations, connoting a more general process of resisting impulsive behaviours. The links between associative and non-associative inhibition have not yet been extensively

researched. However, emerging research suggests that they may be related but nonetheless distinct processes (Brudan et al., 2024, Sosa, 2024).

Impulsivity can be considered a product of difficulties with executive functioning, including inhibitory control. It is a failure to stop a response even when that response presents negative outcomes or obstructs the attainment of goals, or of waiting for a future reward, and is characterised by several different cognitive and behavioural components (Bari & Robins, 2013). The available literature proposes several core components to impulsivity: impulsive action or motor activation, failures of attention and focus, failures of planning and careful thought, novelty seeking, and decreased sensitivity to negative consequences (Barratt, 1994; Fino et al., 2014; Moeller & Dougherty, 2002; Nigg, 2016). A recent large-scale study found a longitudinally stable and well-defined latent factor of impulsivity that was measurable through self-report and observational methods and proved predictively useful for impulsive behaviours (Huang et al., 2024). Additionally, Bari and Robins (2013) suggest that response inhibition can serve as a proxy for the study of impulsivity, whereby poor response inhibition may predict increased impulsivity.

While the links between inhibitory control, impulsivity, and more general executive functioning during development are debated in extant literature, there is evidence for concordant development across these constructs, and aspects of impulsivity and inhibitory control may significantly correlate with executive functioning in adolescence (Fino et al., 2014). In some discussions of impulsivity there is a conflation of trait impulsiveness with inhibitory control. However, research would suggest that they are not as tightly linked as may be assumed. One such study found a significant correlation between trait impulsivity and inhibitory control, however it found that only 12% of the variance in response inhibition could be explained by trait impulsivity (Aichert et al., 2012). Inhibitory control and impulsivity do not overlap completely but represent closely related constructs that often co-occur in psychopathology (Mirabella, 2020; Winstanley et al., 2006). In the present study, we seek to add further understanding to the relationship between these two constructs. Figure 2 below aims to disentangle the constructs outlined above and the conceptual links that underpin this research. Some of the relationships between constructs in the figure are debated in extant literature, and some form part of the hypotheses to be tested in the present study, such as the expected correlation between inhibitory control and impulsivity.

Figure 2: Diagram showing hierarchy of constructs



3.3.3 Study Aims

Trauma experiences in early life are prevalent and impactful to one's whole life trajectory, leading to risk taking behaviours and negative health, social, and mental health outcomes. Difficulties with inhibitory control and impulsivity in early development through to adolescence also significantly predict negative life outcomes. In the present study we sought to explore the potential mediating effect of inhibitory control and impulsivity on the relationship between early

trauma experiences and substance abuse using the dimensional model of adversity. Considering the disparate research into inhibitory control and impulsivity to date, we also aim to further explore the potential for a common mechanism impacting associative and non-associative inhibition, and impulsivity. To the best of our knowledge, this is the first study to explore this relationship using the dimensional model of adversity.

Several measures used in the present study, outlined below, were novel for the target sample and as such we aimed to validate their use with adolescent participants. The aim of this research then is to explore the variance in impulsivity and inhibitory control that may be explained by two distinct dimensions of trauma, threat and deprivation, to inform a broader understanding of the potential mediating role of impulse control and impulsivity between early trauma experiences and negative outcomes in adulthood, here characterised by substance use.

3.3.4 Hypotheses

The following hypotheses were proposed:

1. Greater experiences of early life trauma would lead to reduced inhibitory control and increased self-reported impulsivity.
2. Consistent with a dimensional understanding of trauma, we also hypothesised that experiences of deprivation would have a greater impact on inhibitory control and self-reported impulsivity than experiences of threat.
3. We expect to find an association between substance use (including alcohol, tobacco, and marijuana) and early life trauma, with threat having a greater association than deprivation.
4. We expect to find a significant negative correlation between inhibitory control and impulsivity.
5. Finally, we seek to explore the relationship between traditional non-associative measures of inhibitory control (SSRT and Go/No-go) and an associative measure of inhibition.

3.4 Methodology

3.4.1 Participants

Participants were 72 (37 male[4]) secondary school and sixth form college students aged 16 – 19 (mean age 16.90, SD = .966) recruited through pre-arranged 'gatekeepers' (head teacher or member of SEN support staff), opportunity sampling (participants who took part after asking about the research and reading the study advert), and snowball sampling (participants inviting their friends to take part). Participants were given a £10 Amazon voucher to compensate their participation. A target sample size of 128 was provisionally set on the basis of a simple power analysis conducted with G-Power (Faul et al., 2007). This power analysis indicated power greater than 0.8 for a medium effect size in a comparison of two independent groups such as comparing BIS-11 scores for groups with high and low deprivation. Due to difficulty with recruitment resulting from initial reluctance and lack of capacity from educational institutions, and the time demands of participation, the lower sample of 72 was achieved prior to a pre-agreed cut-off date.

Ethical approval for this study was granted by the University of Southampton ethics committee (ERGO 89437). Twenty-nine participants identified that they have at least one diagnosed educational need such as ASD, ADHD, processing difficulties, or dyslexia. There were several less commonly identified diagnoses including foetal alcohol spectrum disorder (FASD) and hypersensitivity disorder. Several participants responded that they had anxiety, depression, OCD, or another mental health condition. These participants were not considered to have an educational need unless their mental health needs co-occurred with one of the needs listed above.

3.4.2 Materials

Qualtrics online survey manager was used to collate the following screening tools and questionnaires. This collated measure was presented to participants in person on individual laptop computers.

[4] Sex assigned at birth is reported here and will be used throughout when referring to *'male'* and *'female'*. It is worth noting that there were 3 participants who identified as "non-binary or third gender" and 4 participants who identified as transgender (3 female to male, 1 male to female).

3.4.2.1 Substance Use

To capture current substance use, the Alcohol, Smoking and Substance Involvement Screening Tool – Lite (ASSIST-Lite) was used. This short screening tool provides substance specific risk scores for commonly used substances. While typically used with adults, other studies have used the tool with adolescents (Gryczynski et al., 2014). Participants indicated their use of each substance in the past three months through yes/no questions. For several questions, affirmative responses triggered further questions such as, "did you usually smoke more than 10 cigarettes each day?". The tool yields sub-domain scores for tobacco, alcohol, cannabis, stimulants, sedatives, and opioids. For this research, we used summed scores to establish total substance use for alcohol, smoking, cannabis, and other recreational drugs for comparative purposes. This scale had adequate reliability in the current sample (α = .796).

3.4.2.2 Early Trauma Experiences

The Threat, Deprivation, and Unpredictability questionnaire was used to measure early trauma experiences. This questionnaire is a recently developed measure which builds on the dimensional model of adversity. It is not yet validated, and a secondary aim of this research is to explore the validity of this measure with adolescent participants. It is used with permission from Northeastern University, Boston. Relevant subscales for the current study include questions about threat and deprivation inside the home and outside the home. Participants indicated their past trauma experiences through 72 four-point Likert scale items with excellent reliability (α = .956).

For several of the "threat" questions, further detail questions were asked such as, *"Were you injured?"* if a participant indicated that they had, for instance, been hit by a family member. Scale items were summed into ten first-order factors: emotional deprivation in the home, physical deprivation in the home, cognitive deprivation in the home, emotional deprivation in the community, physical deprivation in the community, cognitive deprivation in the community, threat at home, threat in the community, threat relating to identity/protected characteristics, and experience of major events such as natural disaster or life changing injury. Following emergent patterns in the data, an additional factor was generated to test post-hoc differences in threat experience for males and females. This factor was called "sexual threat" and included six questions from within the "threat at home" and "threat in the community" sub-scales (see appendix G).

3.4.2.3 Impulsiveness

The Barratt Impulsiveness Scale (BIS-11) was used to measure self-reported impulsiveness. The BIS-11 uses 30 questions rated on a four-point Likert scale from "rarely/never" to "almost

always/always". The responses can be interpreted cumulatively, with higher scores indicating greater perceived impulsiveness, or across several subdomains (attention, cognitive instability, motor impulsiveness, cognitive complexity, and self-control). For the purposes of this research, we will be using the cumulative score to compare general self-report impulsivity. The scale was found to have good reliability (α = .843).

3.4.2.4 Non-Associative Inhibition tasks

3.4.2.4.1 Stop-Signal Reaction Time test (SSRT)

The SSRT is a measure of response inhibition that specifically allows for the measuring of response inhibition latency, within what window of time you are able to stop a pre-potent[5] reaction. This task consists of two phases, a practice phase which includes one block of 32 trials, and an experimental phase which includes four blocks of 64 trials. Each trial presents a fixation cross, followed by the 'go' stimulus (a left or right facing arrow; see appendix C) after 250ms. The 'go' stimulus will remain on screen until the participant has pressed a corresponding arrow key to indicate the direction. If the participant has not responded after 1250ms the screen will progress to the next fixation cross and an incomplete response will be recorded. The inter-trial interval is 750ms following response to the previous trial. On 'stop' trials, a stop signal (the arrow turning red) will be presented after a variable delay, starting at 300ms and increasing or decreasing by 50ms depending on successful inhibition. Due to the tracking nature of the stop-signal delay time, participants are expected to be unsuccessful in inhibiting stop signals approximately 50% of the time. The procedure for this task was taken from recommendations given in Verbruggen et al. (2019) using freely available software distributed through GitHub. For this measure, the time required to suppress an action following a stop-signal, called the stop-signal reaction time (SSRT), was the measurement of interest with lower numbers indicating better inhibitory control.

3.4.2.4.2 Go/No-Go test.

Participants respond to 'go' signals (a green circle presented after a fixation cross; see appendix D) and withhold their response to 'no-go' signals (a red circle presented after a fixation cross). This task has four blocks of 56 trials, containing sets with 6 'go' trials and 1 'no-go' trial. Trials within sets are randomly ordered. Participants must press a key as quickly as they can when they see the green circle but not press on the red circle trials. The fixation times are randomly selected from 500ms, 750ms, 1000ms, and 1250ms (average 857ms) and the inter-trial intervals are randomly selected from 1000ms, 1250ms, and 1500ms (average 1250ms). If a participant

[5] A response with a more strongly associated reinforcement.

does not respond after 1250ms the trial times out and they are reminded to respond as quickly as possible. For this measure, the response of interest is the number of false alarms, where a participant falsely presses a key for 'no-go' trials. A greater number of false alarms would indicate poor response inhibition.

3.4.2.5 Associative Inhibition task

A predictive learning task, 'flowers', was used to obtain a measure of associative inhibition. In this task participants are presented with several cues (fertilisers; see appendix E) and outcomes (flower colours) that they learn to associate over a series of trials. Cues and outcomes are presented in one of three different contexts (flowerbeds) for each block. These are presented across four blocks: acquisition, extinction, summation test, and recovery test (see table 1 for summary of experimental blocks). In the acquisition block, participants learn to associate each outcome (e.g., X) with a cue (e.g., A). In the extinction block this relationship is changed and participants learn that each outcome is no longer associated with the previously learned cue (e.g., cue A now gives outcome Z). The X and Y outcomes were pink or yellow flowers whilst Z was a white flower indicating no outcome. Participants pressed the 'p' key or 'y' key to register predictions for pink or yellow flowers or did nothing if they expected a white flower. Trials were arranged in randomised orders within blocks, with two trials of each type per block, and took place in one of three distinctive visual contexts (A:, B:, or C:). For example, acquisition context **A: A → X x8** indicates that cue A was presented in context A: with outcome X for 8 trials. The physical identity of the stimuli serving the different cue and context roles were randomly determined for each participant by selecting from a range of possibilities. Similarly, the identity of the X and Y outcomes were determined at random for each participant. For example, for some participants X was pink flowers and Y was yellow flowers and vice-versa. Prior to the acquisition phase, participants were presented with a single practice block of 8 trials. Four of these trials cued a blue flower and four cued a white flower in a context that was not used during the experimental blocks (D:).

Table 4: Structure of trials in "flowers" predictive learning task

	Acquisition	**Extinction**	**Summation Test**	**Recovery Test**
Context	A:	B:	B:	C:
Cue/Outcome	A -> X x8 B -> X x8 C -> Y x8 D -> Z x8 E -> Z x8 G -> X x8	A -> Z x8 C -> Y x8	G -> Z x1	A -> Z x1
Total trials = 66 (excluding practise)	48 trials	16 trials	1 trial	1 trial

This design uses the different contexts (flowerbeds) as a conditioned inhibitor, and participants learn to extinguish (extinction) a previously learned association in this novel context. The rate of extinction can be used as a measure of associative inhibition by calculating the slope for the line of best fit for points between block four (end of acquisition phase) and block eight (end of extinction phase) for each participant. A steeper slope indicates faster extinction and therefore stronger inhibition. In a previous study, the rate of extinction was found to be slower in alcohol dependent participants as compared to light drinkers. Dependent drinkers also had higher BIS-11 scores (Buckfield et al., 2020). Buckfield et al. (2020) suggested that slow extinction and increased impulsivity were both signatures of weak inhibition.

3.4.3 Apparatus

Study components took place on individual laptop computers running Windows. Display resolution was set to 1440x900, and experimental measures were run using individually coded programmes. For some participants, where appropriate accommodations could not be made within the school or college, the research took place inside the University of Southampton mobile research unit. This is a modified long-wheelbase van with individual desks to enable three separate participants to complete the research concurrently.

3.4.4 Procedure

Participants were invited to the mobile research unit, or to the designated room in their school or college. Informed consent was obtained prior to starting the questionnaire measures. The collection of self-report measures took an average of 25-30 minutes. Following this, participants immediately began the battery of inhibitory control measures which typically took a further 25-30 minutes.

This study employs an experimental between-subjects design. Following completion of the study, participants were given a debriefing form that further explained the expected link between early trauma experiences and adolescent impulsivity, as well as linking to several independent support services that they could contact should they wish.

3.4.5 Data Preparation and Analysis Plan

Collected self-report data was exported to SPSS to be processed and to check for incomplete responses before being combined with the experimental data set. Several participants had missing data for one, or several, measures. Due to the limited sample in this research, pairwise deletion was used for analyses to preserve the maximum number of records for each variable.

Several threat and deprivation, and BIS-11 items were reverse coded (see appendix F). To allow conditional questions, that were not answered by all participants, to contribute to summed scores, 'no' responses were recoded to zero and 'yes' responses remained as one. For example, an individual participant who said that they were injured and required medical attention would receive a greater summed score than someone who had the same experience without injury or further care. Scores on the ASSIST-Lite were re-coded in the same way, such that an affirmative response added to the participants' summed score for conditional questions.

Data from the go/no-go and associative learning tasks were initially processed using custom code in R-studio written by Dr Steven Glautier. The SSRT data preparation was achieved using custom code in R-studio, supplied by Verbruggen et al. (2019) and distributed using GitHub. Several participants' SSRT data were removed under stipulations given by Verbruggen et al. (2019) leaving 60 records. The SSRT cannot be calculated when the assumptions of the independent race model are violated. This assumes that the 'go' response and 'stop' response are *stochastically independent*, such that knowing one happened does not impact how likely the other is, and *context independent*, such that the distribution of 'go' response times is not impacted by the presentation of the 'stop' signal (Verbruggen et al., 2019). Participants associative learning data were only analysed for those who were demonstrated to be 'learners', leaving 38 records. It is expected that during the acquisition phase, participants will learn to associate paired cues with their respective outcomes. Learners are those who meet a threshold for correct responses to paired cues in the final block of the acquisition phase. Those who do not meet this threshold are considered non-learners, and their pattern of extinction may not be a valid measure of successful inhibition.

Initial bivariate correlations were explored for all hypotheses before several further analyses (regression analysis, partial correlation) were run to explore the hypothesised effects. In these analyses, summed Likert scale data was treated as continuous. For all variables outliers were removed using stem and leaf plots to identify extreme values. Normality was assessed for all variables prior to analysis and addressed through non-parametric analysis where assumptions were violated. Regression analysis was not possible for all hypotheses due to the significant collinearity between deprivation and threat. Following the identification of several potential covariates (sex and age) additional exploratory analyses were run to explore potential moderating effects. Several additional exploratory analyses were conducted and are discussed below.

3.5 Results

Prior to conducting planned analysis, the data were explored for potential covariates. There was a significant between-groups effect of sex on reported early life trauma, $t(60) = -3.056$, $p < .005$, with female participants reporting significantly greater total trauma ($M = 143.23$, $SD = 28.74$) than their male counterparts ($M = 123.10$, $SD = 22.79$). The effect of sex remained significant when examining deprivation ($t(65) = -2.770$, $p < .05$) separately, but not for threat ($t(63) = -1.833$, $p = .071$). No significant effects of sex were found for any measures of inhibitory control, or self-reported impulsivity. These results suggest that there may be a significant difference in the reported early life trauma of male and female participants, but it is not possible to conclude whether sex differences are present for any of the experimental measures.

Educational diagnosis had a significant between-groups effect on reported early life trauma, $t(60) = 4.070$, $p < .001$, with those reporting an educational diagnosis also reporting greater trauma ($M = 148.68$, $SD = 24.05$) than their un-diagnosed counterparts ($M = 122.68$, $SD = 25.09$). The direction of this effect can be cautiously inferred as, in line with our hypotheses, it should be expected that greater experiences of early-life trauma would lead to difficulties with inhibitory control and impulsivity characteristic of attentional diagnoses. This relationship is explored through post-hoc analysis below.

A one-way ANOVA was performed to explore the effect of age on all outcome variables. This revealed no significant differences in inhibitory control measures or self-reported impulsivity. The difference in mean reported trauma was not significant, $F(3, 58) = [2.711]$, $p = .053$.This non-significance may result from skewness in the data as the number of younger participants (age 16 and 17, n = 56) was far greater than the number of older participants (age 18 and 19, n = 16), however age data met criteria for normality (see appendix H). Additionally, the incidence of substance use was higher amongst the study population than in the general population for alcohol (58.2% vs. 50%), tobacco (36.1% vs. 11.6%), cannabis (32.8% vs. 15%), and other recreational drugs (11.2% vs. 6.4%) (Charrier et al., 2024; Jones, 2023; Revie & Mais, 2023).

Table 5: Summary statistics for all participants

Variable	Male (n = 37)			Female (n = 35)			Total sample (n = 72)		
	N (% missing)	M	SD/%	N (% missing)	M	SD/%	N (% missing)	M	SD/%
Age	37 (0)	16.95	1.05	35 (0)	16.86	.88	17 (0)	16.90	.97
Educational Diagnosis	37 (0)	n = 13	35.1%	35 (0)	n = 17	48.6%	72 (0)	30	41.7%
Total Trauma	31 (19.4)	123.10	22.79	31 (11.4)	143.23	28.74	62 (13.9)	133.2	27.6
Deprivation	34 (8.8)	73.12	11.56	33 (5.7)	82.42	15.68	67 (6.9)	77.7	14.4
Threat	33 (10.8)	51.15	16.21	32 (8.6)	59.25	19.31	65 (9.7)	55.1	18.1
Sexual Threat	36 (2.7)	7.22	2.58	35 (0)	11.20	6.85	71 (1.4)	9.2	5.5
SSRT	31 (19.4)	244.90	34.59	29 (17.1)	262.24	44.19	60 (16.7)	253.3	40.1
Go/No-go	37 (0)	7.81	5.17	35 (0)	6.00	3.73	72 (0)	6.93	4.59
Associative Inhibition	22 (40.5)	-.218[1]	.061	16 (54.3)	-.194	.083	38 (47.2)	-.208	.071
BIS-11	34 (8.8)	72.74	13.49	34 (2.9)	74.94	11.11	68 (5.6)	73.8	12.3
ASSIST-Lite	36 (2.7)	2.22	2.00	34 (2.9)	1.82	2.12	70 (2.8)	2.03	2.06
Alcohol	37 (0)	n = 24	64.9%	35 (0)	n = 18	51.4%	72 (0)	n=42	58.3%
Tobacco	37 (0)	n = 14	37.8%	35 (0)	n = 12	34.3%	72 (0)	n=26	36.1%
Cannabis	37 (0)	n = 10	27%	35 (0)	n = 10	38.6%	72 (0)	n=20	27.8%
Drugs[2]	37 (0)	n = 3	8.1%	35 (0)	n = 5	14.3%	72 (0)	n=8	11.1%

[1]NB, a more negative value of associative inhibition indicates better performance.

[2]amphetamines, stimulants, sedatives, opioids, and other psychoactive substances.

3.5.1 Hypothesis 1: *Greater experiences of early life trauma would lead to reduced inhibitory control and increased self-reported impulsivity.*

Using bivariate Pearson's correlations to explore potential relationships between total reported trauma experiences and the outcome variables found no significant correlations with any measure of inhibitory control, nor self-reported impulsivity. Linear regression analysis exploring the effect of trauma experience on each of the outcome variables also revealed no significant relationships. Thus, this hypothesis was not supported in the present study. Exploratory regression analysis did not find a significant moderating effect of sex or age on the above relationships.

Table 6: Pearson's correlations between outcome variables and total trauma experience.

	SSRT	Go/no-go	Flowers	BIS-11
Total Trauma experience (r)	.089	-.025	.142	.140
Significance	*.514*	*.848*	*.439*	*.290*

NB: an increase in "flowers" score would indicate poorer inhibitory control (less steep slope).

3.5.2 Hypothesis 2: *Consistent with a dimensional understanding of trauma, experiences of deprivation would have a greater impact on inhibitory control and self-reported impulsivity than experiences of threat.*

Using bivariate Pearson's correlations to test any potential relationships between threat, deprivation, and the outcome variables found only one significant correlation. As was hypothesised, deprivation significantly correlated with greater self-reported impulsivity, $r(62) = .249$, $p < .05$. However, deprivation did not significantly correlate with any measure of inhibitory control, and threat was not significantly correlated with any of the outcome variables. Using partial correlations to control for deprivation and threat respectively indicated several significant associations. Notably, after controlling for deprivation, threat was significantly associated with associative inhibition. And, after controlling for threat, deprivation had a stronger association with impulsivity.

Table 7: Pearson's correlations between threat, deprivation, and outcome variables.

	SSRT	Go/no-go	Associative Inhibition	BIS-11
Deprivation (r)	.094	-.035	-.118	**.249***
Significance	*.481*	*.781*	*.493*	*.047*
Threat (r)	.060	-.050	.262	.048
Significance	*.655*	*.692*	*.141*	*.712*
Deprivation controlling for threat (r)	*.074*	-.011	-.298	**.260***
Significance	*.587*	*.933*	*.098*	*.045*
Threat controlling for deprivation (r)	.015	-.038	**.373***	*-.091*
Significance	*.910*	*.772*	*.035*	*.490*

***p < .05**

To examine the hypothesised relationships, multiple linear regression analysis was used to test if deprivation and threat significantly predicted changes in the above outcome measures. Deprivation and threat are highly correlated ($r(60) = .500$, $p < .001$), but do not exceed the threshold for collinearity that would prevent regression analysis. A conservative cut-off for acceptable collinearity in the extant literature suggests regression should not be run for VIF[6] values above 2.5 (Johnston et al., 2017). Multiple linear regression analysis with deprivation and threat as predictors produced a VIF value of 1.33, indicating acceptable levels of collinearity. The overall regressions for SSRT, Go/no-go, and associative inhibition were not significant. For associative inhibition, it was found that threat alone significantly predicted associative inhibition ($\beta = .428$, $p = .035$). Deprivation was not found to significantly predict associative inhibition ($\beta = -.332$, $p = .098$), and the relationship between deprivation and associative inhibition was in the opposite direction to threat. For impulsivity, the overall regression was not significant ($R^2 = .070$, $F(2, 58) = 2.171$, $p = .123$). However, it was found that deprivation significantly predicted impulsivity ($\beta = .300$, $p = .045$). Threat was not found to significantly predict impulsivity ($\beta = -.102$, $p = .490$), and again an opposite relationship was found. These results support the hypothesis that deprivation would be associated with a greater increase in impulsivity than threat, and in fact threat experiences were found to correlate non-significantly with *reduced* impulsivity. Deprivation alone ($R^2 = .062$) explained 6.2% of the variance in

[6] Variance Inflation Factor

impulsivity with a small, standardised beta effect size of 0.25 (Nieminen, 2022). Threat and deprivation together explained 7% of the variance in impulsivity and the effect size of deprivation increases to a medium effect of 0.3, further suggesting that threat and deprivation have opposite effects on reported impulsivity. An additional exploratory result found that increased experiences of threat predicted poorer associative inhibition, after controlling for deprivation.

3.5.3 Hypothesis 3: *We expect to find an association between substance use and early life trauma, with threat having a greater association than deprivation.*

Substance use data were skewed (see appendix H), with relatively few participants indicating use of recreational drugs (n = 8), and a greater number indicating some level of alcohol consumption (n = 42) and smoking (n = 26). As such, non-parametric correlations are reported.

Table 8: Spearman's correlations between dimensions of trauma and substance use.

	Alcohol	Tobacco	Cannabis	Other drugs[1]
Total Trauma (r_s)	.007	.205	**.322***	**.293***
Significance	*.959*	*.110*	*.011*	*.021*
Deprivation (r_s)	-.171	.156	.166	.234
Significance	*.183*	*.076*	*.132*	*.068*
Threat (r_s)	.168	.559	**.305****	**.297***
Significance	*.192*	*.069*	*.002*	*.019*

[1]amphetamines, stimulants, sedatives, opioids, and other psychoactive substances.

***p* < .05, ****p* < .01**

Total trauma experience was found to correlate with cannabis use and other recreational drug use. This relationship seems to be mostly explained by associations with threat, as hypothesised. Multiple linear regression was used to test if threat and deprivation significantly predicted each of the substance use outcomes. This analysis was not run for other drug use due to the highly skewed data, however normality statistics allowed for regression analysis to be run with alcohol, tobacco, and cannabis (see appendix H). For alcohol, the overall regression was not significant (R^2 = .072, $F(2, 59)$ = 2.303, p = .109). However, threat was found to significantly predict alcohol consumption (β = .303, p = .040), and the relationship between deprivation and alcohol consumption was non-significant in the opposite direction (β = -.210, p = .153). Threat alone explained 3.9% of the variance in alcohol consumption (R^2 = .039) with a

small effect size of 0.2. Threat and deprivation together explained 7.2% of the variance in alcohol consumption and the effect of threat increased to a medium effect size of 0.3 suggesting threat and deprivation have opposite effects on alcohol consumption. No significant regression was found for tobacco, and neither threat nor deprivation significantly predicted tobacco consumption. For cannabis, the overall regression was highly significant (R^2 = .211, F(2, 59) = 7.89, p < *.001*). In a regression model with deprivation and threat entered, deprivation was not found to predict cannabis consumption (β = -.002, p = .990). However, threat was strongly predictive of cannabis consumption (β = .460, p = .001). Threat explained 21.1% of the variance in cannabis use, with a medium effect size of 0.46. These results support the hypothesis that trauma experience would be associated with increased substance use, and that threat would have a greater association than deprivation.

3.5.4 Hypothesis 4: *We expect to find a significant negative correlation between inhibitory control and impulsivity*, and Hypothesis 5: *We seek to explore the relationship between traditional non-associative measures of inhibitory control and an associative measure of inhibition*.

No significant correlations were found between any measure of inhibitory control and self-report impulsivity. The non-associative inhibitory control measures were not correlated with each other and showed no relationship to the associative measure of inhibitory control. Small, non-significant correlations were found between the non-associative measures of inhibitory control and self-report impulsivity. Due to non-significance the relationship between non-associative inhibition and impulsivity remains unclear. However, a larger sample may have detected a significant relationship.

Table 9: Pearson's correlations between measures of inhibition and impulsivity.

	SSRT	Go/No-go	Flowers	BIS-11
SSRT (r)	1			
Significance	*/*			
Go/No-go (r)	.031	1		
Significance	*.813*	*/*		
Flowers (r)	.057	.064	*1*	
Significance	*.758*	*.703*	*/*	
BIS-11 (r)	.164	.175	.054	*1*
Significance	*.222*	*.153*	*.751*	*/*

3.5.5 Additional Exploratory Analyses

Several interesting patterns arose in the data and as such the following post-hoc analyses were considered. These should be interpreted cautiously but may indicate avenues for future research.

3.5.5.1 Sexual threat as a specific sub-domain of threat

There were significant between-group differences in reported sexual threat (see appendix G) for male and female participants, $t(69) = -3.254$, $p = .002$, with female participants reporting greater experiences of sexual threat ($M = 11.20$, $SD = 6.85$) than male participants ($M = 7.22$, $SD = 2.58$). Both sexual threat and drug use data were highly skewed (see appendix H), and as such non-parametric correlations were explored between sexual threat and all outcome variables.

Table 10: Spearman's correlations between sexual threat and outcome variables.

	SSRT	Go/no-go	Flowers	BIS-11	Alcohol	Tobacco	Cannabis	Drugs
Sexual threat (r_s)	-.092	.023	.149	.061	.217	**.240***	**.301***	**.309***
Significance	*.488*	*.846*	*.378*	*.626*	*.069*	*.043*	*.011*	*.009*

***p* < .05, ****p* < .01**

No significant associations were found between sexual threat and any measure of inhibitory control or impulsivity. Associations between sexual threat and substance use were found to be in line with broader threat experience, but to a greater extent. Except for cannabis, all categories of substance use were more strongly associated with sexual threat than general threat. This finding should be cautiously interpreted but may warrant future exploration of sexual threat as a specific sub-domain of more general threat experiences within the dimensional model.

3.5.5.2 Risk of educational diagnosis following early life trauma

A logistic regression was performed to establish the effect of trauma experience on the likelihood that participants had an educational diagnosis. The logistic regression model was statistically significant, $\chi^2(1) = 14.58$, $p < .001$. The model explained 28.3% (Nagelkerke R^2) of the variance in educational diagnosis and correctly classified 72.6% of cases. Increased trauma experience was associated with an increased likelihood of educational diagnosis, discussed below.

3.6 Discussion

In the present study we sought to examine the relationship between early experiences of trauma and adolescent self-regulatory development. We expected to find that those who had more significant experiences of trauma in their early development would have difficulties with inhibitory control and develop impulsive traits, including substance abuse. Novel to this study, we sought to specifically examine these relationships using the dimensional model of adversity (McLaughlin & Sheridan, 2016; McLaughlin et al., 2014). We sought to add to the existing body of literature evidencing general developmental difficulties following trauma experiences in early life by exploring how deprivation and threat differently impact three domains of self-regulation development: impulsivity, associative inhibition, and non-associative inhibition. In line with our hypotheses, we found a significant association between deprivation and impulsivity, and significant associations between trauma experiences and substance use.

Contrary to our expectations, increases in total trauma experience did not correlate with inhibitory control difficulties, or impulsivity. This result was unexpected, however, a more nuanced understanding of how trauma experience impacts self-regulatory development can be seen when exploring the data using the dimensional approach. Deprivation was found to have a greater impact on the development of impulsivity than threat, with greater deprivation experiences in early childhood predicting higher self-reported impulsivity.

Contrary to our expectations, neither threat nor deprivation were found to significantly correlate with non-associative inhibitory control development. However, threat experiences, but not deprivation experiences, significantly predicted changes in associative inhibition. This suggests that threat, when controlling for deprivation, may lead to poor associative inhibition. Considering the hyperarousal and hypervigilance often seen in those who have experienced threat, it may be that associative inhibition through extinction becomes more challenging for those who have experienced threat, as they have previously found it adaptive to preserve learned associations that keep them safe and may become less flexible in updating their expectations (Cisler et al., 2015; Van Der Kolk, 2003). The non-significance found for the association between total trauma experience (akin to the traditional cumulative ACEs approach) and self-regulatory development, relative to the associations found for threat and deprivation separately, highlights the importance of considering trauma using the dimensional model. Threat and deprivation were found to have different associations with later self-regulatory development that would not necessarily be captured through a cumulative approach.

The inhibitory control and impulsivity measures were not found to correlate with one another and seem to be, at least in part, contingent on different underlying constructs. There are several potential explanations for the non-significance of these expected relationships. Aichert

et al. (2012) found that trait impulsivity only explained 12% of the variance in response inhibition. In the present study there was a small, non-significant effect of non-associative inhibition (response inhibition) on impulsivity, explaining approximately 6% of the variance. It is possible that the relationship between response inhibition and impulsivity is indeed small, and the present study lacked power to detect a significant relationship. This would support the theory that, while impulsivity is partially contingent on failures of inhibitory control, it is also contingent on several other cognitive processes that are not explained by variance in inhibitory control (Mirabella, 2020; Winstanley et al., 2006). These data do, however, present a challenge to Bari and Robins' (2013) assertion that response inhibition measures can serve as a proxy for impulsivity. We also sought to explore the relationship between associative and non-associative inhibition, finding no significant associations. This supports recent research by Brudan et al. (2024) who concluded that, while associative and non-associative learning may have some similarities, they are likely to have different underlying mechanisms, and associative inhibition warrants inclusion as a separate construct within inhibition research.

From these results some tentative conclusions can be drawn about the different impact of threat and deprivation on our development of self-regulatory processes. Those who have experienced deprivation seem to have higher reported impulsivity, which may be contingent on poor non-associative inhibition, and those who have experienced threat seem to have poorer associative inhibition but may not struggle as significantly with impulsivity. The different associations found between deprivation, threat, and self-regulation support the use of the dimensional model when considering cognitive development following early experiences of trauma. Further research in this area is needed to explore the merit of these conclusions with a larger sample, and to explore the replicability of these results.

The results of this study also support the expected relationships between early trauma experience and adolescent substance use. We expected to find higher reported substance use amongst those who have experienced early trauma, with a potentially greater impact of threat over deprivation through functionally adaptive coping mechanisms (Lo and Cheng, 2007; Wadsworth, 2015). This was found to be the case, with trauma experience correlating significantly with participants' consumption of recreational drugs, including cannabis. Exploring threat and deprivation separately, only threat was significantly associated with substance use. After controlling for deprivation, threat was found to significantly correlate with alcohol and cannabis consumption. This lends support to the hypothesis that threat, through functionally adaptive coping, would associate more strongly with substance use than deprivation. Through post-hoc exploratory analysis, it was found that reported sexual threat (non-consenting sex and sexual touch) had a stronger association with substance use than general threat experiences such as violence. This is consistent with extant literature suggesting substance use is a

common coping-mechanism for those who have experienced sexual assault (Ullman et al., 2013).

Educational diagnoses such as ADHD are partially contingent on difficulties with inhibitory control and impulsivity (Breaux et al., 2020; Herba et al., 2006; Kousha et al., 2011; McKechnie et al., 2023). They are also highly correlated with early experiences of trauma in the extant literature (Brown et al., 2017; Kerns et al., 2015; Sonuga-Barke et al., 2017). While it is not possible to infer any directional causality in the current study due to its cross-sectional nature, the relationship between educational diagnosis and trauma experience is noteworthy. Those who experienced greater trauma were significantly more likely to have an educational diagnosis such as ADHD. This adds support to the existing literature suggesting early trauma experiences can lead to increased prevalence of educational diagnosis (Boodoo et al., 2022; Kennedy et al., 2016; Rucklidge et al., 2006; Sonuga-Barke et al., 2017). The direction of this relationship may not, however, be clear cut, as characteristics of ADHD in early childhood have been found to predict reductions in positive parenting and proclivity towards harsh, power assertive parenting that may amount to abuse in some cases (Blair et al., 2014; Merz et al., 2017). It has also been posited that early maltreatment and educational diagnosis may both be contingent on genetic factors, with an observed bidirectional relationship between educational diagnosis and early maltreatment (Dinkler et al., 2017). Future research longitudinally exploring the relationship between childhood adversity, measures of inhibitory control and impulsivity, and educational diagnoses would be valuable to further untangle the relationships found between these constructs.

3.6.1 Strengths and Limitations

There were several noteworthy limitations to the present study that ought to be addressed. The participants in this study may not be representative of the general population, reporting above-population incidence of all measured substance use, which belies a potential underlying over-representation of participants using maladaptive coping mechanisms. There was also a notable disparity between reported smoking and population average smoking, which may have been impacted by the specificity of the ASSIST-Lite screener, which does not differentiate between cigarette smoking and vaping. Many young people in this demographic regularly use vapes, containing nicotine, and the omission of this from the screener may have altered the reported incidence of smoking.

There was a significant loss of data (n = 34) after excluding ‘non-learners’ in the associative learning task. This is a poor performance (53% failed to learn) and in a recent study (Glautier, in prep) using the same task only 21/211 (10%) failed to learn. There are several potential factors which may have caused the large number of ‘non-learners’. Non-learning may

have resulted from not fully understanding the task instructions, being distracted during proceedings, or being unable to successfully learn the cue/outcome associations for another reason. Reading fluency among participants was not assessed as part of this study, however, the task instructions for the associative learning task required relatively proficient reading skills that may have been challenging for some participants. Wherever possible, misunderstandings and questions were addressed during the practice phase of each assessment. However, some misunderstanding may have persisted due to participants' unwillingness to admit difficulty with reading comprehension. A potential mitigating strategy for future research would be to read instructions aloud to each participant and check understanding explicitly before and after the practice phase. While time-consuming, this may result in fewer instances of non-learning due to lack of understanding. It is also possible that non-learning occurred for some participants due to the level and nature of cognitive skills required. As participants were not assessed for any measure of general cognitive ability, it is not possible to assess whether this was the case, but this may warrant inclusion in future research.

The most recently available data from 2023 reports that 17.3% of children and young people in England have an identified special educational need (4.3% with an education, health, and care plan (EHCP), 13% without). The number of identified needs in this study is considerably above this figure (40.3%) and may be reflective of the education settings that took part, which were predominantly non-selective and vocational sixth form colleges, or of the sample who were readily available to the gatekeepers who were predominantly SEN support staff. For future research in this area, it will be important to recruit participants from other education settings such as academic sixth-form colleges offering a-levels, and those who are NEET (not in education, employment, or training). However, the recruited sample also represents a strength of this research as those with educational diagnoses and difficulties in adolescence were of primary interest to the research aims, and we were able to collect data directly from those whom we seek to support.

3.6.2 Conclusion and Implications

The results of this research serve to confirm several hypotheses concerning the different impact of deprivation and threat in early life. It also presents some potentially hopeful avenues for support to mitigate links between early experiences and negative health, social, educational and vocational outcomes from adolescence into early adulthood. The relationship between cognitive deprivation and difficulties with impulsivity, precursor to many of the negative life outcomes described, highlights a key area for support. Children who are provided with cognitively enriching environments in early life, as well as warm emotional support from their primary caregivers, may experience positive cognitive development despite experiences of

deprivation. There is much that could be said about how familial deprivation reduces parents' capacity for enrichment and emotional support, and this presents a clear area for early intervention from education and social care services to mitigate the effects of early deprivation (Blair et al., 2014; McLoyd, 1990; Merz et al., 2017). There is also a clear need for targeted support to reduce the incidences of substance use amongst those who have experienced threat, particularly sexual threat. The damaging long-term impacts of substance abuse mean early intervention in this area is critical, and the understanding of threat as a specific risk-factor will help to identify children and adolescents who are more at risk of future substance abuse.

Educational psychology professionals can play a key role by providing timely support for families in crisis and supporting education settings to understand and employ trauma informed approaches to support all children. A significant way that educational psychologists can support schools is through staff training. To benefit the greatest number of young people, it will be important to disseminate the key understanding gained from this research so that it can inform broader educational practice. There are also broader implications for how we consider research and conclusions about the impact of early trauma experiences. The results of this study give weight to the dimensional approach, showing clear differences in how threat and deprivation impact development, and this framework for considering adverse experiences should be strongly considered in future research in this area. School staff should be supported to understand the dimensional approach, recognising the different impacts and developmental pathways that children may take depending on their early experiences and using that to inform strategies and support. For educational psychology professionals working with those who have experienced trauma; gaining an understanding of the nature of a child's experiences may guide more targeted and effective support and inform a compassionate view of those whose development has been influenced by experiences outside their control. Practically, having a more nuanced understanding of developmental trauma using the dimensional model can support writing key documents such as education, health, and care plans, informing positive and possible provision statements that take into account an individual's specific experiences. Educational psychologists should seek to advocate for those who have been mistreated, recognising the potential for growth and change, and celebrating the skills and resilience that individuals have developed despite, and because of, their experiences.

Appendix A Quality assessment using the CASP cohort study checklist.

Questions:

1. Did the study address a clearly focused issue?
2. Was the cohort recruited in an acceptable way?
3. Was the exposure accurately measured to minimise bias?
4. Was the outcome accurately measured to minimise bias?
5. Have the authors identified all important confounding factors?
    a. Have they taken account of the confounding factors in the design and/or analysis?
6. Was the follow up of subjects complete enough?
    a. Was the follow up of subjects long enough?
7. What are the results of the study? (See data extraction table)
8. How precise are the results? (See data extraction table)
9. Do you believe the results?
10. Can the results be applied to the local population?
11. Do the results of this study fit with other available evidence?
12. What are the implications of this study for practice? (Addressed in body text)

	1	2	3	4	5	5a	6	6a	9	10	11
Amicarelli et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blair et al. (2014)	Yes	Yes	Yes	Yes	Yes	Yes	N/R	Yes	Yes	Yes	Yes
Cipriano-Essel et al. (2013)	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes
Kahle et al. (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No[2]	Yes
Meliva-Seitz et al. (2015)	Yes	Yes	Yes	Yes	Yes	Yes	N/R	Yes	Yes	Yes	Yes
Merz et al. (2017)	Yes	Yes	Yes	Yes	Yes	Yes	No[1]	Yes	Yes	Yes	Yes
Smith et al. (2013)	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes
Swingler et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes	Yes
Wade et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yu & Hsu (2019)	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	No[2]	No[3]

N/R = not reported, N/A = not applicable

[1]Significant attrition of subjects between T1 and T2 – does not preclude this study from inclusion but may impact results found.

[2]WEIRD (Western, educated, industrialised, rich, and democratic) sample with levels of SES and education that may not fully reflect local populations.

[3]Found non-significant effect of positive parenting. However, they did find a significant inverse effect of negative parenting.

Appendix B Data Extraction Table

	Participant Characteristics (male), (SD)	Inhibitory control Measures Used	Parenting Measures Used	Analysis	Results	Controlled variables	Notes
Amicarelli et al. (2018)	T1 = 406 (199*) children aged 3.02 (.16) T2 = 380 (186) children aged 5.44 (.50) 406 (24*) caregivers aged 33.25 (4.62) at T1 Caucasian – 93% African – 0.5% Asian – 2% Hispanic – 2.5% Other – 2.5%	Sub-tests of the Laboratory Temperament Assessment Battery (LAB-TAB) including: Tower of Patience Snack Delay Gift Bag Simon Says	Three observed joint tasks with child, coded by trained researchers. Self-report ratings using Parenting Styles and Dimensions Questionnaire (PSDQ)	Multiple regression examining associations between positive parenting and children's IC with sex as moderator variable.	Positive parenting at age 3 predicted greater IC at age 5, with a significant moderating effect of child sex. Positive parenting had a significant effect for boys ($p < .05$) whereas it did not for girls ($p = .39$). Boys had significantly lower measured IC than girls at both time points ($p < .03$), although this difference was erased for those who experienced positive parenting.	No control variables reported. Gender included as moderating variable.	*Percentage reported did not equal whole number

	Canada						
Blair et al. (2014)	T1 = 1292* (659**) children aged 3.09 (.15) T2 = 1099 (NR) children aged 5.05 (.27) Demographics for caregivers not reported. Caucasian – 58% African American – 42%	Novel measure	HOME scale and rated observations during structured parent-child interaction tasks.	Multiple regression to examine change in IC as result of parenting. RCA and LCM models to test bidirectionality.	Parental responsiveness, but not sensitivity, at T1 (36 months) predicted (.19, $p < .05$) changes in executive function, including inhibitory control, at T2 (60 months). Executive function, including inhibitory control, at T1 significantly predicted parental responsiveness at T2 (.19, $p < .1$) and sensitivity at T2 (.15, $p < .05$).	Used analysis methods that control for "time invariant characteristics" of the children	*Data derived from "Family Life Project" **Percentage reported did not equal whole number
	USA						
Cipriano-Essel et al. (2013)	118 (56*) children aged 3.7 (.74)	Shapes task Stroop task - Day/night	Structural Analysis of Social	Impact of childhood maltreatment	Warm autonomy support, but not warm guidance, significantly predicted	Controlled for child age, IQ (assessed using	*Percentage reported did not

	118 (0) caregivers aged 28.6 (5.52) Caucasian – 79.8% African American – 2.5% Multi-Racial – 16.2%** USA		Behaviour (SASB) coding system used for observed joint interactions.	controlled for by using ANCOVA. Hierarchical regression used to assess impact of positive parenting.	inhibitory control (.20, p < .05).	SB-5), family income, and maternal education.	equal whole number **93.3% of mothers were Caucasian
Kahle et al. (2017)	T1 = 42 (19) children aged 3.5 (.03) T2 = 37 (18) children aged 4.06 (.07) 42 (0) caregivers, age not reported. Caucasian – 69% Hispanic – 14% Asian – 10%	Modified Stroop tasks including: Day/Night Happy/Sad	Coding of maternal behaviour during structured parent-child activity making a puzzle.	Linear regression analysis used to predict changes in IC from maternal measures. Shared variance in IC tasks 'partialled out' to enable analysis	Changes in accuracy on the "happy/sad" task (emotionally salient) between T1 (3.5 years) and T2 (4.06 years were significantly predicted (.39, p = .01) by maternal emotion explanations. Changes in latency on the "Happy/Sad" task (emotionally salient) between	Controlled for day/night when predicting happy/sad, and vice-versa in-order to predict unique variance in each task.	

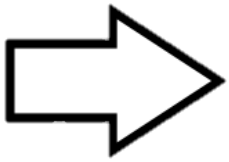
	Other – 7% USA			of unique variance.	T1 (3.5 years) and T2 (4.06 years) were significantly predicted (.27, p = .04) by maternal emotion language. Changes in latency on the "Day/Night" task (emotionally neutral) between T1 and T2 were significantly predicted (.26, p = .01) by maternal scaffolding.		
Merz et al. (2017)	T1 = 534 (267) children aged 4.45 (.52) T2 = 381 (NR) children aged 5** 534 (5*) caregivers, age not reported. Hispanic - 71% African American – 28%	Gift delay wrap task Stroop task - Bear/Dragon	Coding of parental behaviour during parent-child free play sessions.	Cross-lagged structural equation modelling	Good model fit (CFI = .97) Gender significantly predicted delay inhibition; girls outperformed boys at p<.01. Parental responsiveness at T1 (4.45 years) significantly predicted (.11, p < .05) T2 (~5 years) inhibitory control. Inhibitory control at T1 significantly predicted (.13, p	Controlled for age, gender, ethnicity, verbal ability, and maternal education.	*n=2 gender not reported **approximated as T2 reported to be "6.5 months later"

	European American – 1% USA				<.05) parental responsiveness at T2.		
Mileva-Seitz et al. (2015)	752* (369) children aged 4.29 (.12) 752 (121) caregivers aged 32.13 (3.66)** Dutch (Caucasian) – 100% The Netherlands	Auditory Continuous Performance test - Go/No-go	Coded parental behaviour towards child at age 14-months and observed parent-child joint activity at 36 months.	Mean difference tests and regression analysis	Boys made significantly more commission errors (indicating poor IC) at p<.001. Increased parental sensitivity at T1 (18 months) and T2 (36 months) significantly predicted (-.26, p = .05) reduced commission errors (IC) at T3 (52 months) *for boys only*.	Controlled for child age, birth order, and maternal education.	*Part of a larger longitudinal cohort study, IC data taken at 52 months, parental sensitivity recorded at 14 months and 36 months. **Only maternal age was reported
Smith et al. (2013)	409 (200) children aged 3.43 (.28) 409 (29*) caregivers aged 33.53 (5.07)	Sub-tests of the Laboratory Temperament Assessment	Coding of parenting behaviours during parent-	Bivariate correlation	Positive parenting was positively correlated with IC for all children (.16, p < .01) and negative parenting was	Controlled for child sex, age, family income,	*Percentage reported did not equal whole number

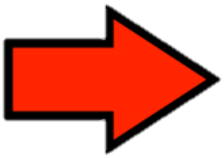
	Canada	Battery (LAB-TAB) including: Tower of Patience Snack Delay	child joint structured play. Coded using Qualitative Ratings for Parent-Child Interactions scale.		correlated with lower IC ($p < .001$). Boys also showed generally lower IC across conditions ($p < .001$).	and verbal ability.
Swingler et al. (2018)	276 (126) children aged 4.67 (.42) 276 (12) caregivers, age not reported. White – 59% Black – 28% Asian – 2% Multi-Racial – 11% USA	Animal based Go/No-go	Coded observations of mother-child semi-structured problem-solving task.	Structural equation modelling	Maternal emotional support significantly predicted (.230, $p = .01$) task accuracy (correct go responses – incorrect no-go responses) for all participants.	Controlled for child age, gender, minority status, and maternal education.

Wade et al. (2018)	T2* = 397 (NR) children aged 1.58 (.16) T3** = 385 (NR) children aged 3.17 (.27) 397 (0) caregivers aged 32.7 (4.9) at T1 Canada	Modified Stroop tasks including: Grass/Snow Bear/Dragon	Coded interactions of joint reading of a picture book.	Latent variable path analysis using Mplus 7.2 with full information maximum likelihood estimation.	Maternal linguistic input, but not responsive behaviour, at T2 (18 months) significantly predicted (.19, $p < .01$) inhibitory control at T3 (3 years).	Controlled for child age, gender, maternal education, and expressive language.	*T1 not used as children too young **IC only measured at T3, T4 measured other study aims not related to this review.
Yu & Hsu (2019)	83 (45) children aged 4.22 (.22) 83 (0) caregivers, age not reported. Caucasian – 83% Other – 17% USA	Mean/good puppet task. Animal Stroop task	Coding of maternal communicative acts during a structured game.	Multiple linear regression.	Maternal collaborative communication did not significantly correlate (.150, non-significant) with inhibitory control. Maternal non-collaborative communication did significantly correlate (-.500, $p < .01$) with reduced inhibitory control performance, for girls only.	Controlled for child sex, age, and maternal education.	

Appendix C Stop-Signal Reaction Time test example stimuli.



Go signal: participant would press right arrow key.



Stop signal: participant would attempt to inhibit response.

Appendix D Go/No-go experimental instructions with stimuli.

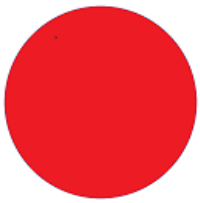
In this experiment, a circle will appear in the center of the screen.

If the circle is **green**, press the letter G on the keyboard as fast as you can.

If the circle is **red**, do not press any key.

Press any key to begin.

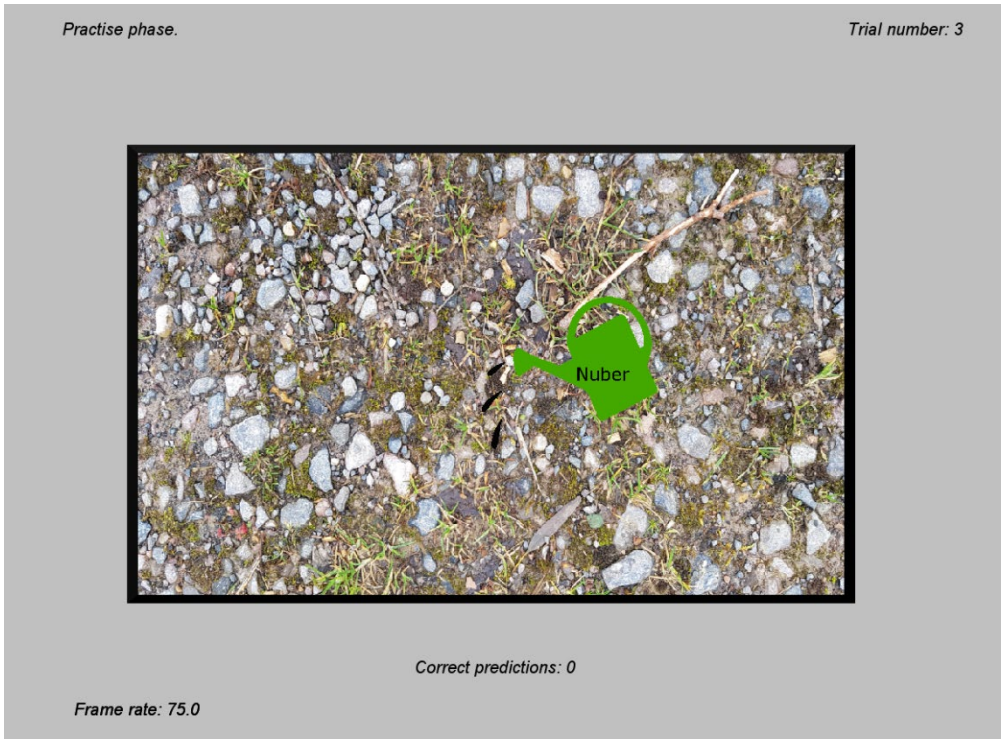
Press the G key



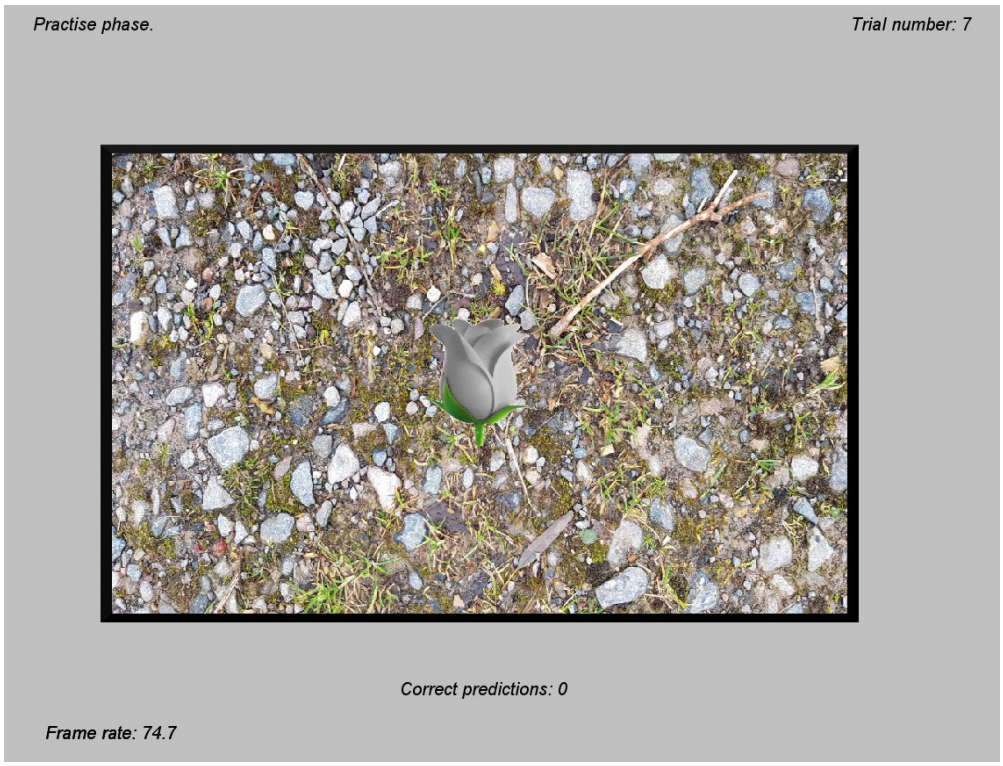
Do not Press any key

Appendix E “Flowers” test of associative learning example stimuli

Example cue stimulus



Example outcome stimulus



Appendix F Reverse coding of scale items

	Reverse coded items	
Barratt Impulsiveness Scale 11	1	*I plan tasks carefully.*
	7	*I plan trips well ahead of time.*
	8	*I am self-controlled.*
	9	*I concentrate easily.*
	10	*I save regularly.*
	12	*I am a careful thinker.*
	13	*I plan for job security.*
	15	*I like to think about complex problems.*
	20	*I am a steady thinker.*
	29	*I like puzzles.*
	30	*I am future oriented.*
Threat and Deprivation Questionnaire	1	*How often did an adult take care of you when you were sick or hurt?*
	2	*How often did an adult try to make you feel better when you were upset?*
	3	*How often did an adult include you in conversations with other adults?*
	4	*How often did an adult talk with you about your interests?*
	5	*How often did an adult get to know your friends and your relationships with them?*
	6	*How often did an adult talk with you about your thoughts and feelings?*
	7	*How often did an adult congratulate you or celebrate with you when you were happy or had accomplished something?*
	10	*Across your childhood in general, how often would an adult take you to the doctor or to the dentist when you were very sick or needed medical attention?*
	19	*How often did an adult take you to a place for learning other than school, like a library or museum?*
	20	*How often did you have access to a computer or the internet outside of school?*
	21	*How often did you go on outings with an adult (e.g., to the grocery store, running errands, etc.)?*
	22	*How often did an adult play games or do activities with you that were designed for learning (e.g., activities with numbers, letters, math, trivia, play board games, etc.)?*

23	*How often did an adult help you learn more about things you were interested in (e.g., dinosaurs, nature, outer space, etc.)?*
24	*How often did an adult read a book with you?*
25	*How often did you eat meals with at least one adult?*
26	*How often did an adult make sure you went to school and did your homework?*
27	*In school, how often did an adult take care of you when you were sick or hurt?*
28	*In school, how often did an adult try to make you feel better when you were upset?*
29	*In school, how often did an adult include you in conversations with other adults?*
30	*In school, how often did an adult talk with you about your interests?*
31	*In school, how often did an adult talk to you about your friends?*
32	*In school, how often did an adult talk with you about your thoughts and feelings?*
33	*In school, how often did an adult congratulate you or celebrate with you when you were happy or had accomplished something?*
35	*In school, how often did an adult take you to a place for learning other than school, like a library or museum?*
36	*In school, how often did you have access to computers or other technology in the classroom to facilitate learning (e.g., tablets, projectors, smartboards)?*
38	*In school, how often was a teacher or classroom aide able to provide individual attention if you had a question or did not understand something?*
39	*In school, how often did you participate in structured activities (e.g., playing on a sports team, music lessons, etc.)?*
40	*In school, how often did an adult help you learn more about things you were interested in (e.g., dinosaurs, nature, animals, etc.)?*

Appendix G Scale items included in the post-hoc factor “sexual threat”.

Each of the questions below were included along with their cascading questions:

- Were you injured?
    - *[if yes]* Did you need medical attention from a doctor or have to go to the hospital?

	Scale item
Q53	How many times has a someone touched you in a sexual way when you did not want them to?
Q54	How many times has a someone forced you to touch them in a sexual way?
Q55	How many times have you been forced to have sex with someone?
Q63	How many times has someone outside your family (e.g., a peer, romantic partner, stranger) touched you in a sexual way when you did not want them to?
Q64	How many times has someone outside your family (e.g., a peer, romantic partner, stranger) forced you to touch them in a sexual way?
Q65	How many times have you been forced to have sex with someone outside your family (e.g., a peer, romantic partner, stranger)?

Appendix H Normality statistics for key variables for all participants. Non-normal data in bold.

	Mean	SD	Min	Max	Skewness	SE Skewness	Kurtosis	SE Kurtosis
Age	16.9	.97	16	19	.873	.283	-.173	.559
Total Trauma	133.2	27.7	75	185	.072	.304	-.840	.599
Deprivation	77.7	14.4	47	107	-.043	.293	-.558	.578
Threat	55.1	18.1	29	97	.389	.297	-.719	.586
Sexual Threat	9.18	5.5	6	36	**2.49**	.285	**7.71**	.563
SSRT	253.3	40.1	162	362	.261	.309	.031	.608
Go/No-go	6.93	4.59	0[1]	19	.724	.283	-.133	.559
Associative Inhibition	-.208	.071	-.30	-.05	.708	.383	-.462	.750
BIS-11	73.8	12.3	40	105	.064	.291	.141	.574
ASSIST-Lite	2.03	2.06	0	7	.927	.287	.013	.566
Alcohol	1.07	1.05	0	3	.380	.283	-1.23	.559
Tobacco	.514	.787	0	3	1.47	.283	1.45	.559
Cannabis	.486	.889	0	3	1.719	.283	1.80	.559
Drugs[2]	.208	.730	0	4	**4.34**	.283	**19.80**	.559

[1]Zero score when participants made no commission errors.

[2]Amphetamines, stimulants, sedatives, opioids, and other psychoactive substances.

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