UNIVERSITY OF SOUTHAMPTON

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Does attachment influence learning? An investigation in to the associations between attachment, executive function and academic attainment.

by

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ABSTRACT

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DOES ATTACHMENT INFLUENCE LEARNING? AN INVESTIGATION IN TO THE ASSOCIATIONS BETWEEN ATTACHMENT, EXECUTIVE FUNCTION AND ACADEMIC ATTAINMENT

Lindsey Claire Foy

In the field of psychology there is a growing interest in the relationship between early experiences and neurocognitive development (Schore & Schore, 2008). It has been suggested that early attachment experiences influence the development of a group of cognitive processes known as executive functions (e.g. Bernier, Carlson & Whipple, 2010). This thesis investigates the association between attachment styles and executive function in children and adolescents. Chapters one and two focus on different age groups. The literature review in chapter one explores the existing studies that consider this relationship in children aged 12 months to 11 years. A number of methodological issues in assessing the association between attachment and executive function are identified and discussed. The empirical paper in chapter two examines the associations between attachment, executive function and academic attainment in early adolescence aged 11 years to 14 years. Students (N=32) completed an attachment questionnaire, three executive function tasks and an IQ test. The results demonstrated an association between executive functions and academic attainment. However, the associations between attachment and executive functions did not reach significance and attachment was not found to influence academic attainment indirectly via executive function. The findings are discussed in terms of future research and implications for professional practice.

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DECLARATION OF AUTHORSHIP

I LINDSEY CLAIRE FOY 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.

Does attachment influence learning? An investigation in to the associations between attachment, executive function and academic attainment.

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

Signed:……..

Date: ……..…

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Definitions and Abbreviations

α	Cronbach alpha
$\bar{x}$	Mean
ADHD	Attention Deficit Hyperactive Disorder
Age	Age of participant (months)
Anxious score	Anxious attachment score
ASD	Autism Spectrum Disorder
Avoidant score	Avoidant attachment score
B	B value from linear regression
BPD	Borderline Personality Disorder
C.I	Confidence interval
EF	Executive function
EF trail	Time difference in trail making task
Stroop (mean)	Average speed difference Stroop task
Stroop (median)	Median speed difference Stroop task
Stroop %error	Percentage of correct answers in Stroop
Spatial WM	Spatial working memory

Verbal WM	Verbal working memory
FSM	Free School Meals
HPA axis	Hypothalamic pituitary adrenal axis
KS3	Key Stage 3
KS4	Key Stage 4
M	Mean
N	Number of participants
NC Level	Average national curriculum score
p	Significance value
Parent Education	Number of years parent has spent in education
r	Pearson's correlation coefficient
SE	Standard error
SE B	Standard error of B
SEAL	Social and emotional aspects of learning
SENCo	Special Educational Needs Coordinator
SES	Socioeconomic status
z	Skewness

Chapter 1: The influence of attachment on the development of executive function

1.1 Introduction

There is a growing interest in the association between the quality of early caregiving experiences and child development (Belsky & Fearon, 2002; Moutsiana et al., 2014; Schore & Schore, 2008). Exploratory research has begun to consider the associations between attachment style and a set of cognitive processes that underlie goal directed behaviour known as executive function (Bernier, Carlson & Whipple, 2010).This literature review describes the key features of attachment theory and the influence of early caregiving experiences on self-regulation, brain development and academic attainment. The construct of executive function is then outlined before the association between attachment and executive function in children is presented. The review discusses the definition of these constructs, the measures used to capture them, their stability over time, and the confounding variables that influence them, presenting the theoretical debates that exist in this area of research. Studies that explore the associations between attachment and executive function in toddlers and young children (age 12 months to 11 years) are identified through a systematic literature search and explored according to these themes. Studies using samples of adolescents were not examined in the literature review. Finally, the academic and practical implications are identified and suggestions for further research are made.

In the middle of the twentieth century, John Bowlby proposed a theory of Attachment (Bowlby, 1969). Although variations and embellishments have been introduced into the field over time, attachment theory is built around three core ideas: the role of the primary caregiver, the internal working model, and the development and use of a secure base. Considering the primary caregiver first, Bowlby (1969) argued that attachment is a 'monotropic' process whereby an infant forms a strong attachment and preference for one primary caregiver during a sensitive period of development. Bowlby theorised that when an infant experiences appropriate bonding interactions with this caregiver, they are likely to develop a secure attachment style but if not, they are at risk of developing an insecure attachment style (Ainsworth, Blehar, Walters & Wall, 1978). Insecure attachment has been explored differently according to the approach taken by different researchers over time. One theoretical approach has been to categorise distinct attachment behaviours into four groups whilst another has been to explore attachment behaviours on a dimensional scale.

Ainsworth et al. (1978) presented a categorical model of attachment that posited that variations in caregiving responsiveness and behaviour are likely to lead to variations in the behaviour demonstrated by a child in times of distress. Three categories of insecure attachment known as insecure avoidant attachment, insecure resistant/ambivalent attachment (Ainsworth et al., 1978), and disorganised attachment (Main & Solomon, 1986) have been identified in the literature and are thought to reflect the adaptive behaviour that the infant has developed to reduce their anxiety based on their experiences with the caregiver (Crowell, Fraley & Shaver, 2008). The third category of disorganised attachment was added by Main and Solomon due to the identification of infants who did not fit into the secure, avoidant or resistant/ambivalent attachment groups. In line with

Ainsworth's categories of attachment, Prior and Glaser (2006) provide a summary as to the way children organise their attachment behaviour based on their caregiving experiences according to these categories of insecure attachment. It has been suggested that children with an insecure avoidant attachment style show little response to a separation from their caregiver and avoid interactions on the caregiver's return. These infants rarely experience the soothing required to reduce the activation of attachment behaviours. Children with an insecure resistant/ambivalent attachment style are more likely to become immediately distressed when separated from their caregiver and combine a resistance to interactive behaviours with contact-seeking behaviour on the caregiver's return. These children take longer to soothe than a child demonstrating securely attached behaviours. Children with a disorganised attachment style are identified on the basis that they lack a clear strategy for dealing with separation from their caregiver, demonstrating contradictory behaviours such as distress or strong attachment behaviours followed by a sudden change to avoidant behaviours.. Ainsworth et al. (1978) identified 8 subgroups within the categories of secure, avoidant, and resistant/ambivalent attachment on a continuum of the suppression of attachment behaviours to the expression of attachment behaviours.

An alternative approach to the classification of secure and insecure attachment behaviours has been proposed using a continuous model of attachment behaviour. It has been suggested that individual differences in attachment organisation are not always suited to a categorical model and it is more precise to explore continuously distributed individual differences in behaviour (Fraley & Speiker, 2003). Fraley and Speiker (2003) proposed a two dimensional model of attachment behaviour. The first dimension referred to as proximity seeking versus avoidant strategies considers the degree to which a child seeks

comfort from their caregiver in a stress eliciting situation. The second dimension addresses angry and ambivalent strategies by observing the amount of anger a child displays towards the caregiver when the attachment system has been activated. In this paper the researchers demonstrated that the categorical attachment styles fall within these dimensions. The use of continuous versus categorical approaches to the nature of attachment remains an ongoing debate in the literature.

Another method of the classification of attachment is the diagnosis of an attachment disorder. It has been suggested that an attachment disorder results from the absence of a caregiver and, as such, many examples come from young people who have been in institutionalised care (Howe, 2003). Labels of disinhibited and inhibited attachment disorder have been used in research including such a sample. When assessing for these diagnoses, O'Connor and Rutter (2000) explored behaviours typical of disinhibited attachment such as a lack of discrimination between adults and a willingness to be with strangers and behaviours typical of inhibited attachment such as a lack of social responsiveness to caregivers. This is a different approach to Ainsworth et al.'s (1978) categories of attachment behaviour and, as aforementioned, is often used in samples of young people who have experienced institutionalised care (Howe, 2003).

The second core tenet of attachment theory is known as the Internal Working Model of relationships (Coan, 2008). The internal working model of relationships is thought to constitute mental structures reflecting experiences of the self with others (Coan, 2008). It develops in accord with lived experiences with the attachment figure and is thus influenced by the caregiver's response pattern and quality to the infant. Such experiences are gradually internalized to form internal representations of self, other, and relationships. The internal working model enables the individual to predict, regulate, and interpret the

behaviour of their caregiver (Bretherton & Munholland, 1999). Over time, as the child begins to acquire language, they will construct models of how they are expected to behave and interact with their caregiver and others, using the framework of the model in different situations (Bowlby, 1969).

The internal working model is one element of an ongoing debate as to the stability of attachment over time. One theoretical interpretation is that an individual seeks out interactions and relationships that fit their past experiences with attachment figures (Mikulincer & Shaver, 2007). In this sense attachment style would be expected to remain relatively stable over time. However, there is an alternative literature base that suggests that changes in an individual's circumstances such as their social support can be associated with changes in attachment behaviour (Sroufe et al., 2005a). A meta-analysis carried out by Fraley (2002) presented two alternative viewpoints as the prototype perspective in which attachment representations remain stable over time and the revisionist perspective in which early representations can be modified by new experiences. The results suggested that a prototype perspective is the best fit as attachment security was moderately stable throughout childhood and adolescence.

The internal working model can also be used to consider global and relationship specific attachment patterns. Research has investigated the individual differences in general attachment patterns and those directly associated with specific relationships such as parents, peers and romantic relationships. Khlonen, Wellerm Luo and Choe (2005) found an association between global attachment representations, peer and parent relationship representations with the strongest association between global and peer representations. In line with this theorising it has been suggested that an individual's general attachment style is related to their interpersonal expectancies in close relationships

(Baldwin, Fehr, Keedian, Seidel & Thomson, 1993). Hazan and Shaver (1987) adapted three infant attachment categories (secure, avoidant and anxious/ambivalent) in order to apply them to adult relationships. Baldwin, Keelan, Fehr, Enns and Koh-Rangarajoo (1996) used Hazan and Shaver's (1987) measure to capture the general attachment style of participants along with attachment patterns in 10 significant relationships (identified by the participant) to determine the associations between general and relationship specific attachment patterns. The study suggested that participants were more likely to report relationships that matched their general attachment style patterns i.e. participants with secure attachment style were more likely to report secure attachment relationships. However participants reported a range of experiences and a large proportion of the sample (88%) reported experiencing relationships in more than one attachment pattern. As such the study lends itself to a multiple models theory in which individuals develop different attachment patterns in different relationships.

Ainsworth proposed that children use their primary caregiver as a secure base from which to explore the world (Ainsworth, & Bell, 1970). Two systems known as the attachment and exploratory behaviour systems coexist so that infants are able to respond to and interact with their environment (Ainsworth & Bell, 1970). When a child feels safe, their exploratory behaviour system is activated and the child will move away from their secure base, exploring independently and experiencing social interactions with peers. If the child identifies a potential threat, their attachment behavioural system is activated, overriding the child's desire to explore, so that they return to the safety of their attachment figure. The activation of these two behaviour systems according to attachment style has been shown to influence a young person's self-regulation (Allen, 2012) and learning (Moullin, Waldfogel & Washbrook, 2014).

Research on attachment theory has continued to investigate the association of attachment patterns with behaviour and development. A caregiver's response to a child's distress is thought to be associated with the development of a child's self-regulation skills (Jones, Brett, Ehrlich, Lejuez & Cassidy, 2014). In Bowlby's (1969) original work he argued that an infant's proximity seeking behaviour is an affect regulation mechanism. Research suggests that attachment plays a role in emotion regulation (Allen, 2012) and stress regulation (Schore & Schore, 2008) in that children and adolescents with a disorganised or insecure attachment style respond to stressful situations differently than those with secure attachment style (Hertsgaard, Gunnar, Erickson & Nachmias, 1995; Pascuzzo, Cyr & Moss, 2013). One biological explanation that has been proposed for this association is that the deprivation of a primary caregiver early in life impacts on the development of the hypothalamic–pituitary–adrenal (HPA) axis in the brain, elevating levels of stress hormones (Hostinar, Sullivan & Gunnar, 2014). This process, in which social experiences influence brain development, is known as neuroplasticity (Kolb, 2013). Empirical evidence demonstrates that children with a disorganised attachment style experience higher cortisol (stress hormone) levels than those with a secure attachment style following an anxiety provoking scenario (Hertsgaard et al., 1995).

Another facet of the investigation into the associations between attachment patterns, behaviour and development focuses on learning. Within this area of research attachment patterns are thought to influence learning and academic attainment (Moullin, Waldfogel & Washbrook, 2014). One explanation for this is the bidirectional model of attachment and exploration. The attachment system is thought to interact with the behaviour system to shift from exploration to proximity seeking behaviours in response to perceived threat (Ainsworth & Bell, 1970). This exploratory behaviour is a key process that underlies a

child's cognitive development and the emergence of early learning skills (Cassidy & Shaver, 2008). This model of attachment and exploration has been observed in the classroom (Geddes, 2005). In developing a learning profile of students demonstrating different attachment behaviours Geddes (2005) suggested that young people with an insecure resistant/ambivalent attachment style often seek frequent attention from the teacher, demonstrating high levels of proximity seeking behaviour whereas young people with an insecure avoidant attachment style are more likely to refuse any attention at all. Geddes (2005) suggested that this behaviour dictates different teacher responses and, as a result, impacts the child's learning. An alternative biological explanation could be that early caregiving experiences influence the underlying learning processes known as executive function (Bos, Fox, Zeanah & Nelson, 2009). The elevated stress hormones that result from the deprivation of a caregiver can alter the structure and function of the prefrontal cortex (Arnsten, 2009) in which these learning processes are located (Merz, Harlé, Noble, & McCall, 2016).

The association between attachment styles and executive functions is an exploratory area of research. The term executive function refers to the self-regulatory, cognitive processes that are used to monitor and control thoughts and actions (Carlson, 2005) such as: planning, working memory, attention, inhibition, self-monitoring, and self-regulation (Goldstein, Naglieri, Princiotta & Otero, 2013). These cognitive processes underlie goal directed, problem solving behaviour (Best & Miller, 2010; Otero, Barker & Naglieri, 2014). Executive function skills have been recognised as a predictor of academic attainment (Hughes, 2011) and school performance (Diamond, Barnett, Thomas & Munro, 2007). Children age 3-4years with superior executive function skills have demonstrated higher scores on tests of academic achievement (including mathematics and reading) when

entering pre-school (Cameron, Brock & Murrah, 2012). Similarly, children with higher executive function ability at age 5 years demonstrate higher levels of literacy and numeracy at age 11 years (Alloway & Alloway, 2010). Executive functions are thought to be important processes in the learning environment as students are required to complete projects and writing assignments that rely on effective executive function processes (Meltzer, Pollica & Barzillai, 2007).

There are a number of theories and models that have been used to describe the development of executive function processes (Meltzer, 2007). Although executive function is widely thought to encompass the skills outlined by Goldstein et al. (2013), different theorists approach the construct of executive function differently. Some research has suggested that executive functions can be separated in to two factors known as Conflict executive function (Conflict EF) and Impulse control (Bernier, Carlson & Whipple, 2010). Conflict EF includes three cognitive processes: working memory (defined as an ability to hold and manipulate information), inhibition (defined as the ability to inhibit distracting stimuli/information), and shift (defined as the ability to move from one task to the next). Impulse control refers to the ability to delay gratification. Zelazo and Muller (2002) use the terms 'cool' and 'hot' executive function, where cool refers to Conflict EF and hot refers to Impulse control. It has been suggested that cool executive function is elicited by abstract tasks whereas hot executive function is elicited by problems that require affect regulation and motivation (Hongwanishkul, Happaney, Lee & Zelazo, 2005). Hot and cool aspects of executive function have been located in different areas of the prefrontal cortex with hot EF situated in the ventral medial prefrontal cortex and cool EF in the dorsolateral prefrontal cortex (Zelazo & Carlson, 2012). However, an alternative model of executive function is highlighted in the meta- analytic review by Alvarez and

Emory (2006). The review suggested that the component factors that have been found to underlie executive function are inhibition, working memory, and selective attention. On examination, these factors appear to mirror those outlined in the construct of Conflict EF but are considered separately in the review.

Resent research has suggested that inadequate social and cognitive stimulation in infancy influences prefrontal cortex and executive function development (Merz et al., 2016). Referring to a sample of institutionalised children who had experienced extreme early caregiving deprivation, Merz et al. (2016) argued that caregivers at these institutions do not provide the frequent interaction or enriching cognitive experiences to infants that are required for the development of prefrontal cortex circuitry. As executive function is a predictor of academic attainment (Hughes, 2011) this biological process provides one explanation as to the association between attachment and academic attainment. However, the evidence presented by Merz et al. (2016) considers extreme experiences of neglect and the absence of care. As these studies do not reflect typical patterns of experience and development it is possible that the relationship between attachment and executive function in this sample of young people is different to that of a sample of young people who have experienced more typical caregiving experiences. This should be considered when contrasting studies in future research.

Summary. This section outlines the likely influence of attachment on self-regulation (Schore & Schore, 2008) and executive functioning (Merz et al., 2016). Research suggests that early deprivation of a caregiver provides inadequate social and cognitive stimulation (Mertz et al., 2016) and elevates the levels of stress hormones, affecting the development of the structure and function of the prefrontal cortex (Arnsten, 2009) and lowing executive function ability (Mertz et al., 2016). However research in this area of psychology remains

at a developmental stage. As a result, the aim of this review was to identify and evaluate the empirical literature in this area to address the following question: to what extent is a child's attachment style associated with their executive function ability? The next section of the review considers to constructs of attachment and executive function in more detail, introducing the conceptualisation of the constructs, the measures used to capture them, their stability over time, and the confounding variables that influence them. These debates are introduced in order to assess the reliability of the research that investigates the association between child attachment style and executive function ability.

Current Review

In order to explore the extent to which a child's attachment style is associated with their executive function skills a systematic review was conducted to identify the literature that investigates this association. As research in this area is at an exploratory stage the results of the studies were assessed based on the approach used by the authors to a number of themes. These themes included the conceptualisation of the constructs of executive function and attachment, the measures used to capture them, and the variables that may influence or alter the associations between them. These debates are introduced before details of the literature search are outlined in order to apply them to the studies identified in a systematic literature search and consider the strength of the findings in this area of research.

Conceptualisation of the constructs

The definitions of executive function and attachment as constructs require exploration. Traditionally attachment style has been viewed as a categorical construct and children have been identified with secure attachment, insecure avoidant attachment, insecure dismissive attachment (Ainsworth et al., 1978), or disorganised attachment (Main & Solomon, 1986). Although these categories were developed by combining a number of continuously scaled behaviours, Ainsworth et al. (1978) adopted a categorical approach to attachment in order to retain clear patterns of behaviour. However methodological tools such as taxometric analysis (Meehl & Younce, 1996) have since enabled researchers to consider whether a construct has a categorical or continuous distribution. Fraley and Speiker (2003) carried out a taxometric analysis of attachment organisation using the behaviour scales required for coding the Strange Situation Procedure (Ainsworth et al.,

1978). The study suggested that the data was more consistent with a dimensional construct of individual differences as applying categories does not sufficiently convey the complexity of attachment. These disputes have led to an increase in the variety of measures that are used to capture attachment style.

Executive function is often considered an umbrella term that encompasses a range of cognitive processes (Goldstein et al., 2013). Executive function has traditionally be conceptualised as a single construct responsible for high level cognitive skills however an alternative conceptualisation is of executive function as a set of inter-related, inter-dependent processes (Anderson, 2002).One interpretation is to present executive function as a three factor model. Miyake, Friedman, Emerson, Witzki, Howerter and Wager (2000) suggested that executive function consist of three factors referred to as shifting, updating, and inhibition. Miyake et al. (2000) used a confirmatory factor analysis to support this suggestion, identifying three separate factors that contribute differently to complex tasks. However, these factors were moderately, if insignificantly, correlated to one another so, although they appear to be different cognitive processes, it seems there are similarities that underlie the separate factors of executive function. Meta analytic studies have explored this three factor model of executive function, highlighting the key component factors that underlie executive function are inhibition, working memory, and selective attention (Alvarez & Emory, 2006). Although many studies have adopted the framework suggested by Miyake et al. (2000), there is also research to suggest that executive function should be considered as a two factor model in some cases. A number of confirmatory factor analyses were carried out by Lee, Bull and Ho (2013) to explore the applicability of a three factor, two factor, and an undifferentiated one factor model of executive function. The researchers found age related differences in the structure of executive function (Lee, Bull

& Ho, 2013). A two factor structure was considered most appropriate in children aged 5 to 13 years due to a strong correlation between inhibition and switch (r=.85). No significant difference between the fit of a two factor or three factor model was identified for 14 year olds. A three factor structure was considered most appropriate for 15 year olds as the association between inhibition and switch was reduced. This research provides evidence to recommend the use of a confirmatory factor analysis in studies that explore executive function in children and adolescents in order to determine the most appropriate conceptualisation and measurement approach for different samples. When comparing and contrasting the literature that explores the associations between executive function and attachment it is important to consider the studies' conceptualisation of both constructs in order to interpret their findings.

Measures of attachment and executive function

Debates over the conceptualisation of the constructs of executive function and attachment lead to discussions as to the most appropriate measures that can be used to capture them. A wide variety of tools have been used to measure attachment and executive function separately and therefore should be considered when examining any associations between them.

Observations and self-report measures are the two main approaches used in the literature to measure attachment. The first measure of attachment developed was the Strange Situation Procedure (Ainsworth & Bell, 1970). This technique requires a trained researcher to observe a child's reactions to a stranger in the absence of their mother and the return of their mother. As a result of this observation, children are given a categorical label of attachment security. However, there are a number of limitations to the Strange

Situation Procedure such as the lack of ecological validity, the use of a single procedure, and the limited sample age (Van Ijzendoorn, Veriejken, Bakermans-Kranenburg & Riksen-Walraven, 2004). The Strange Situation Procedure was designed to measure attachment in children aged 2 years. Van Ijzendoorn et al. (2004) argued that this neglects attachment style at later stages of life. The authors recommended the Attachment Q-sort (Waters & Dean, 1985) as it was designed to measure attachment style in children age 12 to 48 months, enabling its application to a broader age range. The Attachment Q-sort is also carried out at home thus increasing its ecological validity. As a dimensional measure it supports the work by Fraley and Speiker (2003). A maternal Q-sort has also been developed to examine the mother's behaviour in an interaction with her child (Pederson & Moran, 2008). Van Ijzendoorn et al. (2004) demonstrated the convergent validity of the Attachment Q-sort when carried out by a trained observer as it correlated with the classifications from the Strange Situation Procedure in a meta-analysis. However, this was not the case the when the Q-sort was used as a self-report measure and completed by the caregiver (Van Ijzendoorn et al., 2004).

Interviews such as the Adult Attachment Interview have also been used as a self-report measure of attachment (George, Kaplan & Main, 1985). This interview asks an adult to recall their early experiences of relationships. One clear critique is the retrospective nature of this measure. More recent measures such as the Experiences in Close Relationships—Relationship Structures Questionnaire (Fraley, Heffernan, Vicary, & Brumbaugh, 2011) use Likert scales to assess attachment security in different relationships. This is a dimensional measure that differentiates between relationships with mothers, fathers, friends, and romantic partners. It has recently been used as a measure of attachment in adolescence (Brenning, Soerens, Braet & Bosmans, 2011). One criticism of

questionnaires can be taken from the findings of Van Ijzendoorn et al.'s (2004) meta-analytic review. The study found that when caregivers were asked to use the Q-sort to assess their own attachment style the findings did not correlate with classifications from the Strange Situation Procedure suggesting that individuals find it difficult to identify their own representations of attachment, highlighting the need for trained researchers in order to accurately identify attachment style.

Measures of executive function vary widely, perhaps reflecting the challenges researchers face in defining executive function as a construct. Many measures of executive function use experimental tasks or batteries. Single tasks that aim to measure specific aspects of executive function include: the Stroop Task (Stroop, 1935) to measure inhibition, the Trail Making Task (e.g. Kortte, Horner & Windham, 2002) to measure shift, and the dimensional change card sort (Zelazo, 2006) to measure working memory. One critique of experimental tasks when measuring executive function is their ecological validity. Anderson (2002) highlighted the inconsistencies between performance on executive function measures and real life behaviour, suggesting that the requirement of novelty when creating the task means the nature of the design reduces the ecological validity. Self-report measures of executive function such as the Behaviour Rating Inventory for Executive Function (BRIEF; Gioia, Isquith, Guy & Kenworthy, 2000) gather feedback from young people, parents and teachers in order to analyse several components of executive function in children age 5 to18 years. The use of self-report measures is perhaps less reliable, particularly for adolescents who have demonstrated a lack of self-awareness when asked to rate their own behaviour (Dan, Ilan & Kurman, 2013). Furthermore, it has been argued that the developmental trajectory of executive function throughout childhood and adolescence makes it difficult to interpret the performance of

children, even on experimental tasks (Anderson, 2002). The developmental rate of each specific skill must be considered when examining executive function skills in children. When considering the research that examines an association between executive function skills and attachment in children, the measures used to capture the constructs should be addressed and their appropriateness for the sample assessed.

Stability over time

A child's cognition, language and communication all follow a developmental trajectory (Zaccario, Sossin & DeGroat, 2009). It is therefore important to consider any changes that might occur in a young person's executive function skills and attachment style when investigating an association between these constructs. The stability of attachment patterns has been a topic of debate in the literature: Drawing on Bowlby's work, Mikulincer and Shaver (2007) hypothesised that the internal working models formed during early childhood lead an individual to seek out relationships that fit within their model, reinforcing their attachment style. However, Sroufe, Egeland, Carlson, and Collins (2005a) suggested a more complex model in that new experiences are interpreted according to previous patterns of adaptation but established patterns can also be altered by new experiences. This is particularly pertinent during adolescence when young people begin to develop attachments beyond their primary caregiver (Raja, McGee & Stanton, 1992). By adulthood, attachment style has been found to be shaped by a combination of early caregiving experiences, social competence and quality of friendships (Fraley, Roisman, Booth-LaForce, Owen & Holland, 2013). In light of this research it seems that attachment style may follow a developmental trajectory.

A considerable amount of research has found executive function capacity changes across the lifespan (Zelazo & Muller, 2002). It has been suggested that executive function performance develops in an inverted U-shape with children and older adults making more mistakes in executive function tasks than young adults (Zelazo, Craik & Booth, 2004). Other studies have shown that different aspects of executive function develop at different rates. It has been suggested that working memory, shift and inhibition performance vary according to age (Davidson, Amso, Anderson & Diamond, 2006) and reach adult level at different ages (Huizinga, Dolan & Van der Molen, 2006). However, much of this research uses a cross sectional design which makes it difficult to ensure homogeneity across groups over time. This evolving model of executive function is consistent with the premise of neuroplasticity as the influence of the environment on brain development would be expected to influence executive function performance over time. However, not all of these trends reached statistical significance for example, in the study by Zelazo, Craik and Booth (2004), the colour-shape sorting task measuring the participant's ability to shift between rules was the only quadratic shape to reach significance. Even this finding is questionable as the first half of the participants were subject to time restraints whereas the second half of the participants were not.

Cofounding variables

There are a number of variables that must be controlled when conducting research on attachment and executive function in order to identify the unique association between these variables. Research has suggested that socio-economic status (SES) is a predictor of executive function (Hackman & Farah, 2009). In a review of the literature, Hackman and Farah (2009) identified a number of possible explanations for this association including: genetics, quality and quantity of schooling, and brain plasticity. The latter suggests that

SES is thought to influence brain development during early childhood in that children from a lower SES background performed worse on tasks of executive function. IQ has also been identified as a predictor of executive function. Friedman et al. (2008) found a significant association between general IQ and three measures of executive function: inhibition, updating, and shifting. The strongest correlation was between IQ and updating (i.e. working memory). The study demonstrated that children with a low IQ performed worse on tasks measuring executive function. Supporting this finding, Mahone et al. (2002) demonstrated that the performance of young people on executive function tasks improved with a higher IQ. However, Dodrill (1997, 1999) found that IQ was associated with executive function performance in individuals with a low IQ but not individuals with average or above average IQ scores. One explanation provided for this is the ceiling effects present in neuropsychological tests that mean a correlation cannot be observed in participants with a high IQ. This would suggest that the association between IQ and executive function varies as a function of IQ scores and, in line with this theorising, should be controlled in research that aims to capture the unique contribution of executive function.

The association between executive function and language skills is less clear. Children with a significant language impairment have been found to score lower on executive function tasks even when IQ is accounted for (Henry, Messer & Nash, 2012). However research using a normative sample of children has found that the association between language scores and executive function does not reach significance when non-verbal cognition is controlled for (Karasinski, 2015). It is possible that the underlying cause of significant language impairment is different to that of poor language skills. Thus it is important to consider the sample when measuring executive function. If children with

specific learning difficulties such as language impairment are to be included, the impact of this on overall cognition must be identified.

Summary. This section highlights a number of themes that must be considered when exploring the literature that examines associations between attachment and executive function. The next section of this review uses a systematic literature search to identify the studies that have considered these associations, analysing them according to their results, the authors' conceptualisation of the construct of attachment and executive function, the measures used to capture the experimental and the confounding variables that might influence the results. The purpose of this review was to consider the findings and strength of the research that investigates the association between child attachment style and executive function ability

1.2 Method

The Search Process. In order to identify studies that measure associations between attachment and executive function, an initial search was carried out across the following databases: Psych Info, Medline, Web of Science, and Embase. 'Attachment' AND 'executive function' were entered as search terms in each database. A diagram of the process used in the literature search is presented in Appendix A. Only studies with a sample of infants and children were included in the search. No adolescent samples were included in the study in order to reduce the variability caused by the developmental trajectories of attachment (Sroufe et al., 2005a) and executive function (Zelazo & Muller, 2002) between childhood and adolescence. Initially 179 titles were identified to be screened. A number of exclusion criteria were applied to these titles according to the following rationale:

Samples with a diagnosis. Studies exploring specific populations were excluded from the review. Diagnoses included Autism Spectrum Disorder, Attention Deficit Hyperactive Disorder, Conduct Disorder, and Borderline Personality Disorder. This decision was made based on the literature that highlights the impact of these diagnoses on executive function skills (Baez et al., 2015; Carlson, Claxton & Moses, 2015; Ezpeleta & Granero, 2015et al..)

Alternative outcome variables. Only studies that included executive function as a primary outcome measure were eligible for inclusion in the review. Studies with outcome measures of externalising behaviour, emotion regulation and theory of mind were therefore excluded.

Evaluations of measurement tools. Studies were excluded from the review if the investigation related to the validity of a measure of attachment or executive function. Only studies investigating the association between attachment and executive function were included in the review.

Non-human samples. Animal samples were excluded from the review due to the 'existence of serious species differences' (p28) highlighted by Mercer (2011) in a criticism of non-human attachment research.

Publication requirements. Empirical studies were only included if they were published in a peer reviewed journal. Studies published in a foreign language were excluded from the review.

On the basis of these criteria 146 studies were excluded from the literature review. Full copies of the remaining 33 studies were retrieved and assessed for eligibility. From these, duplicate studies were removed. Studies were then excluded based on the following rationale:

Inattention/overactivity as variable. Studies using measures of inattention and overactivity were excluded due to their associations with an ADHD diagnosis.

Intervention. Interventions were not included in the review as the focus of this review was to identify any associations between attachment and executive function before intervention.

On this basis 24 studies were excluded from the literature review. Three studies were added as a result of manual searching and reference lists. Five theoretical and review papers were excluded.

Data extraction and synthesis

On completion of this systematic search process, six studies were included in the results section of this review. A summary of these studies can be found in a table in Appendix B. This table outlines the study purpose, the characteristics of the sample, the study measures, and the main findings. The results section of this systematic literature review outlines the main findings of the studies before discussing them according to these themes in order to assess the strength and direction of the findings.

1.3 Results

Overall, the studies in this review demonstrate an association between child attachment and executive function. First the correlations between measures of executive function are outlined, followed by their individual associations with attachment.

Associations amongst measures of executive function. Three studies used more than one measure of executive function enabling an exploration of the associations between executive function measures. Using a principle component analysis on a battery of tasks, Bernier, Carlson and Whipple (2010) and Bernier, Carlson, Deschenes and Matte-Gagné (2012), identified two factors of executive function labelled Conflict EF and Impulse control. The researchers suggested that Conflict EF encompassed the skills of working memory, set shifting, and inhibition whereas Impulse control represented delay of gratification skills. Both studies found moderate correlations between these two factors of $r=.28$, $p<.05$ (Bernier, Carlson & Whipple, 2010) and $r=.40$, $p<.001$ (Bernier et al., 2012).

Bernier, Beauchamp, Carlson and Lalonde (2015) examined the associations between four experimental tasks and a teacher questionnaire from the behaviour rating inventory of executive function known as the BRIEF (Gioia, Espy & Isquith, 2003) used to measure executive function at age 5 years. The experimental tasks were: the backward word span (Carlson, Moses & Breton, 2002), the dimensional change card sort (Zelazo, 2006), the NEPSY (Korkman, Kirk & Kemp, 1998), and the flanker task (adapted from Rueda et al., 2004). The researchers did not state which factor of executive function each task was measuring however on examination, tasks reflected the skills of working memory, shift, planning and inhibition respectively. Tasks measuring working memory,

shift and inhibition were significantly correlated to one another. However, the NEPSY task that measured planning was only significantly associated with the backward word span task that measured working memory. Correlations between the NEPSY and the other tasks did not reach significance. The BRIEF questionnaire provided scores for self-control (inhibition and emotion control), flexibility (shift and emotion control), and metacognition (working memory and planning). The three subscales demonstrated strong correlations to one another ($p<.001$). Following a principal component analysis two factors were identified. One encompassed the BRIEF measures and the other the EF task scores. These two factors were associated in the expected direction ($r=-.4$) and two composite scores were used in all further analyses.

Associations between attachment and executive function. The associations between attachment and executive function are outlined below according to the measure of executive function used in the studies. Overall an association was found between executive function and attachment security in children and young people.

Studies that used a composite measure of Conflict EF in their analysis identified attachment security as a significant predictor of Conflict EF at age 3 years, $\beta=.41$, $p<.01$ (Bernier et al., 2012). It was also found that Conflict EF was associated with the parenting dimensions of maternal sensitivity and autonomy-support (Bernier, Carlson & Whipple, 2010). Attachment security was not a significant predictor of Impulse control accounting for only 1% of the variance (Bernier et al. (2012).Attachment security was found to be a significant predictor of inhibitory control, $\beta=.26$, $p<.05$ (Heikamp, Trommsdorff, Druey, Hübner & Von Suchoddetz, 2013). Another study demonstrated that children with a disinhibited attachment style performed significantly worse on the stroop task measuring inhibition (Colvert et al., 2008). Von der Lippe, Eilertsen, Hartmann and Killen (2010)

used the Running Horses Game Test to measure executive function. Children's working memory, cognitive flexibility and inhibitory control ability were scored. These scores were combined to provide a composite score of executive function. The study found that children with a secure attachment style achieved higher scores on the executive function task ($r=.43$, $p<.01$). Bernier et al. (2015) considered experimental and self-report measures of executive function. Attachment security was associated with executive function for experimental tasks, $r=.37$, $p<.001$, and teacher reports, $r=-.34$, $p<.001$ (Bernier et al., 2015). This negative association was expected as high scores on the BRIEF indicate executive function difficulties.

The findings outlined above demonstrate significant associations between attachment, Conflict EF and inhibition. The relationship between attachment and executive function appears to exist in tasks measuring overall executive function, specific tasks measuring different components of executive function, and in teacher reports of a student's executive function skills. In order to consider the findings of these studies in further detail and consider the quality of the research, the studies will be discussed according to the authors' approach to the conceptualisation of the constructs, the measures used to capture them, and the confounding variables that may have influenced the results.

The constructs of executive function and attachment

Recent research has considered attachment as a categorical and a continuous construct (Fraley & Speiker, 2003). The studies included in this review largely use the categorical construct of attachment. This is expected as The Strange Situation Procedure (Ainsworth & Wittig, 1969) used ratings on behavioural scales to categorise infants into attachment styles. Children in the studies are given different labels such as secure,

insecure (Bernier, Carlson & Whipple, 2010; Bernier et al., 2102; Bernier et al., 2015; Heikamp et al., 2013) or disinhibited (Colvert et al., 2008) according to the measure of attachment that is used. One explanation for a categorical approach to the studies included in this review is the age of the participants. As samples included toddlers and young children, the observational methods used in the Strange Situation Procedure are appropriate. One study used a dimensional construct of attachment style (Von der Lippe et al., 2010). The researchers referred to the work of Fraley and Speiker (2003) as the rationale for their decision. They argued that a continuous measure of attachment would provide higher statistical power in a study with a small sample size. If researchers chose to investigate attachment in an older population such as a group of adolescents, alternative measures of attachment must be considered.

Previous research has presented executive function as a unitary, two factor, and three factor model (Lee, Ho & Bull, 2013; Miyake et al., 2000). Three of the studies included in this review used a factor analysis to define the construct of executive function within the context of the research. Bernier, Carlson and Whipple (2010) submitted their data to a principle component analysis that identified a two factor solution of executive function accounting for 64.7% of the total variance. The researchers used the labels 'Conflict EF' and 'Impulse Control' to describe these factors. This finding reflects previous empirical research that identifies working memory, set shifting and inhibitory control as three components of Conflict EF (Carlson, Mandell & Williams, 2004). More recent work by Bernier et al. (2012) and Bernier et al. (2015) also used a two factor model of executive function. However, the two factor model identified by Bernier et al. (2015) grouped the experimental EF tasks into one factor and teacher report measures into the other. These

factors do not represent Conflict EF and Impulse Control therefore cannot be directly compared to previous research that uses a two factor model encompassing these labels.

The two factor model presented by Bernier, Carlson and Whipple (2010) and Bernier et al. (2012) appears to reflect the work by Zelazo and Muller (2002) who suggested that executive function could be divided in to two factors referred to as cognitive executive function and affective executive function. They suggested that the difference between these factors is their location within the brain, the former situated in the dorsolateral area of the prefrontal cortex and the latter located in the ventral and medial area of the brain. Previous studies have referred to these factors as cool EF and hot EF respectively (Hongwanishkul et al., 2005; Zelazo & Carlson, 2012). In this review, the study that included Impulse control in the analysis found no significant association between this measure and attachment (Bernier, Carlson & Whipple, 2010). The differences between the location and function of these factors of executive function add further complexity to debates over the construct. It is possible that the umbrella term of executive function is too generic when carrying out academic research. According to the results of these studies attachment is significantly associated with Conflict EF (cool EF) but not Impulse control (hot EF). It might be that a child's early environment influences the development of specific brain regions. However, at present the literature on the association between attachment and executive function does not provide sufficient empirical evidence to support this theoretical model.

Alternative models of executive function presented in the literature explore Conflict EF in more detail. Miyake et al. (2000) argue that working memory, inhibition, and shift are three separate factors of executive function whereas Lee, Bull and Ho (2013) propose that in some age groups a strong association between shift and inhibition means a two

factor model of executive function is more appropriate. As Bernier, Carlson and Whipple (2010) identified strong associations amongst all Conflict EF variables (working memory, shift and inhibition) they incorporated these variables into a single composite score for analysis. At present, the models of executive function used in the literature do not allow for comparisons between specific factors of executive function and attachment. Further consideration as to the unique contribution of early attachment experiences on different factors of executive function is required. However if the factors are highly correlated, exploring their influences separately would mean that the results are at risk of collinearity (Fidell & Tabachnick, 2003). This must be addressed in future research.

Summary. Research continues to explore the constructs of executive function and attachment. The term executive function is broad and a variety of measures are required in order to ensure different factors of executive function are addressed. The use of a principle component analysis ensures that specific factors of executive function are identified in a study. However, the studies in this review applied this analysis to differentiate between Conflict EF and Impulse control. Although the former was associated with attachment style, the components that underlie Conflict EF were not addressed separately. It is possible that working memory, inhibition and shift should be considered separately as suggested by Miyake et al. (2000).Equally, the construct of attachment has been subject to debate and the studies used different measures according to their interpretation of attachment as categorical or continuous. Research investigating the association between attachment and executive function must consider each construct in line with the measures used and the age of the sample.

Measuring the constructs

Since the development of The Strange Situation Procedure (Ainsworth & Bell, 1970), a range of measures have been developed to capture attachment style. Ainsworth's original work used ratings on a range of behaviour scales in order to categorise infants into attachment styles (Ainsworth et al., 1978). Studies in this review used a categorical measure of attachment such as the Strange Situation Procedure (Von der Lippe et al., 2010), the attachment Q sort (Bernier et al., 2015; Heikamp et al., 2013), and the maternal behaviour Q sort (Bernier, Carlson & Whipple, 2010; Bernier et al., 2012). Von der Lippe et al. (2010) converted categorical measures used in the Strange Situation into quasi-quantative measures of security of attachment in order to address attachment as a continuous construct. A meta-analysis of the validity of the attachment Q sort found that it has good convergent validity with the strange situation procedure (r=.31) and predictive validity with sensitivity measures (r=.39) when completed by an observer as opposed to a self-report measure (van IJzendoorn, Vereijken, Bakermans-Kranenburg & Riksen-Walraven, 2004). Other research has found that scores provided by the maternal behaviour Q-sort are highly correlated with scores provided by Ainsworth's rating scales in the Strange Situation Procedure (r>.8) as well as scores calculated from the attachment Q-sort (r>.44) when scored by different observers (Pederson, Moran, Sitko, Campbell, Ghesquire, & Acton (1990). . The studies in this review used age appropriate measures to capture attachment style in sample of infants and children. The validity and reliability of these measures means that the accurate measurement of attachment is a strength of the research investigating associations between attachment and executive function in children.

Executive function has previously been measured using experimental tasks (Kortte, Horner & Windham, 2002; Stroop, 1935) and self-reports (Gioia et al., 2000). All of the studies included in this review used at least one experimental task to measure specific

processes of executive function. Von der Lippe et al. (2010) used the Running horses game test to measure executive function. This method was critiqued by Bernier et al. (2015) who suggested that, given the task taps into a variety of skills, it is difficult to determine the extent to which the association between attachment and executive function applies specifically to executive function skills as opposed to problem solving skills in general. As the such the researchers used a variety of experimental tasks as well as the self-report BRIEF (Bernier et al., 2015). The BRIEF was designed as an assessment of executive function in a real world setting but it has been emphasised that the tool should be used in context with other measures (Gioia, Isquith, Guy & Kenworthy, 2000). As this method was used by Bernier et al. (2015), it provides an opportunity to compare associations of attachment with different measures of executive function. Results of the study demonstrated mild to moderate correlations between four experimental tasks and the BRIEF as rated by teachers. Similarly, there were mild to moderate inter-correlations between the experimental tasks and within the BRIEF. However, not all of these correlations were statistically significant and, in a factor analysis that included all subscales, two factors were identified. One included all experimental tasks and the other all BRIEF measures. This suggests these that experimental tasks and self-report measures capture different aspects of executive function.

Summary. The range of measures used to capture attachment and executive function reflect debates over the nature of these constructs. Measures of executive function are predominantly experimental and each task measures a specific skill underlying executive function. It is likely that the measurement of attachment and executive function will continue to evolve as the definition and interpretation of each construct develops.

Stability of the constructs

An additional consideration that must be made when examining the associations between attachment and executive function is the developmental changes that occur naturally over time. The studies included in this review did not aim to detect changes in executive function skills over time. Although a number of the studies had more than 1 time point for data collection, executive function was only measured at 2 time points in one study: Bernier, Carlson and Whipple (2010) measured executive function at 18 and 26 months. However, the purpose of this was to examine the possibility of tapping into executive function skills at an early age. Working memory and categorisation skills were measured at age 18 months. The study found that the task used to capture working memory at age 18 months was positively correlated to Conflict EF and Impulse control at age 26 months. However, the task used to measure categorisation at age 18 months was only associated with Conflict EF at age 26 months. As working memory was not examined independently at 26 months it is unclear whether this variable remained constant. Additionally, the time span of 8 months may not have been long enough to detect changes in executive function skills. A longitudinal follow up study would be required in order to examine the development of executive function in this sample over time.

As contemporary research suggests that attachment style develops dynamically with new experiences and has the potential to change previous patterns (Sroufe, 2005), longitudinal research would be required to assess the impact of attachment on executive function at different stages. The studies included in this review did not measure attachment at different time points therefore the development of an association between attachment and executive function over time is unknown. It would be interesting to determine the relationship between attachment and executive function during adolescence

when a second period of rapid brain development occurs (Blakemore & Choudhury, 2006) and young people increase the range of their attachment relationships beyond that with their primary caregivers (Raja, McGee & Stanton, 1992).

Summary. The studies in this review do not address the relationship between attachment and executive function over time and therefore cannot be generalised to different age groups.

Confounding variables

Previous research has demonstrated an association between SES and executive function (Hackman & Farah, 2009) therefore this variable should be controlled in research exploring associations between attachment and executive function. Studies in this review used a variety of methods to control for SES using a homogenous sample of one socioeconomic group or including a measure of SES in the main analysis. Von der Lippe et al. (2010) used a homogenous sample and recruited families who owned their own homes in economically advantaged neighbourhoods. The majority of families in the sample met these criteria. The mothers' average age was 38 years and their length of education was 15 years. The homogenous sample used in the study demonstrates an association between attachment and executive function in economically advantaged families..

Other studies in the review included a measure of SES in their analysis. Heikamp et al. (2013) asked mothers to rate their SES on a five point scale (1=low and 5=high). This score was entered in to the first block of each regression analysis to control for its variance and attachment remained a significant predictor of inhibitory control. Although Heikamp et al. (2013) did not provide a detailed account for this decision; research has highlighted

subjective self- ratings as an accurate reflection of social status when examining its associations with other outcomes (Singh-Manoux, Adler & Marmot, 2003). Bernier, Carlson and Whipple (2010) included child gender, number of siblings, maternal and paternal age and education, and family income as socio-demographic variables. They found the only association with executive function to reach significance was mother's level of education so this was controlled for in further analysis. This reflects previous research that has identified significant correlations between parents' levels of education and child executive function skills in children (age 5-6 years) and adolescents (age 13-14 years) in that a higher level of parent education (measured in years) is associated with higher executive function scores (Ardila, Rosselli, Matute & Guarjardo, 2005). It has been suggested that the cause of the association in that parents with higher levels of education provide a more stimulating environment for their children and interact with them differently, particularly in their use of language (Hoff, Laursen, & Tardif, 2002). As a result, previous studies that have investigated the influence of executive function on learning have included factors such as mother's level of education and age of the mother when leaving school as covariates in a main analysis (Alloway, Gathercole, Adams, Willis, Eaglen & Lamont, 2005). Bernier et al. (2012) used three measures of SES and identified high correlations between maternal and paternal education and family income (.55-.66). As a result, these SES variables were standardised and averaged into one composite index of SES to be controlled for in the main analysis. Bernier et al. (2015) used the same SES measure as over half of the sample was taken from the previous study. Grouping variables that demonstrate strong associations does reduce the risk of collinearity, suggesting that grouping the SES factors in this study increases the reliability of the measure. However research that considers the methods used to ensure an accurate

measurement of SES highlights the importance of including specific factors including both income and education in the main analysis even when correlations have been identified between the two variables (Braveman et al., 2005). It is possible that by grouping factors of SES that demonstrate correlations, as in the study by Bernier et al. (2012), some of the unique variation caused by different elements of SES is lost. Despite this debate the studies in this review all considered the influence of SES on the experimental variables and demonstrate that a positive association between attachment and executive function remains when SES is controlled for.

et al.et al.IQ and language ability have been associated with executive function (Friedman et al., 2008; Henry, Messer & Nash, 2012). The studies in this review vary in the extent to which they controlled for these variables. As several of the studies began data collection when the participants were age 9 to 12 months, commonly used psychological cognitive assessments could not be utilised as their scores are standardised for older children. Bernier, Carlson and Whipple (2010) used the Mental Development Index of the Bayley Scales of Infant development (Bayley, 1993) to control for general cognitive functioning because it is standardised for children age 1 to 46 months. The study found that general cognitive functioning was positively associated with scores on the working memory task at age 18 months and both Conflict EF and Impulse control at age 26 months. Bernier et al. (2015) used the lollipop test (Chew & Morris, 1984) as a measure of general cognitive ability. This test was developed to predict school readiness in young children. The study found that scores on the lollipop test were positively associated with scores on the backward word span task, overall executive function, and all of the BRIEF measures. However, no significant associations were found between lollipop test scores and performance on the dimensional change card sort or the NEPSY task. The researchers

included the measure of cognitive ability as a covariate in their regression analysis and found that attachment security remained a significant predictor of performance on all executive function tasks. Bernier et al. (2012) measured verbal ability rather than general cognitive ability using the Peabody Picture Vocabulary Test 3 (Dunn & Dunn, 2007). They found child verbal ability was positively associated with executive function and included this as a covariate in their regression analysis. Attachment remained a significant predictor of conflict EF but not impulse control at the age of 3 years. This study did not use a general measure of IQ despite the fact that, given the age of the participants, appropriate measures were available.

Von der Lippe et al. (2010) chose to measure the verbal ability of the mother rather than the child despite the final data collection occurring when the child was age 5 to 6 years and an appropriate measure would have been available. As a result it is unclear whether an association between attachment and executive function would remain significant if child IQ was controlled for in this sample of economically advantaged families.

Colvert et al. (2008) used the McCarthy scales to measure cognitive ability at age 6 years and the WISC-III to measure IQ in their sample at age 11 years. These measures were used to identify a cut off value that indicated cognitive impairment in the sample. This demonstrates an association between attachment and executive function in children without a cognitive impairment. Heikamp et al. (2013) did not include a measure of IQ in their study and it is not possible to determine whether an association between the experimental variables would remain in this particular sample of children.

Summary. Socioeconomic status, IQ, and language skills demonstrate significant associations with factors of executive function. Studies in this review used a variety of measures to analyse or control for the influence of these factors. Overall the results demonstrated that an association between attachment and executive function remains after variables of SES are controlled in that children who demonstrate secure attachment performed better in tasks requiring executive function skills. However, the impact of IQ and language skills is not considered in all the studies. Of the studies that included these variables the positive association between attachment security and executive function remained significant after they were controlled for in the main analysis.

1.4 Discussion

As demonstrated in the small number of studies included in this literature review, research on the associations between attachment and executive function is at an exploratory stage. At present, the literature suggests t that there is a relationship between these two constructs in that children who demonstrate a secure attachment style perform better in executive function tasks. Attachment security has been identified as a significant predictor of performance in experimental executive function tasks (Bernier et al., 2012; Bernier et al., 2015; Heikamp et al., 2013) and teacher reports of a child's executive function skills (Bernier et al., 2015). Attachment security has also been positively associated with performance in general measures of executive function in that children demonstrating a secure attachment style achieve higher scores on the Running Horses Game Test that captures working memory, cognitive flexibility and inhibitory control (Von der Lippe et al., 2010).

The studies approach their investigation differently, exploring executive function using a variety of models and measures, applying different categorical or continuous criteria to identify attachment styles. This is a strength of the main findings in this review as the association remains significant when a variety of methods are used. Variables such as IQ, SES and language are inconsistently measured and, in some studies, are not controlled for. However, in studies that include these measures as covariates, the association remained significant for all measures of executive function with the exception of impulse control which was not significantly associated with attachment security when verbal ability was controlled for (Bernier et al., 2012).

Studies identified in the literature review do not address the changes in attachment and executive function that occur during child development as the results demonstrate an association between the experimental variables in children. Research into this association in adolescents was not included in the review due to the age criterion used in the systematic literature search and the requirement that studies should be peer reviewed. However, the results of studies using adolescent samples that include measures of attachment and executive function are less clear. Escobar et al. (2013) found a positive correlation between secure attachment and shift in adolescents whereas Brown (2014) found that attachment style did not predict performance on a task capturing executive function skills. The exploratory nature of research in this area should continue to investigate these associations in adolescence in order to establish whether the association found in children remains prevalent in adolescent samples. The initial results of this review present a number of opportunities for further research and can be incorporated into professional practice with caution.

Implications of findings for further research

Future research in this area of psychology must be conducted using consistent measures. A significant body of research has suggested that executive function can be examined using Miyake et al.'s (2000) three factor model. As executive function appears to be an umbrella term used to describe a number of underlying cognitive skills, tasks measuring inhibition, working memory, and shift could be used to consider different factors of the construct and similarities or differences of their associations with early caregiving experiences and attachment style.

A consistent measure of attachment should be used in future studies. Researchers should address the ongoing debate as to the categorical or continuous nature of attachment (Fraley & Speiker, 2003) when selecting a measure of attachment. Although the Strange Situation Procedure (Ainsworth & Bell, 1970) has been used extensively in infant samples, it is not appropriate for older children. Further research should consider the use of different observational and self-report methods for the identification of attachment style.

The age of children included in the research should also be expanded. As highlighted in this review, executive function has been found to develop across the lifespan (Davidson et al., 2006). This might be due to the continuity of brain development, particularly in the prefrontal cortex, beyond early childhood (Blakemore & Choudhury, 2006). Significant changes in the brain occur during puberty, with reorganisation and pruning continuing throughout adolescence (Blakemore & Choudhury, 2006). Likewise it is possible that attachment style develops dynamically as children and adolescents experience changes in their social environment, develop their understanding of relationships (Allen & Land, 1999), and increase the range of their attachment relationships (Raja, McGee & Stanton, 1992). It is important to consider this second period of change and the influence it might have on the association between attachment and executive function. The current review did not consider this association in adolescence.

Implications for professional practice

Despite the need for further research, the literature discussed in this review presents a number of opportunities for psychological practitioners working with young people. Primarily, these practitioners should be aware of the associations between attachment and

executive function. The evidence presented would suggest that the development of a secure or insecure attachment style influences a child's executive function skills.

A wide variety of programmes to support the development of a secure attachment style are utilised in the United Kingdom. These take place at different stages of a child's life. Early interventions such as Family Nurse Partnership (Ball, Barnes & Meadows, 2012) provide direct parenting support to teenage mothers in order to ensure the development of a healthy caregiving relationship with their child in the first 3 years of life. School initiatives such as the social and emotional aspects of learning (SEAL) programme and the Family SEAL programme (DfES, 2006) provide nurturing opportunities for young people at a later stage. Interventions such as Brain Gym (www.braingym.org.uk) have been designed to enhance specific elements of executive function such as working memory. However, interventions that focus on a child's attachment style and their executive function skills could not be identified. Based on the principles of neuroplasticity (Lenroot & Giedd, 2006), it is possible that providing support in the form of an attachment figure, focusing on altering a child's attachment style and teaching them strategies for self-regulation, may improve a child's executive function skills via the development of the prefrontal cortex. As this is a relatively new area of research, pilot interventions would need to be carried out in order to measure the validity of such a programme.

It is possible that the associations between attachment and executive function could have an influence on the academic attainment of young people. Research has shown that separately both constructs influence the academic outcomes of children (Hughes, 2011; Moullin, Waldfogel & Washbrook, 2014). It might be that a secure attachment promotes the development of executive function, providing a child with the skills required to access the curriculum and achieve academic success. Alternatively, an insecure attachment could

have a detrimental effect by preventing the development of executive function, leading to poorer academic outcomes. Although this is a theoretical interpretation of the evidence, interventions for children who are not making academic progress should support the development of secure attachment and executive function skills. If secure attachment leads to the development of executive function skills, practitioners would need to train parents to be sensitive and reliable caregivers in order to improve executive function skills and academic achievement.

'Looked after children' (LAC) is a societal group associated with poor educational, social and socio-economic outcomes in adulthood (Viner & Taylor, 2005). Attachment problems have been highlighted for children who are placed in foster care (Jones et al., 2011). This vulnerable group of young people require high levels of support in order to enhance their overall wellbeing. Jones et al. (2011) conducted a review of research investigating the outcomes for LAC children and the interventions that have a positive impact on their wellbeing. Training for foster carers was found to reduce emotional and behavioural problems. In order to improve academic outcomes for LAC children it might be beneficial to provide training to foster carers on the association between attachment and executive function. If a LAC child's primary caregiver has a sufficient understanding of this association it is possible that applying this knowledge could enhance the development of executive function. Once young people reach adolescence it is important to provide them with a similar insight so that they understand the association and can participate in selected interventions.

Dissemination of this research to school staff is important. The introduction of nurture groups to primary and secondary schools in the UK took place in order to support young people with attachment difficulties (Boxall, 2002). It is possible that adding a

cognitive element to the structure of a nurture group would improve a child's executive function skills. If a member of school staff becomes the trusted adult for the child, they have the opportunity to improve the child's executive function skills. Once again a pilot study would be required in order to determine the effectiveness of such a suggestion. Additionally, schools may wish to alter their learning interventions to include a focus on relationships in order to support young people whose learning difficulties might have resulted from their early experiences with a caregiver.

Chapter 2: An investigation in to the associations between attachment, executive function and academic attainment in adolescence

2.1 Introduction

Neurological research has demonstrated that a human brain continues to develop throughout the lifespan in an inverted-U shape trajectory that begins in infancy, peaks during adolescence and declines into adulthood (Blakemore, Burnett & Dahl, 2010; Giedd et al., 1999). Research highlights the role of early caregiving experiences in brain development, particularly in the growth and organisation of the prefrontal cortex (Merz et al., 2016; Schore, 1996). This area of research is at an exploratory stage and initial studies have examined the influence of caregiving experiences on a set of cognitive processes that are located in the prefrontal cortex known as executive function (Best & Miller, 2010). These studies suggest that children with secure attachment styles demonstrate superior executive function skills compared to their peers with an insecure attachment style (Bernier, Carlson & Whipple, 2010) supporting the theoretical argument that different patterns of insecure attachment may be expressed neurologically (Schore, 1996). However, research investigating the association between attachment style and executive function in adolescence presents contradictory findings (Brown, 2014; Escobar et al., 2013) suggesting that the longitudinal influence of attachment experiences on brain development is more complex and requires further exploration.

The attachment relationship that is formed between an infant and their primary caregiver has also been associated with learning and academic outcomes for children who have an insecure attachment style at risk of school underachievement (Moss & St Laurent, 2001). Executive function skills have been identified as a strong predictor of school performance (Alloway & Alloway, 2010; Blair & Razza, 2007) suggesting that these skills underlie learning. Given the influence of attachment related experiences on brain development, it is possible that executive function acts as a mediator in the association between attachment and academic outcomes. However, this conceptual model is yet to be explored in academic research.

Attachment

Bowlby's original work on attachment theory emphasised the important role of the primary caregiver in child development (Bowlby, 1969). It has been proposed that in times of distress an infant's attachment system is activated leading the child to demonstrate proximity seeking behaviours to alert their primary caregiver. The caregiver must respond to and reduce a child's level of distress by providing physical and emotional security. Further research suggests that this caregiver becomes the child's secure base from which to explore the world (Ainsworth et al., 1978) and enables the activation of a child's exploratory system. In this system the child is able to take in information, learn and explore. The attachment and behavioural systems are thought to remain active throughout the lifespan.

Variations in child attachment quality have been linked to the caregiver's sensitivity and responsiveness (De Wolff & van Ijzendoorn, 1997). If an infant is exposed to appropriate bonding experiences with their primary caregiver it is likely they will

become develop a secure attachment style and feel safe to explore the world. The caregiver of a securely attached child is thought to have a supportive presence that nurtures exploration and play (Bretherton & Munholland, 1999). If a caregiver does not provide an appropriate environment for the infant, they are more likely to become insecurely attached.

One method of identifying different attachment styles in children was presented by Ainsworth et al. (1978) who developed an assessment to categorise the behaviours demonstrated by a child in situations that elicit distress. Three classifications of child insecure attachment have been recognised in the literature as insecure avoidant attachment style, insecure resistant/ ambivalent attachment style (Ainsworth et al., 1978), and disorganised attachment style (Main & Solomon, 1986). The behaviours exhibited by a child who is identified with an insecure avoidant attachment style are demonstrating a limited response when separated from their caregiver and avoiding interactions with them on the caregiver's return (Prior & Glaser, 2006). The behaviours demonstrated by children identified with an insecure resistant/ambivalent attachment style are observed as becoming immediately distressed when separated from their caregiver and combine angry ambivalent behaviour with contact-seeking behaviour on the caregiver's return. It has been theorised that these children have learnt that the caregiver's response to proximity seeking behaviour is unpredictable but can sometimes reduce anxiety. The behaviours observed by a child who has been identified with a disorganised attachment style include contradictory behaviour, undirected expressions of distress, and apprehension towards their caregiver (Prior & Glaser, 2006). More recent research has identified attachment styles using a dimensional approach in which children are rated on two dimensions (Fraley & Speiker, 2003): In the first dimension children are observed and rated on their proximity

seeking versus avoidance behaviours and in the second dimension they are rated on their angry and ambivalent behaviours. Debates as to categorical or dimensional nature of attachment behaviour are ongoing in the literature.

It has been theorised that over time infants internalise the pattern of interactions they experience with the primary caregiver and develop a conceptual representation of their relationship. This is referred to as an internal working model and is thought to be used by the infant to predict, regulate and interpret the behaviour of the caregiver (Bretherton & Munholland, 1999). It has been suggested that beyond infancy the child continues to shape their model of how they are expected to behave and engage with others, enabling them to use the model in different situations and different relationships (Shaffer, 2008). Recent debates in the literature consider the stability of this internal working model with some researchers arguing that it remains fixed throughout the lifespan and others suggesting that it can be altered by experience. The suggestion that the internal working model is fixed has been based on the premise that attachment style is fixed because an individual seeks interactions consistent with their Internal Working Model, reinforcing their previous attachment experiences (Mikulincer & Shaver; 2007). In his initial conceptualisation of attachment theory Bowlby (1969) suggested that the pathways of secure and insecure attachment become increasingly resistant to change because of the continuity of life circumstances (Moss, St-Laurent, Dubois-Comtois, & Cyr, 2005) however it has been acknowledged that changes in circumstance such as social support or life stress are associated with changes in attachment behaviour (Sroufe et al., 2005a). A meta-analysis carried out on this subject proposed that attachment style remains moderately stable throughout childhood and adolescence (Fraley, 2002) thus strengthening the argument that the internal working model remains relatively resistant to change.

There is an increasing body of research that identifies variations in relationship specific attachment styles. In initial attachment research Bowlby (1988) theorised that relationship specific attachment models are likely to change with experience, influencing an individual's abstract general model of attachment. In a study investigating the associations between general and relationship specific models of attachment Khlonen, Weller, Luo and Choe (2005) rated avoidance and anxiety patterns of thoughts, feelings and behaviours in participants' (mean age of 19 years) relationships with parents, peers and in romantic relationships. The findings demonstrated strong associations between peer relationship representations (friend and romantic partner) and parent relationship representations (mother and father). The study also found a stronger association between peer and global attachment representations than between parent and global attachment representations. Within this theorising, although there are associations between attachment patterns in different relationships, there are likely to be variations in an individual's global attachment patterns and relationship specific attachment patterns.

Attachment and executive function.

Recent research has proposed an association between attachment style and a set of cognitive processes known as executive function. These processes are thought to underlie goal directed behaviour (Best & Miller, 2010) and enable an individual to carry out a task through planning and perseverance (Jurado & Rosselli, 2007). Executive function processes are located in the prefrontal cortex, with memory and attention deficits being common implications of prefrontal brain damage (Voytek et al., 2010). Miyake et al. (2000) identified three factors of executive function, referring to them as working memory, shift and inhibition. These factors, clustered by some as Conflict EF (Bernier, Carlson & Whipple, 2010), demonstrate moderate correlations suggesting that they are

separate factors of the same construct. Another cluster of executive functions referred to in the literature as Impulse control are thought to represent delay in gratification (Bernier et al., 2012). Executive function ability has been associated with socio-economic status (SES; Hackman & Farah, 2009), IQ (Friedman et al., 2008), and language (Henry, Messer & Nash, 2012).

Research in this area of child development is at an exploratory stage although a general association between attachment style and executive function appears to have emerged from the literature, Attachment security has been positively linked to Conflict EF but not Impulse control in childhood (Bernier, Carlson & Whipple, 2010; Bernier et al., 2012). Securely attached children have been found to demonstrate superior inhibitory control when compared to their insecurely attached peers (Colvert et al., 2008; Heikamp et al., 2013). Associations between attachment and executive function have been found when using experimental tasks and teacher reports to capture executive function (Bernier et al., 2015). This relationship has also been examined in young people who have experienced severe deprivation. Bos et al. (2009) compared institutionalised children with non-institutionalised children and found that history of care significantly predicted spatial working memory skills in that young people with a history of institutionalised care performed significantly worse on a spatial working memory task than those who had not. However, history of care did not predict performance on a spatial planning task (the stockings of Cambridge task taken from the Cambridge Neuropsychological Test and Automated Battery; Cambridge Cognition, 2016.

There are several limitations to the empirical evidence for this association. Research is at an exploratory stage and thus far a limited number of studies are available. At present it is difficult to identify the unique associations between attachment and

specific factors of executive function. The use of a composite score in the studies by Bernier and colleagues (Bernier, Carlson & Whipple, 2010; Bernier et al., 2012; Bernier et al., 2015) prevents a comparison of the individual associations between attachment, working memory, shift, and inhibition. As some research has identified these factors as the processes that underlie executive function skills (Miyake et al., 2000) it is possible that attachment style might influence them differently. The identification of attachment is carried out in a number of ways and children in the studies are labelled with insecure attachment (Heikamp et al., 2013), disinhibited attachment (Colvert et al., 2008), or attachment style is assumed based on extreme early caregiving experiences (Bos et al., 2009). As the criteria for these labels vary, it is possible that making comparisons between these studies reduces the complexities involved in identifying attachment styles, behaviours and experiences. . Finally, although the studies collected data at a number of time points suggesting a longitudinal design, only one study measured executive function at separate time points over a period of eight months (Bernier, Carlson & Whipple, 2010). Therefore the longitudinal associations between attachment style and executive function performance remain unclear. In order to consider the lasting association between these constructs, studies using samples of adolescents should be explored.

Relatively little research has investigated the specific association between attachment and executive function in adolescence. However, some studies investigating the relationship between attachment and affect regulation have included a measure of executive function: Escobar et al. (2013) investigated the association between attachment patterns and emotional processing in adolescents but included a measure of shift in a battery of neuropsychological tasks. Results demonstrated a positive correlation between secure attachment and shift (measured using the trail making task). The friends and family

interview (Steele & Steele, 2005) was used to capture the adolescent's representations of attachment. Although this semi-structured interview is used to identify four global attachment categories (secure, insecure dismissing, insecure preoccupied, and disorganised), the study grouped all of the insecure attachment profiles together to accommodate for a small sample size. This means that different types of insecure attachment could not be compared.

Brown (2014) drew different conclusions having investigated the link between attachment, stress and executive function: The study compared scores on the tower of London planning task (Shallice, 1982) of adolescents with secure, preoccupied, and dismissive attachment styles and found that attachment style was not a significant predictor of executive function. Attachment was measured using the Behavioral Systems Questionnaire (Furman & Buhrmester, 2009), a self-report measure completed by the adolescents.

The studies present conflicting findings but, as for the literature with child samples, these findings are difficult to compare as the researchers approach the construct of executive function differently. Escobar et al. (2013) use one measure of shift, thus in keeping with Miyake's (2000) three factor model of executive function. However, Brown (2014) used a planning task that would suggest executive function has been addressed as a single construct, measuring the full set of processes in one task. In order to establish a clearer understanding of these associations, it is important to consider the mechanism by which they are related. Research that explores neuroplasticity and brain development serves as a possible neurobiological explanation of the link between attachment and executive function.

Attachment and brain development

New developments in non-intrusive neuroscientific methods used to investigate the brain have enabled psychologists to consider the influence of attachment on brain development (Schore & Schore, 2008). The brain develops throughout the life span in an inverted-U shape with accelerated development beginning in infancy and peaking in adolescence (Giedd et al., 1999). Throughout this development, the structure and organisation of the brain is influenced by an individual's experiences in their environment (Kolb, 2013). This process has been referred to as neuroplasticity (Kolb, 2013) and demonstrates the malleable nature of the brain. Research has suggested that early caregiving experiences influence the growth and organisation of the prefrontal cortex (Schore, 1996). Schore (1996) argued that a primary caregiver acts as an 'external psychobiological regulator' (p60) of experience dependent brain development. Schore proposed a developmental model in which an infant's exposure to optimal caregiving experiences leads to the development of more complex auto-regulatory brain systems. A deprivation of these positive experiences inhibits this growth. In this sense, adverse early caregiving experiences are thought to inhibit the development of the prefrontal cortex in infancy. A lack of any experience i.e. neglect, may also disrupt neurodevelopment (Perry, 2002). These heuristic models are supported in some recent empirical research.

Bos et al. (2009) found that children with a history of institutionalised care made more errors and demonstrated poor strategy abilities in a spatial working memory task. They suggested that children who had experienced early deprivation demonstrate a pattern of impairment in the prefrontal cortex. Merz et al. (2016) argued the underlying cause of this pattern was the negative influence of elevated stress reactivity on the structure and function of the prefrontal cortex. This is supported by research that highlights a

programming effect of the early environment in that the duration of extreme adversity is associated with impaired cognition and neural damage (Rutter & O'Conner, 2004). Rutter and O'Conner (2004) found this effect to be stable for children age 4 to 6 years regardless of adoptive parents' level of education demonstrating the potential longitudinal effect of early caregiving experiences on brain development, cognition, and learning.

Attachment, executive function and adolescence

During adolescence, significant cognitive, social, and developmental changes occur: On entering adolescence, young people begin to develop their generalisation and abstract reasoning skills (Allen & Land, 1999). Their continuing cognitive development is thought to lead to a greater understanding of relationships and they transition from depending on others to becoming self-sufficient (Allen, 2008). Researchers have theorised that these processes lead to the development of a single attachment organisation with one internal working model guiding the actions and expectations of a young person across different social relationships (Allen, 2008). Adolescence is also a time of rapid brain development (Blakemore & Choudhury, 2006) as it brings an additional sensitive period of development during which structures such as the prefrontal cortex undergo rapid reorganisation (Crews, He & Hodge, 2007). As these changes seem to result from experience (Perry, 2002), it appears that adolescence provides a second opportunity for experiences broadly, and attachment style specifically, to influence executive function.

Research that investigates the association between attachment and executive function remains at an exploratory stage in both child and adolescent samples. Further investigation is needed to examine whether variations in attachment style or attachment security are associated with variations in executive function. It is important to understand

the association between attachment and executive function because of the unique contributions these constructs are thought to have on school performance and achievement (Alloway & Alloway, 2010; Moss & St Laurent, 2001).

Academic attainment

Executive function is thought to be a predictor of academic attainment (Hughes, 2011; McClelland et al., 2014). Within this theorising, a young person's executive function skills have been identified as an independent contributor towards academic achievement at pre-school entry (Cameron, Brock & Murrah, 2012) and research has suggested that working memory skills at age 6 years are the strongest predictor of literacy and numeracy at age 11 years (Alloway & Alloway, 2010). Given the importance that problem solving skills, abstract reasoning and effortful control are thought to have in a learning environment (Brock, Rimm-Kaufman, Nathanson & Grimm, 2009), cool executive function seems to underlie academic learning. An association that is less transparent is that between attachment and academic attainment. The quality of early caregiving and attachment security are thought to be predictors of academic performance (Moss & St-Laurent, 2001; Moss et al., 2005). Research has also demonstrated that attachment style has a unique contribution towards school performance and school dropout (Ramsdal, Bergvik, & Wynn, 2015). Although the process of this association is yet to be confirmed, the neurobiological research explored previously provides one possible explanation. It has been theorised that the early caregiving environment influences experience dependent brain development in the prefrontal cortex (Merz et al., 2016; Perry, 2002; Schore, 1996). As a result, a child who develops an insecure attachment style is more likely to perform poorly on tasks requiring executive function skills (Bernier, Carlson & Whipple, 2010; Bernier et al., 2012; Colvert et al., 2008; Heikamp et al., 2013).

Children with executive function deficits are likely to struggle with higher order tasks required in the classroom (Brock et al., 2009) and achieve lower academic outcomes (Blair & Razza, 2007). In this sense it is possible that attachment style influences academic attainment indirectly via executive function.

Current study

The current study explores the relationship between attachment, executive function, and academic attainment in adolescence. This age group was selected to examine the associations during the second period of rapid brain development (Crew, He & Hodge, 2007) when the environment is particularly influential on changes in the brain (Perry, 2002). The study approached this task in three stages. First it sought to add further insight and clarity into research investigating the relationship between different attachment styles and executive function skills in adolescence. Second, the study aimed to examine the relationship of attachment style and executive function with academic outcomes in adolescence. Finally, the study considered the indirect influence of attachment style on academic attainment via executive function skills. Attachment was addressed as a continuous variable to identify levels of anxiety and avoidance in young people (Fraley & Speiker, 2003) Participants were rated on these two dimensions and identified on a numerical scale of high to low anxiety and high to low avoidance. Low scores on these separate scales demonstrate that a young person's thoughts, feelings, and behaviours are more representative of an individual with a secure attachment style. A three factor model of executive function was applied to capture working memory, shift, and inhibition (Miyake et al., 2000). In line with previous research, four main hypotheses were developed:

1) Students with low anxious or avoidant attachment scores (indicating secure attachment) will perform significantly better on tasks measuring working memory, shift and inhibition than students with high anxious or avoidant attachment scores.

2) Students with low anxious or avoidant attachment scores will achieve higher levels of academic attainment that those with high anxious or avoidant attachment scores.

3) Students who perform better on tasks measuring working memory, shift and inhibition will achieve higher levels of academic attainment than students who perform poorly on these tasks.

4) High anxious or avoidant attachment scores will have a negative influence on academic attainment indirectly via executive function skills. This will not be found in students with low anxious or avoidant attachment scores.

Due to previous research, measures of SES and IQ were taken in order to control for their influence on the dependent variables.

2.2 Method

Participants

The present sample was recruited from five schools in two local authorities in the South East of England over a period of 10 months. Students in Key Stage three (KS3) in academic school years 7 to 9 were identified by the Special Educational Needs Coordinator (SENCo) at each school. The school SENCo was first asked to identify all students in this age group who were registered as receiving free school meals (FSM) in order to control for the influence of SES on executive function (Hackman & Farah, 2009) and academic attainment (Sirin, 2005). The study used this individual measure of SES rather than a neighbourhood measure such as the Income Deprivation Affecting Children Index in order to consider the individual circumstances of each young person participating in the study. This decision was made based on research arguing that the FSM measure is calculated officially and annually, has been collected for several decades, and has been linked to a number of educational and other outcomes (Gorard, 2012).

The school SENCo was then asked to identify students within this FSM group with known mental health conditions and learning and language difficulties in order to exclude them from the study and control for their association with executive function (Baez et al., 2015; Ezpeleta & Granero, 2015; Henry, Messer & Nash, 2012). The SENCo identified these children through the SEN register. Students who were on the SEN register for behavioural needs were not excluded in the recruitment process. Alternative approaches such as asking parents or students to identify their own needs were considered along with the use of individual assessments however the decision to use the SEN register

was made to provide clear guidelines to the SENCo in an attempt to ensure consistency across schools. In order to support any young people who may have developed such needs but have not been identified at school a debrief was carried out at the end of the data collection session and the contact details of the SENCo and an external support group (the Samaritans) was given to all students who participated in the study.

A consent form and an information sheet were given to all students who met these criteria to take home to their parents to be signed and returned. All students who returned these consent forms were included in the study. This active parental consent process was used in order to ensure parents were fully informed about the study design. However it has been acknowledged that this process often leads to a lower response rate, particularly when one teacher is responsible for the distribution and collection of consent forms (Ji, Pokorny &Jason, 2004). In the current study this process did lead to a small sample size and the effect of this may have been reduced if consent forms were given out with a school form that parents had to sign and return to school. This was identified by Ji, Pokorny and Jason (2004) as the process leading to the highest response rate. Unfortunately this sampling process was beyond the scope of some of the SENCos included in the recruitment process. Despite attempts no looked after children were included in the study as no forms in any of the schools were returned by the caregivers. Each school SENCo liaised with the researcher when they were satisfied that no more consent forms would be returned. Participants ranged between 11 years 6 months and 14 years 11 months (M=13 years 2 months, SD=10.6 months). The final sample consisted of 32 participants. 18 of the participants were male. Unfortunately due to time constraints the researcher was unable to increase the sample size which led to an issue of low power in the analysis. The influence of low power is addressed in the discussion section of the study.

Design

The study used a correlational design to investigate the associations between attachment, executive function, and academic outcomes. The predictive nature of these associations was examined using a regression analysis and a mediation analysis.

Measures

Attachment. The study used a continuous measure of attachment. This decision was based on recent research that suggested attachment should be viewed as a continuous construct rather than categorical construct (Fraley & Speiker, 2003). The current study also sought a measure of attachment that had been validated on an adolescent population.

The **s**tudy used the Experiences in Close Relationships- Relationship structures questionnaire (ECR-RS; Fraley et al., 2011) as a continuous measure of attachment. The scale was designed following a meta-analysis of a number of other attachment scales (Fraley et al., 2011). Questions aim to capture two separate constructs: attachment anxiety and attachment avoidance in line with the work by Brennan, Clark and Shaver (1998) and are scored using a seven point likert scale (1=strongly disagree, 7= strongly agree). An example item is 'It helps to turn to people in times of need' (see Appendix C for full questionnaire).This study used the questionnaire to measure global attachment rather than domain specific attachment in which parental, peer and romantic relationships are considered separately. High scores for anxious attachment suggest an individual has a need for closeness, and fears being rejected. High scores for avoidant attachment suggest an individual is uncomfortable with intimacy and rejects closeness with others (Dan, Ilan & Kurman, 2013). Low scores on each scale suggest secure attachment. Avoidant and anxious scores are examined as separate constructs.

The ECR-RS has been validated as an assessment of adolescent attachment structures in young people aged 15 to 18 years (Donbaek & Elklit, 2014) Brenning et al. (2011) adapted the Experiences in Close Relationships Scale-Revised (ECR-R) questionnaire to develop a version more appropriate for the developmental and reading levels in middle childhood. Donbaek and Elklit (2014) explored the ECR-RS with an adolescent sample and found it to be a valid assessment of the assessment of adolescent relationship structures. High reliability was found in both the avoidance (>.81) and anxious subscales (>.86) for parent and friend relationship ratings. . However, the reliability of the questionnaire in the current study was not as strong for anxiety (α=.72) or avoidance (α=.54). On examination of the item statistics, there was no benefit of item deletion. For the anxiety scale, α=.72 was the highest Cronbach's alpha. For the avoidance scale, the largest increase in the Cronbach's alpha was to α=.59. Due to this small difference and the small number of items (N=9), all items were used in the main analysis. It is possible that age of the younger students in the sample (11 years) contributed to the low Cronbach's alpha scores as the questions may not have been as appropriate for their developmental level.

The researcher in the current study sat a short distance away from the student and read the questions aloud whilst the young person read them simultaneously. This was done to increase the reliability of the measure by ensuring that the reading level of the young people in the study did not influence the answers provided in the questionnaire. The researcher sat away from the student to provide more privacy in an attempt to reduce the effect of social desirability bias that can occur when conducting sensitive surveys (Krumpal, 2013). However, the researcher remained present in the room whilst the questionnaire was completed and it is possible that this also contributed to the low

Cronbach's alpha scores demonstrated in the analysis. The questionnaire was scored according to the publisher's instructions. Items 1-4 were reverse keyed and the questionnaire generated an avoidant score and an anxious score. These two scores were kept separate throughout the analysis as recommended by the authors (Fraley et al., 2011).

Executive function. This study used a three factor model of executive function as proposed by Miyake et al. (2000). The three executive functions measured were: inhibitory control, working memory, and shift. Inhibitory control was measured using a modified version of the Stroop Task ((Bryce, Szücs, Soltész & Whitebread, 2011). The adaptation was made to ensure that performance was not affected by reading experience and word reading ability. During the test, two coloured animals of different sizes were flashed up on a computer screen (see Figure 1 for example image). The two animals were presented in two different sizes on the screen. Participants were told to select the animal that was larger in real life using two labelled keys on the keyboard (left and right). The trials presented congruent and incongruent images. For congruent trials the animal was larger on screen and in real life. For incongruent trials, the animal was larger on screen but smaller in real life or vice-versa.

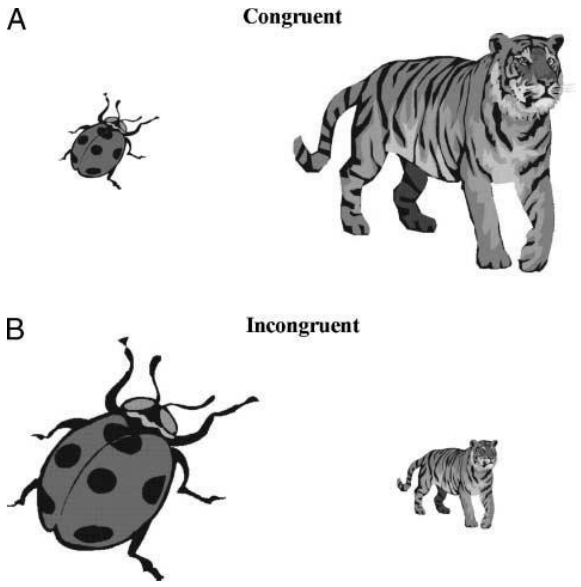
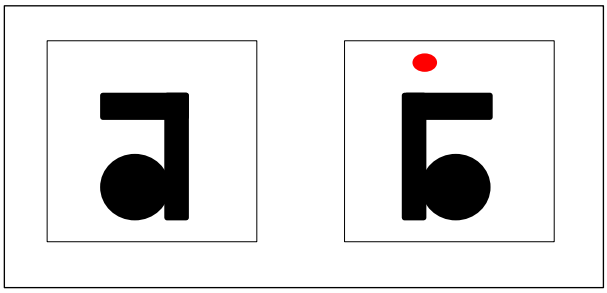


Figure 1. Example stimuli from stroop task. (A) Congruent condition. (B) Incongruent condition. Adapted from 'Real-time Tracking of Motor Response Activation and Response Competition in a Stroop Task in Young Children: A Lateralized Readiness Potential Study' by D. Szűcs, F. Soltész, D. Bryce and D. Whitebread, 2011, *Journal of Cognitive Neuroscience 21(11),* 2195–2206.

Participant reaction times were recorded for congruent and incongruent trials. The mean reaction time (ms), median reaction time (ms), and accuracy of answers (%) were recorded for each participant. These were labelled in the analysis as stroop mean, stroop median and stroop %error respectively. The median stroop reaction time was included in the analysis as it was likely to be less sensitive to outliers in individual raw scores than the mean stroop reaction time.

Working memory was measured using the automated working memory assessment (AWMA; Alloway, 2007). The AWMA is used by professionals as a screening tool to identify children who may be at risk of working memory difficulties. The AWMA has demonstrated good diagnostic validity when compared to the WISC-IV working memory

index (Alloway & Gathercole, 2008). The study used the AWMA screener subtests that are designed for screening individuals with suspected working memory difficulties. The AWMA also provides a short form and long form assessment that consist of 4 or 12 subtests respectively. These forms of the assessment are designed to explore specific areas of working memory difficulties. As the students in the current sample had not been identified with working memory difficulties and the study did not aim to explore working memory in such detail, the screener task was used and included a spatial subtest and a verbal subtest. These subtests were incorporated separately in the analysis. Students in the current study completed two subtests used for the screener assessment of the AWMA. During the Spatial Recall task individuals viewed two shapes where the shape on the right had a red dot on it. They were asked to identify whether this shape was the same or opposite to the shape on the left and then recall the location of the red dot on each shape in the correct order (see Figure 2 for example item).



Response 1: 'opposite'

Recall 1:

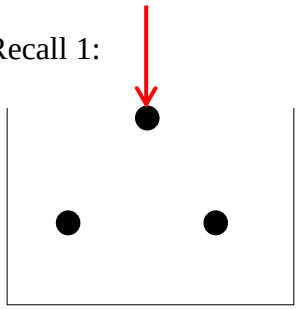


Figure 2. Example of a 2 shape trial in the AWMA

During the listening recall task individuals heard a series of sentences and were asked to judge whether these were true or false. Then they had to recall the word at the end of each sentence in the correct order (see Figure 3 for visual representation of a trial). The number of correct answers in each task was recorded and a standard score was calculated by the AWMA software in order to compare students of different ages. This provided a spatial working memory score (Spatial WM) and a verbal working memory score (Verbal WM).

Trial	Response	Recall
Bananas live in water	False	
Flowers smell nice	True	Water, nice

Figure 3. Example of a 2 sentence trial in the AWMA

Shift was measured using the Trail Making Task . The trail making task is a measure of executive control and a participant's ability to flexibly shift their attention (Kortte, Horner & Windham, 2002; Sanchez-Cubillo et al., 2009). Kortte, Horner and Windham (2002) found that the trail making task (task B) is sensitive to deficits in cognitive flexibility. This deficit accounts for the difference in scores for task A and task B. Participants with deficits in flexibility will take significantly longer to complete task B than task A.

In task A, participants must draw lines to connect circles labelled 1-25 in ascending order. In task B, the circles include both numbers (1-13) and letters (A-L). The participant is required to join the circles up in ascending order, switching between numbers and letters (1-A-2-B-3-C). Both tasks were demonstrated using a sample sheet. Final scores were calculated by subtracting a participant's score in task A from that in task B (trail score). All students identified and corrected mistakes during the task therefore error rates were not calculated.

Academic outcomes. Academic scores for all pupils were provided by the school SENCO. Each score was taken from a report that had been published during the school term in which the data was collected (summer 2015, autumn, 2015 or spring 2016). National curriculum levels were provided in the form of teacher assessments completed in the classroom. Due to the age of the sample no external standardised examination scores were available for the study. At the time of data collection all five schools taking part in the research were using national curriculum levels as the main form of summative assessment for KS3 pupils despite recent changes that have enabled schools to develop their own assessments (Department for Education, 2014). The reliability of the quality of teacher assessment versus external examinations has been debated in educational research (Black, Harrison, Hodgen, Marshall & Serret, 2011) however, as no external examination data was available for the purpose of this study, the decision to use national curriculum levels was made in an attempt to increase reliability when comparing pupil scores from different schools. National curriculum levels for English, Mathematics, and Science were provided and converted into a numerical value. National curriculum levels begin at level 1 and continue in ascending order. Each level contains three alphabetical sublevels in descending order where 1c represents the lowest sublevel and 1a the highest (1c, 1b, 1a,

2c, 2b, 2a etc.) Ascending numerical values were applied to each sublevel (1c =1, 1b=2, 1a=3, 2c=4 etc.) A numerical score was applied to each core subject and then an average score was calculated. Individual scores for mathematics, English, and science were highly correlated (r>.8 for all variables).

Control measures. The study included a number of measures to control for confounding variables. In order to control for SES, an inclusion criteria in the sampling process was set in that all students in the study were registered as receiving free school meals. This meant that all families were on low-income wages or receiving benefits. Furthermore, the participant's caregiver was asked to provide the number of years they had spent in education from the age of 5 onwards (parent education). This measure has been applied in other research investigating the influence of SES on child academic achievement (Davis-Kean, 2005) and has been included in research investigating child attachment (Benoit, Parker & Zeanah,1997; Kerns, Aspelmeier, Gentzler, & Grabill, 2001). The study asked parents to provide this information in the consent form to ensure an accurate measure as research has demonstrated a low correlation between adolescent reports and parent reports of the parent's level of education as well as a lower response rate in adolescent reports (Lien, Friestad & Klepp, 2001). Two measures of SES were included to account for education and income in order to increase the reliability of the measure. The importance of including both variables to provide an accurate measure of SES was highlighted by Braveman et al. (2005).

Finally, a measure of IQ was taken using the Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler, 2013). This measure was included for control purposes as IQ was expected to influence academic attainment (Moss & St-Laurent, 2001; Zettergren & Bergman, 2014). Students completed one verbal (vocabulary) and one non-

verbal (matrix reasoning) subtest in order to establish a general IQ score (IQ). An average IQ score is 100. The two subtests of the WASI-II were calculated according to the standardised instructions outlined in the manual.

Procedure

An ethics application (Submission number: 14393) was submitted and approved by the University of Southampton Ethics Committee (see Appendix D for confirmation email). An amendment application to extend recruitment to another local authority (Submission number: 17739) was also approved (see Appendix E for confirmation email). Five schools agreed to participate in the study (see Appendix F for school information sheet and consent form). Once students were selected, a letter of consent was sent to their parent/guardian via the SENCo. On the consent form, parents/guardians were asked to state the number of years they had spent in education as an additional measure of SES and confirm their child was receiving FSM (see Appendix G for parent information sheet and consent form). Students returned the consent form to the SENCo. The number of years parents had spent in education ranged between 8 to 25 years (M=13.71, SD=3.55).

Each student was seen on an individual basis in a quiet room at their school. Data collection took approximately one hour per student. At the start of the meeting the researcher read out the information sheet (see Appendix H for child information sheet and assent form) and informed the student of their right to withdraw at any time. Students were given the opportunity to ask any questions before signing the assent form. All of the students who returned their parental consent form agreed to take part in the study.

During the meeting, students completed a short questionnaire, three executive function skills tests and an IQ test. The order in which these tasks were presented was

randomly assigned to prevent order effects. At the end of the meeting students were given a debrief form (see Appendix I) and an opportunity to ask any further questions about the research.

Statistical analysis approach

Prior to recruitment, consideration was given to the target sample size for the study based on the sample size used in previous research and a statistical power calculation. Previous studies investigating the association between attachment and executive function in adolescents have used between n=40 (Escobar et al., 2013) and n=150 (Brown, 2014) participants. Research investigating the association in children have used between n=40 (Von der Lippe et al., 2010) and n=105 (Bernier et al., 2015) participants. A power calculation was conducted using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007) and, assuming an 80% power level and a 5% significant level the estimated sample size for the analysis was n=84. The final sample in this study was at the low end of previous research and was much lower than the power calculation. As such the results of the current study are risk of low power.

Initially the raw data was examined to ensure it met assumptions of normality and identify any outliers in the data. All measures included in the analysis were examined for distribution and outliers. A bivariate correlation was calculated to determine the associations amongst all variables. The correlation matrix was also used to identify any significant correlations between the experimental variables (attachment, executive function, and academic attainment) and the control variables (IQ, parent level of education). A partial correlation was then conducted in order to control for extraneous variables that demonstrated significant associations with the experimental variables. Both IQ and parent years in education were associated with measures of executive function. As

a result these variables were controlled for in the partial correlation calculations. A multiple linear regression was carried out to examine the predictive nature of the associations between predictor and outcome variables. Experimental variables were included in the regression if they had demonstrated a significant association with the outcome variable (national curriculum levels) in the partial correlation analysis. The predictor variables included in the linear regression were spatial working memory and the percentage of errors made in the stroop test. No other experimental variables were included in the analysis to reduce the risk of collinearity. Finally a mediation analysis was considered to explore the indirect influence of attachment on academic outcomes via executive function skills. However, as there was not a significant association between the attachment variables and the executive function variables and the attachment variables were not included in the regression analysis, a mediation analysis was not conducted for this study.

2.3 Results

Data preparation

Prior to analysis, the distribution of data for each measure was assessed (see Appendix J for histograms demonstrating these distributions). The trail making task scores demonstrated skewness. As a result, the data was examined and an outlier was identified (7.7 SDs above the mean). This outlier was removed from further analysis. On examination of the data, no significant outliers were identified in the other measures. The descriptive statistics for all measures included in the study are displayed in Table 1.

Table 1

Descriptive statistics

	Mean*	Std. Deviation*
Avoidant score	3.60	1.05
Anxious score	2.90	1.52
Trail score	40.67	17.94
Stroop (mean)	86.50	50.79
Stroop (median)	86.33	59.78
Stroop %error	2.94	5.34
Spatial WM	96.88	16.37
Verbal WM	95.50	17.54
NC level	13.67	4.78
Age	157.60	10.59
Parent education	13.38	3.55

*results given to 2 d.p.

Associations between variables

National curriculum scores for mathematics, English, and science were highly correlated with one another (r>.8 between all subjects). Accordingly, an average score was taken across all three indicators to create an overall academic attainment score (NC level).

Bivariate correlations were carried out to assess the associations between all measures (see Table 2).

Table 2

Bivariate correlations amongst variables

	1	2	3	4	5	6	7	8	9	10	11	12
1.Avoidant score	1											
2.Anxious score	.360*	1										
3.Trail score	.040	-.024	1									
4.Stroop (mean)	-.040	.174	.044	1								
5.Stroop (median)	-.052	.244	-.018	.892***	1							
6.Stroop %error	.101	.048	.298	.616**	.549**	1						
7.Spatial WM	.190	-.055	-.410*	-.331	-.319	-.237	1					
8.Verbal WM	.253	-.179	-.386*	-.382*	-.336	-.270	.536**	1				
9.NC level	.027	-.121	-.468**	-.204	-.207	-.239	.596**	.567**	1			
10.IQ	.185	.133	-.435*	-.035	.065	.078	.460**	.647**	.624**	1		
11.Age	.060	-.004	.169	-.078	-.191	-.112	.104	-.188	.317	-.174	1	
12.Parent education	.186	-.146	-.245	-.214	-.132	-.144	.312	.567**	.488**	.466*	.057	1

*p<.05, **p<.01, ***p<.001

The measures of IQ and the years the young person's parent had spent in education correlated with a number of the experimental variables. As a result, a partial correlation analysis was carried out in order to control for IQ and parent years in education and consider the associations between attachment scores and executive function. Age and gender were not controlled for as they did not demonstrate any significant correlations with the experimental measures. The correlation coefficients in this analysis are presented in Table 3.

Table 3

Correlations between measures when controlling for IQ and parent education

	1	2	3	4	5	6	7	8	9
1.Avoidant score	1.000								
2.Anxious score	.380*	1.000							
3.Trail score	.144	.020	1.000						
4.Stroop (mean)	-.019	.144	.020	1.000					
5.Stroop (median)	-.056	.219	.004	.897***	1.000				
6.Stroop %error	.119	-.029	.364	.606***	.541**	1.000			
7.Spatial WM	.124	-.125	-.258	-.355	-.396	-.315	1.000		
8.Verbal WM	.167	-.296	-.135	-.450*	-.497**	-.379*	.348	1.000	
9.NC level	-.131	-.222	-.267	-.209	-.316	-.351	.438*	.192	1.000

*p<.05, **p<.01, ***p<.001

Relationship between measures of attachment. Scores on the anxious measure of attachment were positively correlated with scores on the avoidant measure of attachment . Results suggest that young people who report high levels of attachment avoidance will also report high levels of attachment anxiety.

Relationships amongst measures of executive function. Spatial working memory and verbal working memory were positively correlated .This suggests that young people who performed better on the spatial working memory task also performed better on the verbal working memory task. Errors in the stroop task negatively correlated with verbal working memory. A similar relationship existed for spatial working memory although this correlation did not reach significance. This suggests that young people who made fewer errors in the stroop task performed better in both working memory tasks. Average stroop response times were negatively correlated with verbal working memory. Results demonstrated that students with quicker response times performed better on the verbal working memory task. A similar trend was found for stroop response times and spatial working memory although this correlation did not reach significance . The trail making task demonstrated a relationship with percentage of errors in the stroop task. Young people who made more errors in the stroop task performed worse on the trail making task. There were no significant correlations between working memory scores and performance on the trail making task.

Hypothesis 1. Students with low anxious or avoidant attachment scores (indicating secure attachment) will perform significantly better on tasks measuring working memory, shift and inhibition than students with high anxious or avoidant attachment scores**.** When the effects of IQ and parent education were controlled for there were no significant

correlations between measures of attachment and executive function. There appeared to be a negative trend between anxious attachment and verbal working memory however the correlation was not significant. It is possible that young people with low scores on the anxiety measure of attachment performed better on the verbal working memory task than children with higher scores. There were no associations between avoidant attachment and measures of executive function.

Hypothesis 2. Students with low anxious or avoidant attachment scores will achieve higher levels of academic attainment that those with high anxious or avoidant attachment scores. No direct correlations were found between attachment measures and academic attainment before and after controlling for the effects of IQ and parent education.

Hypothesis 3. Students who perform better on tasks measuring working memory, shift and inhibition will achieve higher levels of academic attainment than students who perform poorly on these tasks. After controlling for the effects of IQ and parent education, spatial working memory was positively correlated with academic attainment. Young people who performed better on the spatial working memory task demonstrated higher levels of academic attainment. A similar trend was found between errors in the stroop task and academic attainment although this correlation did not reach significance. Young people who made fewer errors in the stroop task achieved higher levels of academic attainment. There was no association between shift and academic attainment.

Predictors of academic attainment

A multiple linear regression was calculated in order to determine the direct predictors of academic attainment (see Table 4). This was done using a hierarchical

(blockwise) entry method. IQ and parent years in education were entered in to the first block of the regression analysis to control for their influence on academic attainment. These variables were included in this first block as they are known predictors of academic attainment. The decision to include these variables first in a regression analysis is recommended by Field (2013). In addition, both IQ and parent years in education demonstrated strong associations with NC levels in the bivariate correlation analysis conducted for this study. Spatial working memory and the percentage of errors in the stroop task were entered together in to block two. Other variables of executive function and attachment were not included in the regression analysis because they did not demonstrate any association with academic attainment in the partial correlation analysis.

Table 4
Predictors of academic attainment

		B	SE B	T	95% C.I	
Step 1		-4.194	3.778	-1.110	-11.920	3.532
	IQ	.144	.045	3.182**	.051	.237
	Parent education	.363	.210	1.723	-.068	.793
Step 2		-8.925	4.203	-2.124	-17.549	-.301
	IQ	.114	.046	2.452*	.019	.209
	Parent education	.274	.196	1.396	-.128	.675
	Spatial WM	.094	.043	2.164*	.005	.182
	Stroop %error	-.143	.121	-1.180	-.392	.106

Step 1 R^2=.45, F(2,31)=11.67***; Step 2 R^2=.58, F(4,31)=9.2***; R^2 change=.13
*p<.05, **p<.01, ***p<.001

Results from the regression analysis demonstrated that IQ ($t(25)=3.18$, $p<.01$) and spatial working memory ($t(25)=2.16$, $p<.05$) were both significant predictors of academic attainment. The role of multicollinearity was considered and results suggested that the regression analysis was not at risk of multicollinearity as the tolerance values (>.6) and the VIF values (<.1.6) were both within an acceptable range. This demonstrates that the predictor variables were not too highly correlated and were measuring different concepts.

Indirect associations between attachment and academic attainment

As no significant association was found between the independent variables (anxious and avoidant attachment scores) and the mediators (executive function variables) the data did not meet the requirements for conducting a mediation analysis. As a result the mediation analysis was not conducted in this study and hypothesis 4 was not accepted.

2.4 Discussion

This study investigated the associations between attachment styles, executive function skills (working memory, shift, and inhibition), and academic attainment. No significant correlations were identified between attachment and executive function when IQ and parent years in education were controlled for. However, trends indicated that young people with high anxious attachment scores demonstrate poorer verbal working memory skills. All three executive function variables were positively associated with academic attainment but only the association between spatial working memory and academic attainment reached statistical significance at $p<.05$. No statistically significant direct or indirect associations were found between attachment and academic outcomes. It is possible that the small sample size led to the non-significant results due to an issue of low power in the study. This means the findings are at risk of Type II errors. As a result the discussion section will explore the findings separately before outlining this limitation along with other methodological and measurement limitations and proposing suggestions for future research.

Attachment and Executive function

Unexpectedly, the correlations between measures of avoidant and anxious attachment and executive function did not reach significance in the present sample. This finding contrasts previous research which demonstrated: (i) a longitudinal association between attachment security as assessed in toddlers and executive function measures in 5 to 6-year-old children (Bernier et al.., 2015; Von der Lippe et al., 2010), (ii) an association between attachment disinhibition and more errors and slower response times on the Stroop task in

11-year-old post institutionalised children (Colvert et al.., 2008), and (iii) an association between attachment insecurity in adolescents and deficits in a number of executive functions including cognitive flexibility, attention, visual spatial abilities and processing speed (Escobar et al., 2013). These studies included a larger sample size than the current study and are therefore likely to demonstrate a higher power. This means the findings can be more confidently held than the findings of the current study. The present findings are consistent, however, with the findings by Brown (2014) who explored the link between attachment style and executive function using the tower of London task (Shallice, 1982) in a sample of 150 fifteen year olds taken from the National Institute of Child Health and Development Study of Early Child Care and Youth Development. Although the sample was taken from a longitudinal study, the data collected by Brown (2014) was cross sectional, involving a home visit and a laboratory visit. Brown (2014) reported that secure attachment was not a significant predictor of planning efficiency (executive function), $\beta = -.02$, $p > .05$. This result was based on a larger sample size and, as with other previous research highlighted in this section, is likely to have a lower risk of Type II error.

Although there were no statistically significant correlations between either anxious or avoidant attachment scores and executive function in the present sample, there were a number of trends that might suggest a relationship between these measures. Due to the small sample size it is possible that the issue of low power influenced the pattern of results obtained. The associations between attachment and executive function tasks used in this study are considered separately below:

Working memory and attachment. The findings for anxious attachment are discussed first in relation to working memory. The findings for avoidant attachment and

working memory are discussed afterwards. Although it did not reach statistical significance, the study found a negative trend between anxious attachment and verbal working memory (*r*=.-30, p=.10). As the anxious attachment scale had good internal reliability (α=.72) this suggests that young people who report lower levels of attachment anxiety tend to score higher on verbal working memory tasks.

Unlike verbal working memory, there was no trend between anxious attachment style and spatial working memory. This suggests that, despite the strong correlation between verbal working memory and spatial working memory scores, they show differential patterns of association with measures of attachment. Baddeley's (1992) model of working memory outlined two domain-specific storage systems. The phonological loop managed verbal information and the visuospatial sketchpad was responsible for visual and spatial information. The findings in the present study support this theoretical model as verbal and spatial working memory have different associations with attachment. However, Kane et al. (2004) argued for a domain general model of working memory using empirical research that previously supported a domain specific model (Daneman & Tardif, 1987) to suggest that some verbal tasks require more domain specific knowledge than spatial tasks. They suggested this knowledge was partially responsible for domain specific findings. Kane et al. (2004) found that verbal and visuospatial working memory shared 70% of their variance when domain specific knowledge was accounted for, concluding that they are similar constructs and any variance stems from other variables. In the current study it is possible that the domain specific language knowledge required in the verbal working memory task led to the different associations between anxious attachment and verbal and spatial working memory. It has been suggested that language input from adults is likely to contribute towards the development of executive functions (Carlson, 2003). Von der Lippe

et al. (2010) found that maternal vocabulary was associated with a child's executive function skills ($r=.38$, $p<.05$). Although the study does not explore verbal and spatial working memory separately it highlights the importance of maternal tutoring in the association between attachment and executive function. The present study found that parent's years in education was positively associated with verbal working memory but not spatial working memory. It is possible that maternal vocabulary and education influence the development of language required for the verbal working memory task via maternal tutoring skills. Further research should consider the influence of prior knowledge and language skills on different working memory tasks when exploring their associations with attachment.

The correlations for avoidant attachment with both working memory measures were weak and not significant. It is possible that the low internal reliability of the avoidant attachment scale ($\alpha=.54$) meant that the measures used in the study did not capture the associations between avoidant attachment and working memory.

Inhibition and attachment. No significant associations were identified between measures of inhibition and attachment despite the correlation amongst stroop scores and working memory scores. In this study inhibitory control was not associated with attachment style even before controlling for IQ. This finding is not supported by previous research that demonstrates a significant association between selective attention and attachment security when the number of errors made in a flanker task were calculated, $r=.31$, $p<.001$ (Bernier et al., 2015). The current study found no association between the percentage of errors in the inhibition task and attachment anxiety or attachment avoidance. Both the current study and the study by Bernier et al. (2015) used non-verbal stimuli in the inhibition task and controlled for cognitive ability. However, the age of the sample was

different (M=13yrs and M=6yrs respectively) as was the measure of attachment (self-report and observational respectively). It is possible that these factors are responsible for the different findings, demonstrating the need for longitudinal research.

Shift and attachment. No significant association was found between the measure of shift (trail making task) and the measures of attachment. This finding remained the same before and after controlling for IQ and provides counter evidence to the results in a study by Escobar et al. (2013) who found that securely attached adolescents scored lower on the trail making task B. However Escobar et al. (2013) explored scores on tasks A and B separately, including the time taken for the participant to complete task B in the main analysis. In the trail making task A, participants are required to connect circles labelled 1-25 in ascending order. In the trail making task B, participants must switch between numbers and letters when joining them in ascending order. Previous research that examines shift using the trail making task has calculated the difference between the time taken to complete task A and task B as a number or a ratio (Lamberty, Putnam, Chatel, Bieliauskas, & Adams, 1994). Examining this difference removes the variance that influences both task A and B (e.g. visual scanning) and captures the unique variance of shifting between number and letter (Misdraji & Gass, 2010). The current study calculated the difference in time between task A and B in seconds in line with this research. As Escobar et al. (2013) examined task times separately it is possible that the study captured a different set of skills that underlie performance in task B rather than the unique variance of shift. It may be that the different methodology used in the current study and the study by Escobar et al. (2013) has led to the different findings.

Attachment and executive function in adolescence. The current study did not identify any significant associations between attachment and executive function. It is

likely that the low power that resulted from a small sample size influenced the pattern of results however it is possible that the relationship that has been identified between these variables in early childhood (e.g., Bernier et al.., 2015; Von der Lippe et al.., 2010) becomes more complex in adolescence. In his original theory of attachment, Bowlby (1973) held a dynamic view of development in which patterns of adaptation and attachment behaviour can be altered by experience, whilst at the same time, new experiences are interpreted according to this history of adaptation (Sroufe, 2005). Sroufe et al. (2005a) found that sibling and peer relationships, social support, and life stress are all associated with development and change. Sroufe (2005) suggested that prior adaptation is incorporated and built on at each phase of development. As such attachment style in adulthood has been shown to be influenced by an interaction between early caregiving experiences, social competence, and quality of friendships (Fraley et al., 2013).

The current study uses a global measure of anxious and avoidant attachment that aims to tap into an overarching internal working model incorporating all attachment relationships including parents, peers, and romantic relationships (Fraley et al., 2011). This decision is based on the premise that as they get older, young people begin to widen their attachments beyond their initial caregiver, developing friendships and romantic relationships (Raja, McGee & Stanton, 1992). The perceived support of parents and friends shifts during adolescence from parents to friends (Helsen, Vollebergh & Meeus, 2000). Although these shifts vary according to gender, a significant reduction in perceived parent support and increase in perceived peer support between the ages of 12 and 14 years has been identified (Helsen, Vollebergh & Meeus, 2000). As the age of the sample in the current study ranges from 11 to 14 years (M = 13yrs 1 month) it might be that the young people were thinking about their relationships with peers rather than parents when

answering the attachment questionnaire. As such the current study may not capture the unique contribution of early caregiving experiences that initiate attachment style have on the development of executive function. Alternatively the dynamic development of attachment (Sroufe, 2005) and executive function (Zelazo & Muller, 2002) may mean the associations between the two variables evolve as the young person develops. An alternative explanation as to the lack of significant associations between attachment and executive function in the present study may be the methodological limitations as outlined below.

Measures

Attachment style was captured using a questionnaire that provided two overall scores for attachment avoidance and attachment anxiety. The Cronbach's Alpha indicated that the internal reliability of the anxious attachment scale was good (α=.72) however the avoidant attachment scale did not reach the same level of reliability (α= .54). This was unexpected as previous research has demonstrated a higher level of internal reliability with alpha scores above α>.8 (Donbaek & Elklit, 2014). It is possible that the questionnaire did not capture avoidant attachment as reliably in this study.

This study used a global measure of attachment, asking young people to consider close relationships in general. Previous research has considered adolescent attachments in specific relationships. Escobar et al. (2013) used the Family and Friends Interview as a semi-structured assessment of attachment relationships with significant attachment figures such as friends, siblings and parents in order to identify a global attachment category. Brown (2014) used the Behavioural Systems Questionnaire as an assessment of attachment to parents only. Research investigating the association in young children also

focuses on attachment to the primary caregiver (e.g. Von der Lippe et al., 2010). The current study employed a measure of attachment which does not differentiate between attachments to peers and parents. Perhaps this lack of differentiation between different attachment relationships diluted any attachment relationship specific effects of attachment patterns on executive function. The low alpha for the avoidant attachment scale (α=.54) further suggests that the measure may not have been reliable for this sample.

Alternatively, the use of self-report measures may not be appropriate. Researchers have debated the accuracy of self-report measures in adolescence particularly when questions are of a sensitive nature (Turner, Rogers, Lindberg, Pleck & Sonenstein, 1998). Turner et al. (1998) found that using audio technology that allowed participants to complete a questionnaire privately meant participants disclosed more risky behaviour when compared to interviews and traditional paper- pencil self-administered questionnaires. Dan, Ilan and Kurman (2013) used the Experiences in Close Relationships questionnaire as a measure of attachment and suggested that findings may be biased as a result of adolescent embarrassment. As the questions used in this study were personal (e.g. I'm afraid other people may abandon me), it is possible that using an on-line questionnaire could prevent embarrassment and elicit more accurate attachment styles.

A further limitation of the current study relates to the lower IQ in the present sample (mean IQ = 90.4, SD = 16.5) when compared to the expected average (mean IQ=100; Wechsler, 2013). It is possible that the young people in the study struggled to understand questions or misinterpreted their meaning, particularly as some of the statements were negatively worded (e.g. I prefer not to show others how I feel deep down).

Executive function tasks were selected based on the three factor model of executive functioning developed by Miyake et al. (2000). The model assumes that working memory, inhibition, and shift are separate factors that correlate to one another. However, Lee, Bull and Ho (2013) suggested that a three factor model was not the best fit for younger students. They found strong associations between inhibition and shift for young people age 13 years (r=.85) and slightly weaker associations between these variables in students age 14 years (r=.72) and therefore proposed a two factor model would be more appropriate for this age group. The current study applied a three factor model as these associations were not found between response times in the inhibition task and response times in the shift task (r=.02) and were not significant between the number of errors in the inhibition task and response times in the shift task (r=.36). However, measures of inhibition and shift demonstrated a similar pattern of associations with attachment and academic attainment, suggesting the constructs do have some similarities. Although the sample ranged from 11:6 years to 14:11 years (M= 13years) the small sample size (N=32) meant that the factor structure of different age groups was not considered. It is possible that utilising a different model for different age groups would increase the reliability of the measure of executive function and, in turn, change the associations between executive function and attachment.

Attachment and academic attainment

No significant associations between attachment styles and academic attainment were detected, either before or after controlling for the influence of adolescents' IQ and parents' years in education. This finding is inconsistent with previous research that has found children with insecure attachment styles demonstrate poorer reading and mathematics skills when maternal education, income and early cognitive skills are accounted for (McCormick, O'Connor & Barnes, 2016). One explanation for this is the

limitations of the measure used to capture attachment style as outlined in the previous section of this discussion or the low power that resulted from a small sample size. Alternatively, it is possible the measure of academic attainment was too broad and a specific assessment of these skills, as used by McCormick, O'Connor and Barnes (2016) would produce different findings.

Executive functions and academic attainment

After controlling for the effects of IQ and parent years in education, spatial working memory was positively and significantly associated with academic attainment and significantly predicted academic. Non-significant associations with academic attainment were found for verbal working memory, shift, inhibition response time, and inhibition errors. Although these values were not statistically significant at $p<.05$ they suggest young people who perform better in executive function tasks achieve higher levels of academic attainment. The trends identified in this study reflect those found in previous research (Alloway & Alloway, 2010; Cameron, Brock & Murrah, 2012; McClelland et al., 2014) although the correlation coefficients are smaller. This suggests that executive function skills, particularly spatial working memory, are associated with attainment in national curriculum assessments.

The indirect effect of attachment on academic outcomes

The study found that attachment did not have a significant association with executive function and, as a result, a mediation analysis was not carried out. Despite the fact that attachment and executive function have demonstrated significant associations with academic attainment in previous research (Blair & Razza, 2007; McCormick, O'Connor & Barnes, 2016), the findings in the main analysis do not support the theoretical

model proposed in the introduction section of the study. The small and insignificant associations between attachment and executive function as well as the difference in their individual associations with academic attainment would suggest that they should be considered separate constructs. However, this result should be interpreted with caution because of the low power that is likely to have influenced the pattern of results.

Limitations

The main limitation of this study was the sample size (N=32). As a result, the small sample might not have provided sufficient power to detect significant associations amongst the variables included in the analysis. There is an increased risk of type II error and it is possible that, in some cases, the null hypothesis should not have been accepted. As such, results from previous research that has included a larger sample size can be more confidently held than the findings demonstrated in the current study. Further research should aim to include a larger sample of participants to reduce the risk of type II error.

There are also methodological limitations that must be addressed. The current study used national curriculum levels as a measure of academic attainment. These were provided by class teachers as no external examination results were available due to the age of the sample. The quality of teacher assessment has been debated in educational research (Black et al., 2011) however the decision to use national curriculum levels was made in an attempt to ensure homogeneity in scoring between schools. From September 2014 the system of levels was removed by the Department of Education in order to provide schools greater flexibility in how they plan and assess learning (Department for Education, 2014). All schools that participated in this study had chosen to continue using National Curriculum levels to assess attainment. However it is possible that this measure of

academic attainment may not have been an accurate measure in comparison to external examination grades and as such may have influenced the pattern of results obtained. Furthermore, as schools develop alternative methods of assessment, it is likely to become more difficult to compare the academic attainment of KS3 students from different schools. In this case the first opportunity to compare students nationally would be using their GCSE examinations at the end of Key Stage 4. Therefore the measure used to capture academic attainment must be considered in future research.

An additional methodological limitation is that the data in the study was gathered at one time point. The cross sectional nature of the current study is consistent with the design of other studies using an adolescent sample (Brown, 2014; Escobar et al., 2013). However, some studies have used a longitudinal approach spanning across toddlerhood and early childhood (Bernier, Carlson & Whipple, 2010; Bernier et al., 2015; Colvert et al., 2008). Due to the evolving nature of executive function skills across childhood and adolescence, future research should employ a prospective longitudinal design to measure the changes in the association between variations in attachment quality and executive function as a child develops and moves into adolescence and adulthood. Collecting data at different time points may have increased the reliability of the findings in the current study and increasing the confidence of the results when comparing them to previous research.

A further limitation lies in the sample of the study. Students on the SEN register were excluded from the study in order to control for the influence of mental health conditions, language and learning difficulties on the results. However, it is possible that young people with these difficulties may not have been identified by school staff meaning that these difficulties may have reduced the reliability of the results..

Finally the measures used may have presented a further limitation to the study. As the measure used to capture attachment style was continuous rather than categorical, it was unclear how many of the young people could be considered as insecurely attached. It is possible that the relationship between attachment and executive function in extreme early caregiving experiences is different and may present a different pattern of results to those identified in the current study. Merz et al. (2016) argued that the influence of attachment on executive function was the result of deprivation from a caregiver in an institutionalised setting. The study highlighted research outlining the influence of this environment on the development of the HPA axis, elevating levels of stress hormones (Hostinar, Sullivan & Gunnar, 2014) and, as a result, altering the structure and function of the prefrontal cortex (Arnsten, 2009). Although a sampling criterion of FSM was applied in this study to recruit young people from low socioeconomic backgrounds, further research should investigate the relationship between attachment and executive function in a broader sample with a wider range of early attachment experiences including young people who have experienced extreme deprivation

2.5 Conclusion

This study investigated the relationship between attachment, executive function and academic attainment in adolescence. No significant relationship was found between attachment and different measures of executive function. However, there was a negative trend between anxious attachment and verbal working memory. There was no association between either measure of anxious attachment or avoidant attachment with academic

attainment. All three measures of executive function were related to academic attainment although spatial working memory was the only measure to reach statistical significance.

Suggestions for further research

A number of suggestions can be made for future research. Firstly, recruitment of a larger sample would increase the statistical power of the analysis. Measures of executive function should be consistent. Studies should consider the use of a one, two, or three factor model of executive function according to the associations between the measures, their associations with other variables, and the age of the adolescent sample (Lee, Bull & Ho, 2013)

Due to the significant association between working memory and IQ, further research should reflect on the underlying skills required to complete a cognitive IQ test. Research on the association between IQ and executive function is inconsistent. In some studies, measures of executive function have demonstrated very few associations with IQ (Ardila, Pineda & Rosselli, 2000). The study found that a Full IQ score was not associated with shift. However, others have demonstrated a significant association between IQ scores and executive function tasks measuring inhibition and shift (Arffa, 2007). Friedman et al. (2008) found that, alongside cultural and social experiences, executive function influenced IQ scores. Future research should ensure that executive function is not affected by controlling for IQ.

Finally, the relationship between attachment, executive function, and academic attainment should be examined in a sample of young people who have experienced more extreme caregiving experiences. The relationship between variables might be more

apparent in this sample due to the influence of chronic stress on the development of the prefrontal cortex as highlighted in institutionalised samples (Merz et al., 2016).

Implications for practice

Young people who are at risk of low academic attainment should be supported in developing their executive function skills. Particular focus should be given to working memory due to the significant association between spatial working memory and academic attainment in this study and previous research that suggests working memory is the most significant predictor for literacy and numeracy skills (Alloway & Alloway, 2010). A number of programmes have been developed (e.g. Brain Gym; www.braingym.org.uk) that focus on working memory. The reliability and validity of these programmes, as well as their effectiveness, should be considered before any programmes are implemented in schools as an intervention for these students.

Training on how to support young people with executive function difficulties should be provided to all staff. Blair and Razza (2007) suggested that the school curriculum should be designed to enhance self-regulation skills as well as academic abilities. As the current study found an association between academic attainment and executive function in a normative sample of young people, executive function support should be applied as a wave one intervention as classified by the Waves of Intervention model in the National Strategies Programme (DfES, 2006a). This would mean embedding executive function strategies into whole class teaching practice.

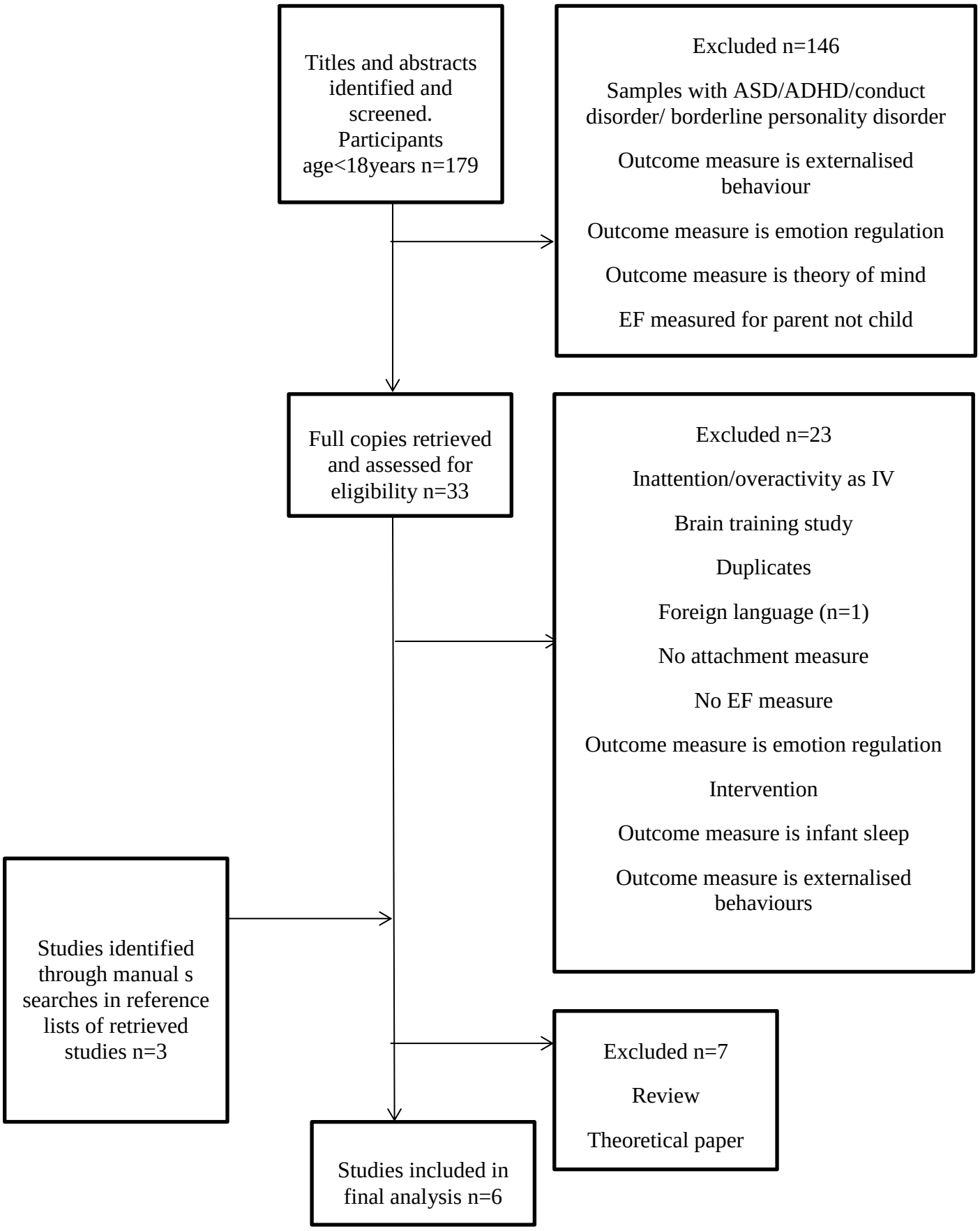
Teaching staff should consider the needs of learners in terms of their anxious and avoidant attachment styles. Students with high anxiety scores achieved lower scores in the verbal working memory task. If this is the result of the domain specific language required

for verbal tasks (Kane et al., 2004) teachers must ensure that tasks involving language are accessible to these students.

Finally, students with high avoidant attachment scores performed slightly, but not significantly, better on both verbal and spatial working memory tasks. It might be that, as a result of their attachment profile, these students are more focused on the task rather than their interactions with staff and other adults in the classroom (Geddes, 2005). Teachers must provide appropriate support for these students, following suitable strategies recommended by Geddes (2005).

Appendices

Appendix A Literature search process



Appendix A

Appendix B Summary of studies included in the review

Authors	Study purpose	Study characteristics	Study measures	Findings
Bernier, Carlson & Whipple (2010)	To investigate the links between parent-infant interactions and subsequent executive function skills	**N**= 88 **Gender**: 44girls **Age assessed**: 12-13, 15, 18, and 26 months **SES:** Middle class **Design:**	**Measures:** Maternal mind-mindedness free play sequence (Meins, Fernyhough, Fradley & Tuckey, 2001) . Maternal behaviour Q-sort (Pederson & Moran, 2008). Maternal autonomy support problem solving task. Mental development index (Bayley, 1993). **EF measures 18 months:** Hide the pots (adapted from Hughes & Ensor, 2005). Categorisation (adapted from Carlson, Mandell & Williams, 2004) **EF measures 26 months:** Spin the pots (Hughes & Ensor,	All three parenting dimensions predicted Conflict-EF (working memory; inhibition; and shift) Children whose mothers were more autonomy-supportive when they were aged 15 months performed better on working memory and categorization tasks at 18 months and Conflict-EF tasks at 26 months.

Appendix B

		Longitudinal (4 time points over 14 months)	2005). Delay of gratification (Kochanska, Murray & Harlan, 2000). Shape stroop (Kochanska, Murray & Harlan, 2000). Baby stroop (adapted from Hughes & Ensor, 2005).	Maternal mind-mindedness was the only predictor of change (increments) of EF between aged 18-26 months.
Bernier, Carlson, Deschênes, & Matte-	To investigate the link between the quality of the early caregiving	**N**= 62 **Gender**: 32girls	**Measures:** Maternal mind-mindedness free play sequence (Meins, Fernyhough, Fradley & Tuckey, 2001) . Maternal behaviour Q-sort (Pederson & Moran, 1995). Maternal autonomy support problem solving task. Mental	Early attachment security predicts individual differences in Conflict EF age 3yrs. Attachment security did not predict

Gagné (2012)	environment and subsequent executive function skills	**Age assessed**: 12-13, 15, 18 months , 2, 3 yrs. **SES:** Middle class **Design**: Longitudinal (5 visits over 2years)	development index (Bayley, 1993). SES measured using gender, age, no.of siblings, maternal and paternal age and education, household income. Adapted version of the Mutually Responsive Orientation scale (MRO; Aksan, Kochanska & Ortmann, 2006) Attachment behaviour Q-sort (Waters, 1995) The Peabody Picture Vocabulary Test 3 (Dunn & Dunn, 1997). **EF measures at 2 years**: Spin the pots (Hughes & Ensor,	impulse control. Children who received high quality parenting and were securely attached performed better in Impulse Control and Conflict-EF tasks.

			2005). Delay of gratification (Kochanska, Murray & Harlan, 2000). Shape stroop (Kochanska, Murray & Harlan, 2000). Baby stroop (adapted from Hughes & Ensor, 2005). **EF measures at 3 years:** Bear/Dragon (Reed, Pien & Rothbart, 1984); Day/Night (Gerstad, Hong & Diamond, 1994); Dimensional change card sort (Zelazo, 2006); Delay of gratification (Kochanska, Murray & Harlan, 2000).	
Bernier, Beauchamp,	To investigate the associations between attachment security in toddlerhood and	**N**= 105 (included 58 of the participants	**Measures:** Attachment behaviour Q sort (Waters, 1995). Lollipop test (Chew & Morris, 1984)	Early attachment security predicted flexibility, metacognition and global

Carlson and Lalonde (2015)	children's executive function skills	from Bernier et al., 2012 sample) **Gender**: 58girls **Age assessed**: 5yrs **SES:** Middle class **Design:** Longitudinal (over 2 years)	**EF measures at 3 years:** Bear/Dragon (Reed, Pien & Rothbart, 1984); Day/Night (Gerstad, Hong & Diamond, 1994); Dimensional change card sort (Zelazo, 2006) **EF measures age 5**: Backward word span (Carlson, Moses & Breton, 2002); dimension change card sort (Zelazo, 2006); NEPSY tower (Korkman, Kirk, & Kemp, 1998); flanker task (adapted from Rueda et al.., 2004).Behaviour rating inventory of executive function-Pre-school version (Gioia, Espy, & Isquith, 2003)	executive composite scores on the BRIEF. Attachment security predicted all EF tasks age 5. This remained significant in DCCS, NEPSY and flanker tasks when EF scores at age 3 were controlled for. Attachment has a broad effect on the development of a child's executive functioning (rather than a direct impact on specific types of EF).

Appendix B

Colvert, Rutter, Kreppner, Beckett, Castle, Groothues, Hawkins, Stevens and Sonuga-Barke (2008)	To investigate outcomes associated with early deprivation	**N=** 165 Romanian children (144 institutionalised care) 52 UK adoptee comparison group **Gender:** 55% girls (Romanian sample), 35% girls (UK sample) **Age assessed:** 11 yrs.	**Measures:** Index of deprivation prior to adoption, Strange stories task (Happe, 1994), McCarthy scales (McCarthy, 1972) Wechsler Intelligence scales for Children (Wechsler, 1991), Social Communication questionnaire (Rutter et al., 2003), Rutter scales (Elander & Rutter, 1996)Wechsler Objective Reading Dimensions Test (Rust, Golombok & Trickey, 1993), disinhibited attachment (Rutter et al., 2007a) **EF measures**: Stroop task (Stroop, 1935)	For EF the Romanian institutionalised group made more mistakes on the stroop task than both the UK adoptee group and the non-institutionalised Romanian sample. The latter groups were combined in later analyses. Children with disinhibited attachment performed worse in the stroop task.

		Design: Cross sectional (2 visits)		
Heikamp, Trommsdorff, Druey, Hübner, von Suchodoletz (2013)	To investigate children's' attachment security, inhibitory control and internalisation of rules of conduct.	**N**= 82 **Gender**: 36girls **Age assessed**: 4-6yrs	**Measures:** German version of the attachment Q-sort (Waters & Dean, 1984). "My Child" questionnaire (Kochanska, Murray & Harlan, 1994) **EF measure:** Stop-task (Logan, 1994).	Attachment security significantly predicted inhibitory control.
Von der Lippe, Eilertsen, Hartmann,	To investigate the role of maternal attachment in child attachment and	**N**= 40 (previously investigated by Killen, Klette & Arnevik, 2006)	**Measures:** Care Index (Crittenden, 2001), Strange situation (Ainsworth et al., 1978), Adult Attachment Inventory (George, Kaplan & Main, 1985). WIAT vocabulary test (Wechsler, 1991) California child Q set	Secure attachment style was positively associated with scores in the executive function task.

& Killen (2010).	executive functioning.	**Gender**: 20girls **Age assessed**: 6yrs **SES:** Predominantly recruited from economically advantaged area. **Design:** Longitudinal (observed in 4 waves)	(Block, 2008) **EF measure:** Running horses game test (Hartmann & Haavind, 1981)	Maternal sensitivity accounted for link between maternal secure attachment and child secure attachment Maternal tutoring accounted for the link between maternal attachment and child's executive function Mothers internal working models shape child's EF

Appendix C Attachment style questionnaire

Please read each of the following statements and rate the extent to which you believe each statement best describes your feelings about **close relationships in general**

1. It helps to turn to people in times of need.

strongly disagree 1 2 3 4 5 6 7 strongly agree

2. I usually discuss my problems and concerns with others.

strongly disagree 1 2 3 4 5 6 7 strongly agree

3. I talk things over with people.

strongly disagree 1 2 3 4 5 6 7 strongly agree

4. I find it easy to depend on others.

strongly disagree 1 2 3 4 5 6 7 strongly agree

5. I don't feel comfortable opening up to others.

strongly disagree 1 2 3 4 5 6 7 strongly agree

6. I prefer not to show others how I feel deep down.

strongly disagree 1 2 3 4 5 6 7 strongly agree

7. I often worry that other people do not really care for me.

strongly disagree 1 2 3 4 5 6 7 strongly agree

8. I'm afraid that other people may abandon me.

strongly disagree 1 2 3 4 5 6 7 strongly agree

9. I worry that others won't care about me as much as I care about them.

strongly disagree 1 2 3 4 5 6 7 strongly agree

Appendix D Ethical approval of study

Your Ethics Submission (Ethics ID: 14393) has been reviewed and approved

ERGO [ergo@soton.ac.uk]

Actions

To:

Foy L.C.

Inbox

20 May 2015 10:44

Submission Number: 14393

Submission Name: Is academic achievement associated with attachment style and executive function in adolescence?

This is email is to let you know your submission was approved by the Ethics Committee.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment)

Comments

None

Click here to view your submission

ERGO: Ethics and Research Governance Online

http://www.ergo.soton.ac.uk

DO NOT REPLY TO THIS EMAIL

Appendix E Ethical approval for amendment to study

Your Ethics Amendment (Ethics ID: 17739) has been reviewed and approved

ERGO [ergo@soton.ac.uk]

Actions

To:

Foy L.C.

Inbox

14 October 2015 20:39

Submission Number 17739:

This email is to confirm that the amendment request to your ethics form (Is academic achievement associated with attachment style and executive function in adolescence? (Amendment 1)) has been approved by the Ethics Committee.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment)

Comments

None

Click here to view your submission

ERGO: Ethics and Research Governance Online

http://www.ergo.soton.ac.uk

DO NOT REPLY TO THIS EMAIL

Appendix F School information letter and consent form

School Information Sheet (Version 1.3, 09/10/2015)

Study Title: **Is academic achievement associated with attachment style and executive function in adolescence?**

Dear Head teacher/SENCO,

I am writing to invite your school to take part in a research project funded by the University of Southampton.

I am a trainee Educational Psychologist working for the Educational Psychology Service in the LA ANONYMISED. As part of my doctoral studies I am carrying out a piece of research in secondary schools in LA ANONYMISED.

What is the study about?

The study aims to investigate the link between attachment and academic outcomes. It has been found that young people who have not developed an appropriate relationship with their primary caregiver (due to a number of factors that could include neglect, abuse or absence) during their early stages of development have a different view on relationships. This has been found to impact on their academic attainment later on in life.

Recently, researchers have started trying to understand why this is the case. One suggestion is that this relationship has an impact on a child's brain development and specifically, on the skills that underpin learning. These skills are known as executive functions.

Executive functions enable us to plan and carry out a task. An example of an executive function is working memory. Working memory is used when an individual is required to hold information in mind whilst using it to answer a question (e.g. remembering a list of directions whilst driving to a new destination).

This research aims to investigate whether the link between attachment style (relationships) and academic attainment is influenced by a child's executive function skills.

What will happen if my school takes part?

If you consent to your school taking part I will contact you directly. An information sheet and consent form will then be given to approximately 10 pupils in year 7, 8, and 9 to take home in order for parents/carers to give signed consent. These 10 pupils should consist of 5 boys and 5 girls who are registered as receiving free school meals with the aim to include looked after children. Parents/carers will be asked to provide opt in consent for their children to take part in the study. Once the pupil returns this form to the school I will

arrange a convenient time to come in and collect the data. Each student will be required for approximately forty five minutes.

I will provide all the consent forms and information sheets.

How will the research benefit the school?

The findings of the study will be summarised and fed back to your school. A discussion of these findings and the implications in education will be clearly outlined. These can be discussed with your educational psychologist and incorporated into school practice where applicable.

Who will have access to the research records?

All information collected in this research will remain strictly confidential and will be compliant with the Data Protection Act (1998). The details of students and schools participating in the study and all data collected will be kept confidential. Findings will be summarised and disseminated throughout the schools in Hillingdon, with the aim of informing professionals as to how to support young people with attachment difficulties to improve their academic attainment.

If you have any further questions please do not hesitate to contact me using one of the methods listed below:

Address: Educational Psychology Services

Anonymised for confidentiality

E-mail address: lcf1g13@soton.ac.uk

I look forward to hearing from you.

Yours Sincerely,

Lindsey Foy

Headteacher/SENCO Consent Form (Version 1.3, 09/10/2015)

Study Title: **Is academic achievement associated with attachment style and executive function in adolescence?**

Researcher name: Lindsey Foy

Study reference: 14393

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet (Version 1.3, 09/10/2015) and have had the opportunity to ask questions	☐
I agree to the school's participation in this research project	☐
I understand the school's participation is voluntary and we may	☐
I agree for parental consent to be sought for each child.	☐

Data Protection

I understand that information collected about the school during its participation in this study will be stored on a password protected computer and that this information will only be used for the purpose of this study. All files containing any personal data will be made anonymous.

Name of Headteacher/ SENCO (print name)……

Signature of headteacher/ SENCO……..

Date……

Appendix G Parent information letter and consent form

Parent/guardian Information Sheet (Version 1.3, 09/10/2015)

Study Title: **Is academic achievement associated with attachment style and executive function in adolescence?**

Researcher: Lindsey Foy **Study ID:** 14393

Please read this information carefully before deciding whether your child can take part in this research. If you are happy for them to participate you will be asked to sign a consent form.

What is the research about?

This project is being carried out to fulfil part of the requirements for a doctorate in Educational Psychology. It aims to investigate a link between attachment style and academic achievement and whether this is influenced by executive function (learning skills). The project is funded by the University of Southampton.

Why has my child been chosen?

Your child has been chosen because they are in year 7, 8, or 9 in a school in LA ANONYMISED and receives free school meals. This age group has been chosen because the project focuses on adolescents.

What will happen to me and my child if they take part?

If you give consent to your child taking part in the study you will be asked to record the number of years you have spent in education (from age 5 onwards) and whether your child receives free school meals. These two pieces of information are needed to make sure that nothing else is affecting academic levels. This is to ensure that any link between attachment style, executive function and academic achievement cannot be explained by other factors.

Your child will then meet with the researcher for approximately 45 minutes. During this time they will complete 1 questionnaire and 4 short skills tests. This meeting will happen in school during school hours. At the end of the meeting your child will have a chance to ask any questions and talk to the researcher. This is the only meeting your child needs to attend.

Are there any benefits in my child taking part?

The research will hopefully benefit your child as the findings of the study will be fed back to their school so that staff can incorporate them into their teaching practice.

Are there any risks involved?

There are no physical risks in participating in the study. If your child does not want to participate in any of the skills tests or answer the questionnaire they can leave the meeting at any time.

Will my child's participation be confidential?

All the data gathered during the meeting with your child will remain confidential. It will be stored on a password protected computer. The data will be coded and none of the details about your child or the school will be included in the findings.

What happens if I change my mind?

You can withdraw your child from the study at any time without your legal rights being affected. Your child can also choose to leave the meeting at any time.

What happens if something goes wrong?

If you have a cause for concern or a complaint you can contact the Chair of the Southampton University ethics committee using the following details:

Address: Psychology,
University of Southampton,
Southampton,
SO17 1BJ.

Phone: +44 (0)23 8059 3856

Email: fshs-rso@soton.ac.uk

Where can I get more information?

If you have any questions please feel free to contact Lindsey Foy using the contact details below:

Address: Educational Psychology Service,
LA anonymised for confidentiality

Email: lcf1g13@soton.ac.uk

CONSENT FORM (*Version 1.3, 09/10/2015***)**

Study title: Is academic achievement associated with attachment style and executive function in adolescence?

Researcher name: Lindsey Foy

Study reference: 14393

Please initial the boxes if you agree with the statements:

I have read and understood the information sheet (version 1.3, 09/10/2015) and have had the opportunity to ask questions	☐
I give consent for my child to take part in this research project	☐
I give consent for my data to be used for the purpose of this	☐
I understand that my child's participation is voluntary and he/she	☐
I understand that information collected about me and my son/daughter during their participation in this study will be stored on a password protected computer and that this information will only be used for the purpose of this study. All	☐

Please answer the following questions:

How many years did you (the main parent/carer) spend in education ? ☐

(from age 5 onwards)

Is your child receiving free school meals? ☐

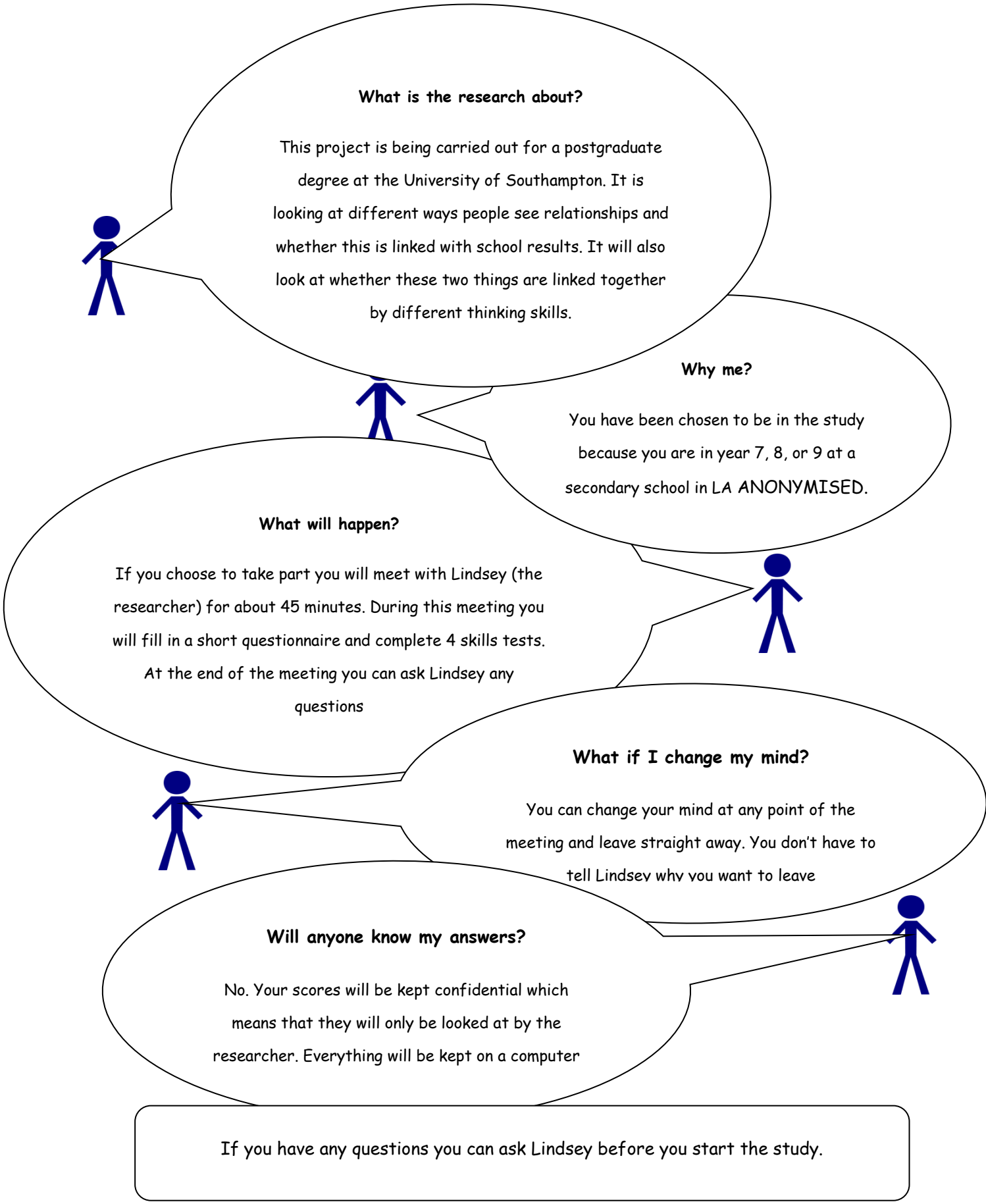
Name of parent/carer (print name)……

Signature of parent/carer……..

Date……

Appendix G

Appendix H Child information sheet and consent form



Appendix H

ASSENT FORM (*Version 1.3, 09/10/2015***)**

Study title: Is academic achievement associated with attachment style and executive function in adolescence?

Researcher name: Lindsey Foy

Study reference: 14393

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet (version 1.3, 09/10/2015) and have been able to ask questions about the ☐

I agree to take part in this project and agree for my scores to be ☐

I understand that it is my choice whether I take part in this study and I can leave whenever I like. ☐

Name of participant (print name)……

Signature of participant……..

Date……

Appendix I Debrief form

Why did we do this?

The aim of this study was to look at the link between relationship styles, learning and school grades. It is expected that the way we see relationships will impact on our school grades because of the way it impacts on how we learn.

Your input will help us to understand this topic a bit more.

The research did not use any deception (you were not lied to at all).

Now what?

You can keep this form if you would like to and you can have more information once the project has finished in July 2016. If you would like to know the outcome of the study you can ask for a copy from school. It will be ready in September 2016.

If you were upset by anything you did today and you don't want to talk to me, your parents or any of the teachers you can contact the Samaritans in LA ANONYMISED:

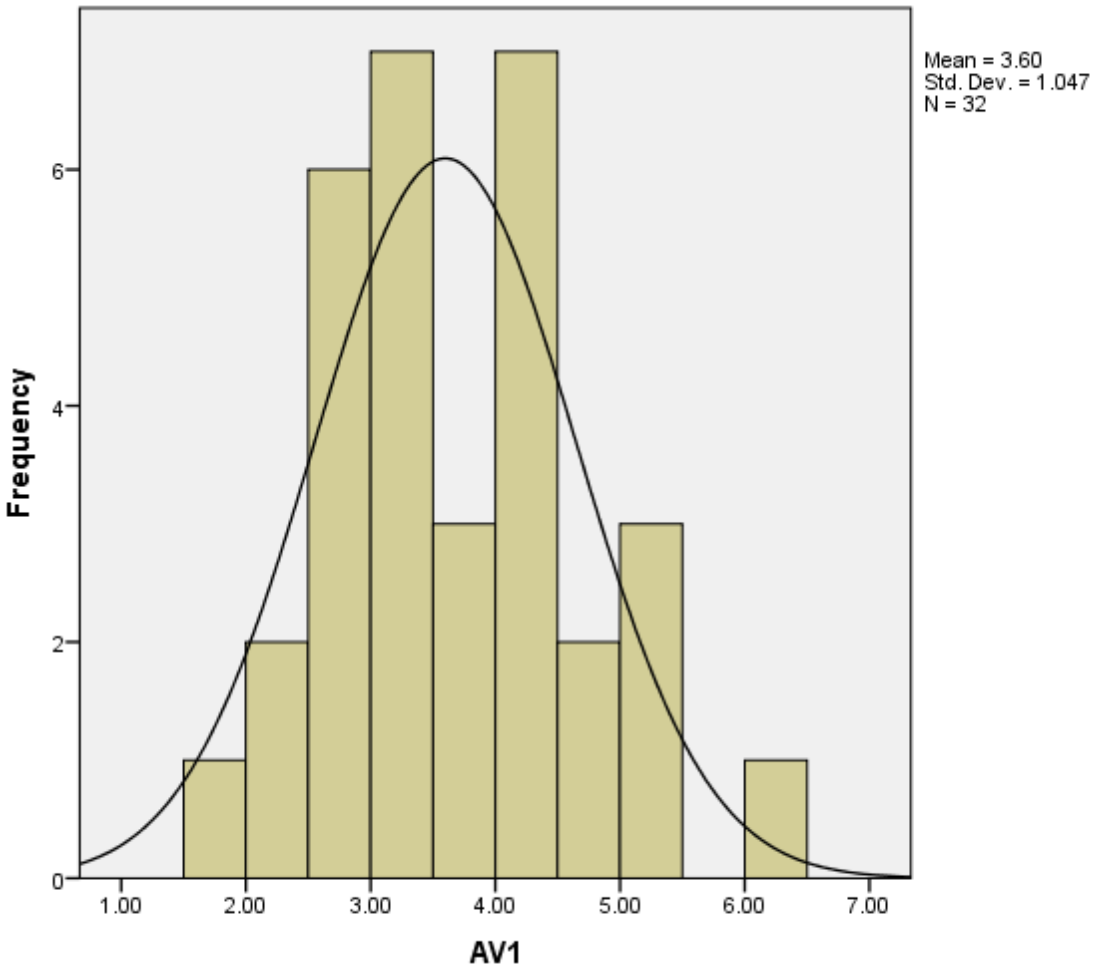
Address: ANONYMISED FOR CONFIDENTIALITY

Telephone: xxxxxxx

You could also go and see your doctor.

If you have questions about your rights as a participant in this research, or if you feel that you have been placed at risk, you may contact the Chair of the Ethics Committee, Psychology, University of Southampton, Southampton, SO17 1BJ. Phone: +44 (0)23 8059 3856, email fshs-rso@soton.ac.uk

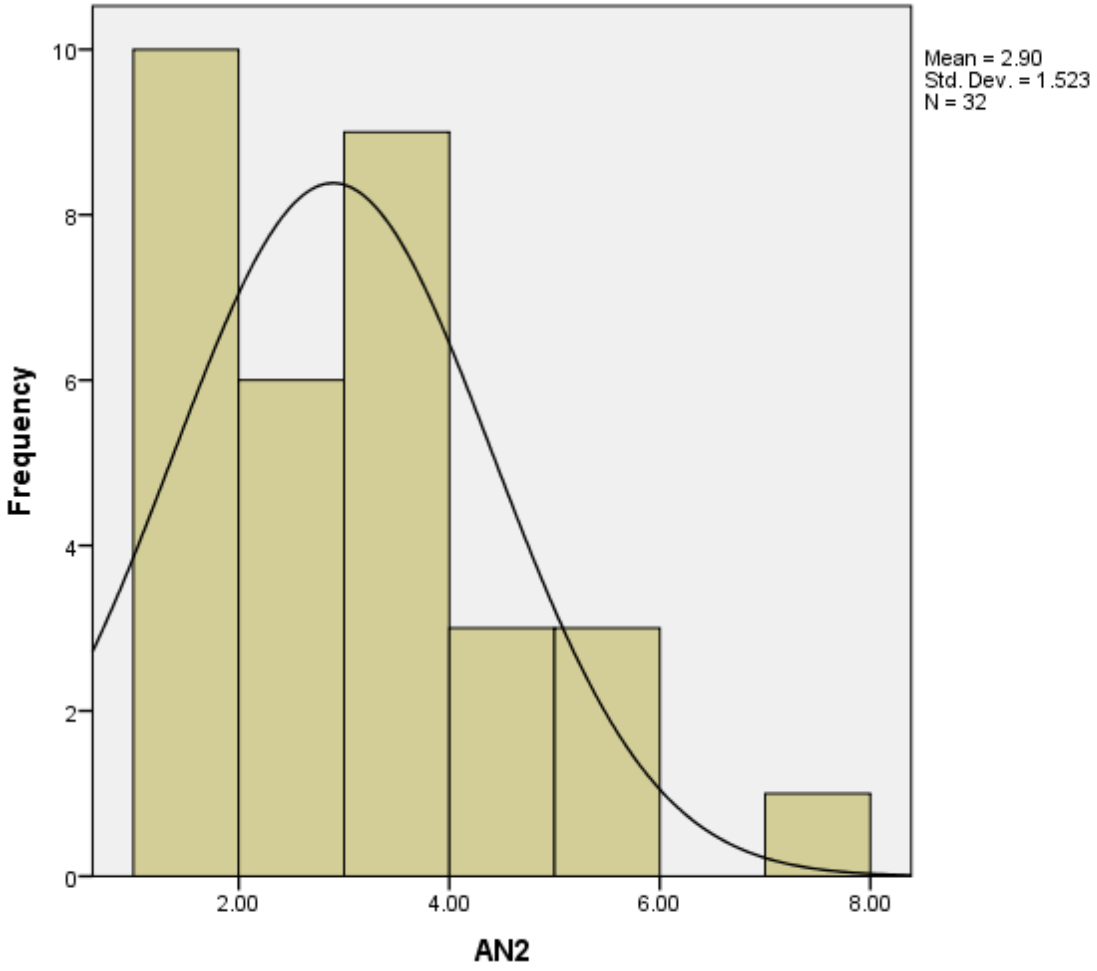
Appendix J Histograms demonstrating distribution of data



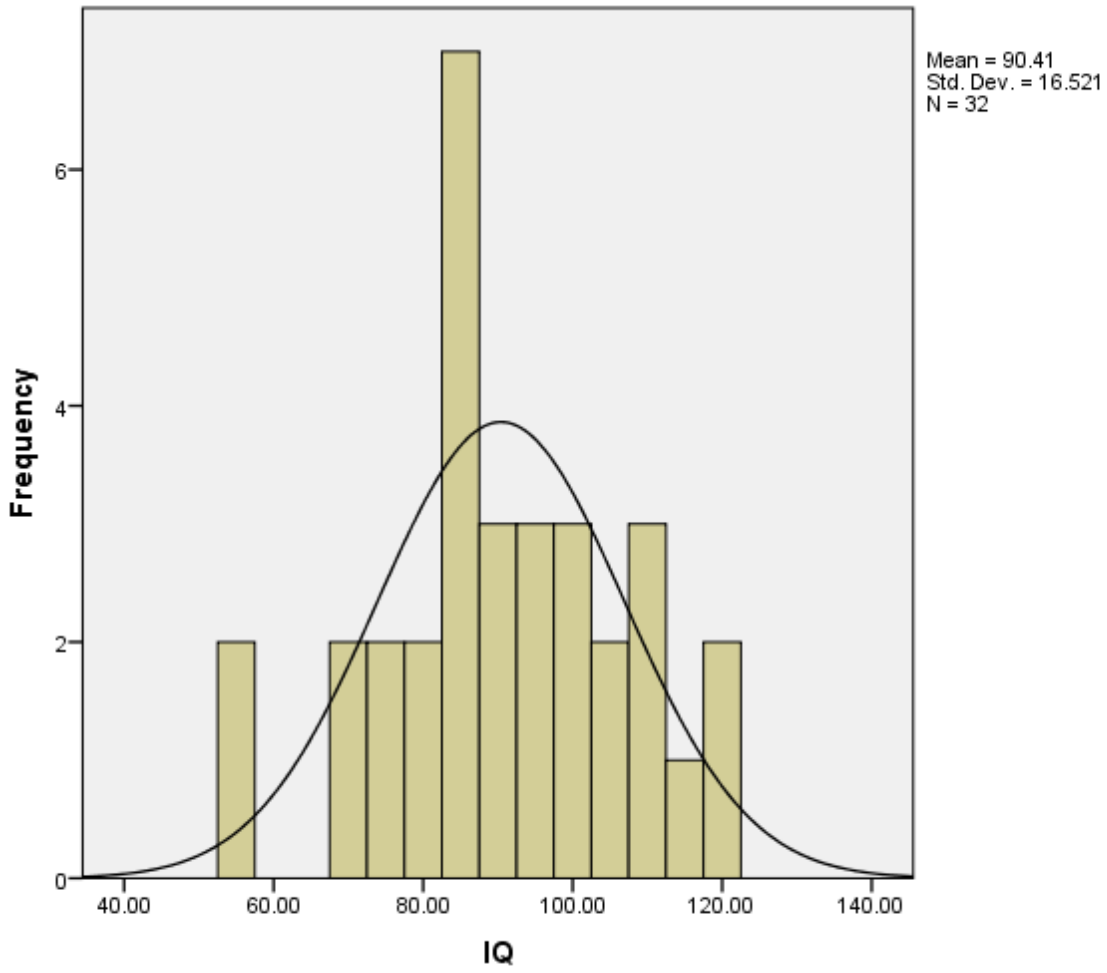
1) Histogram demonstrating the distribution of avoidant attachment scale scores

Appendix J

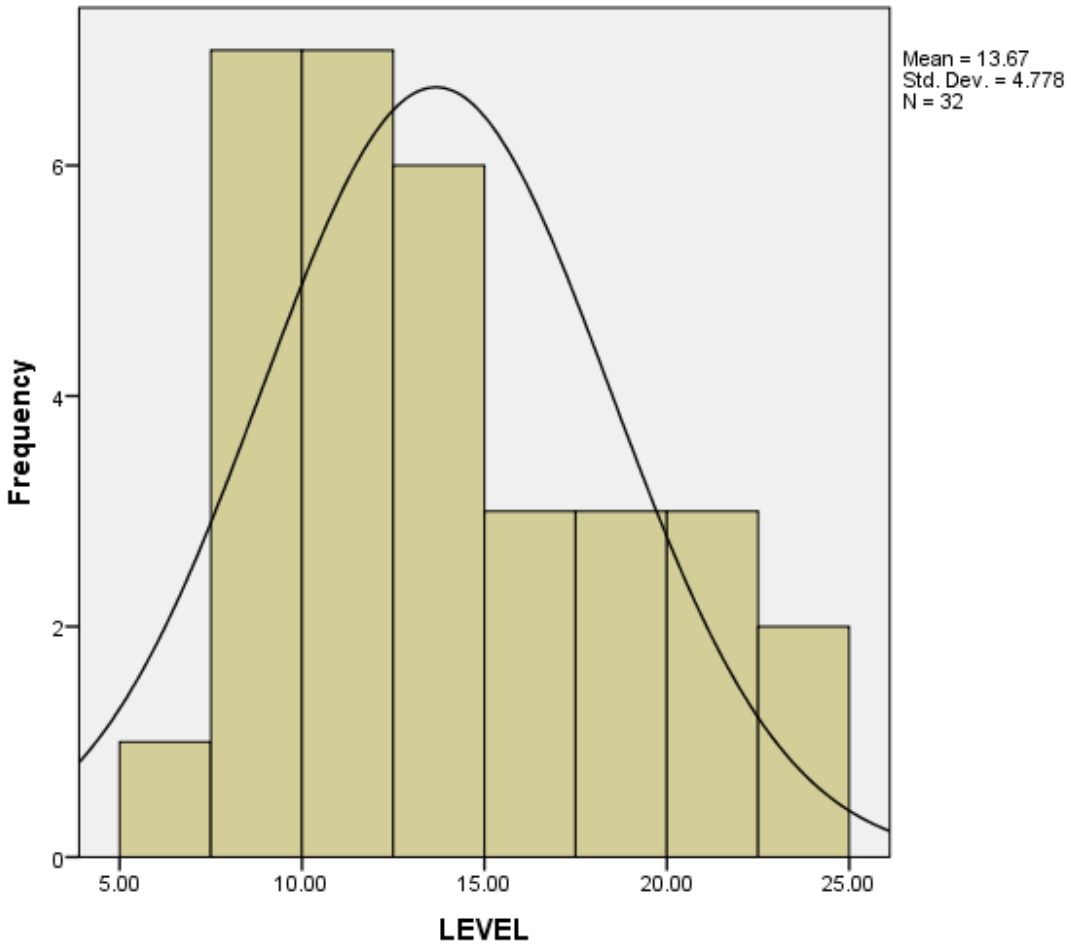
2) Histogram demonstrating the distribution of anxious attachment scores



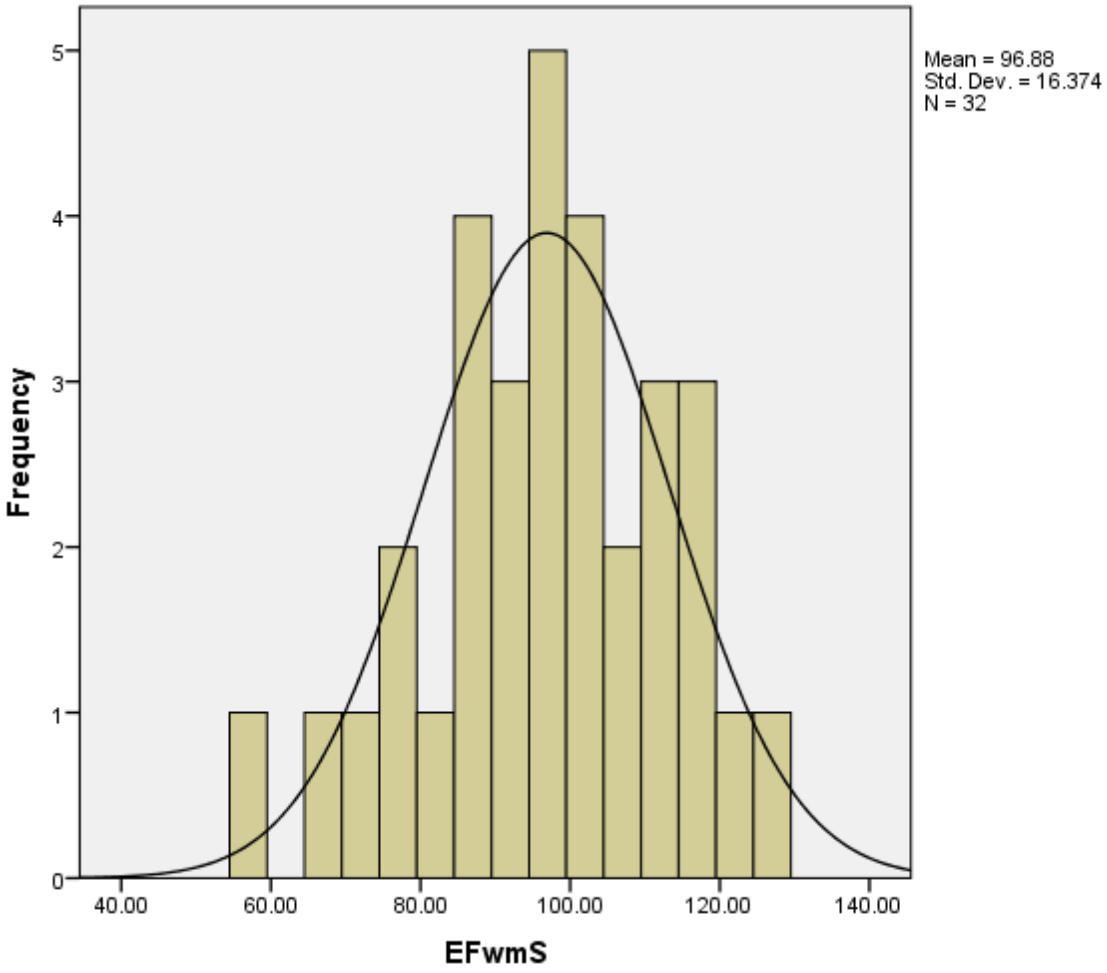
3) Histogram demonstrating the distribution of IQ scores



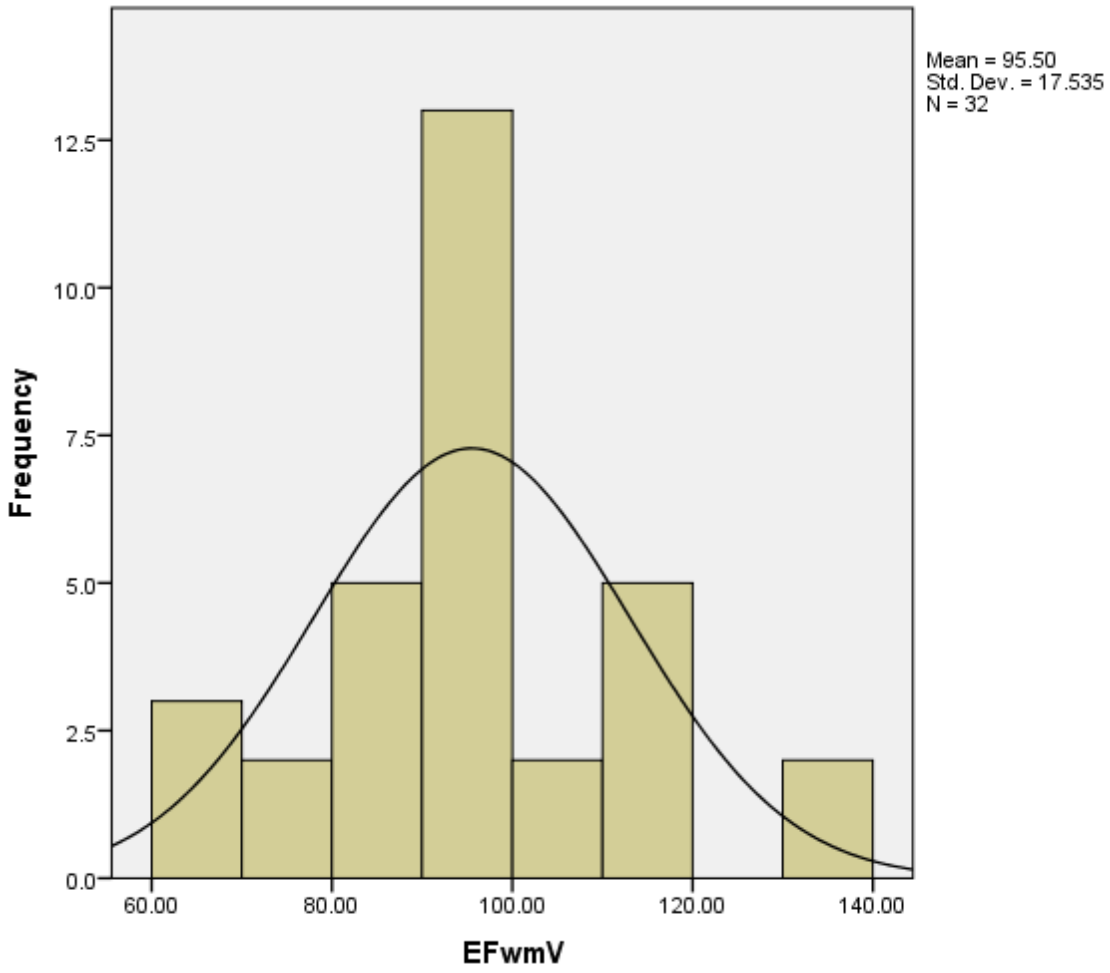
4) Histogram demonstrating the distribution of national curriculum scores



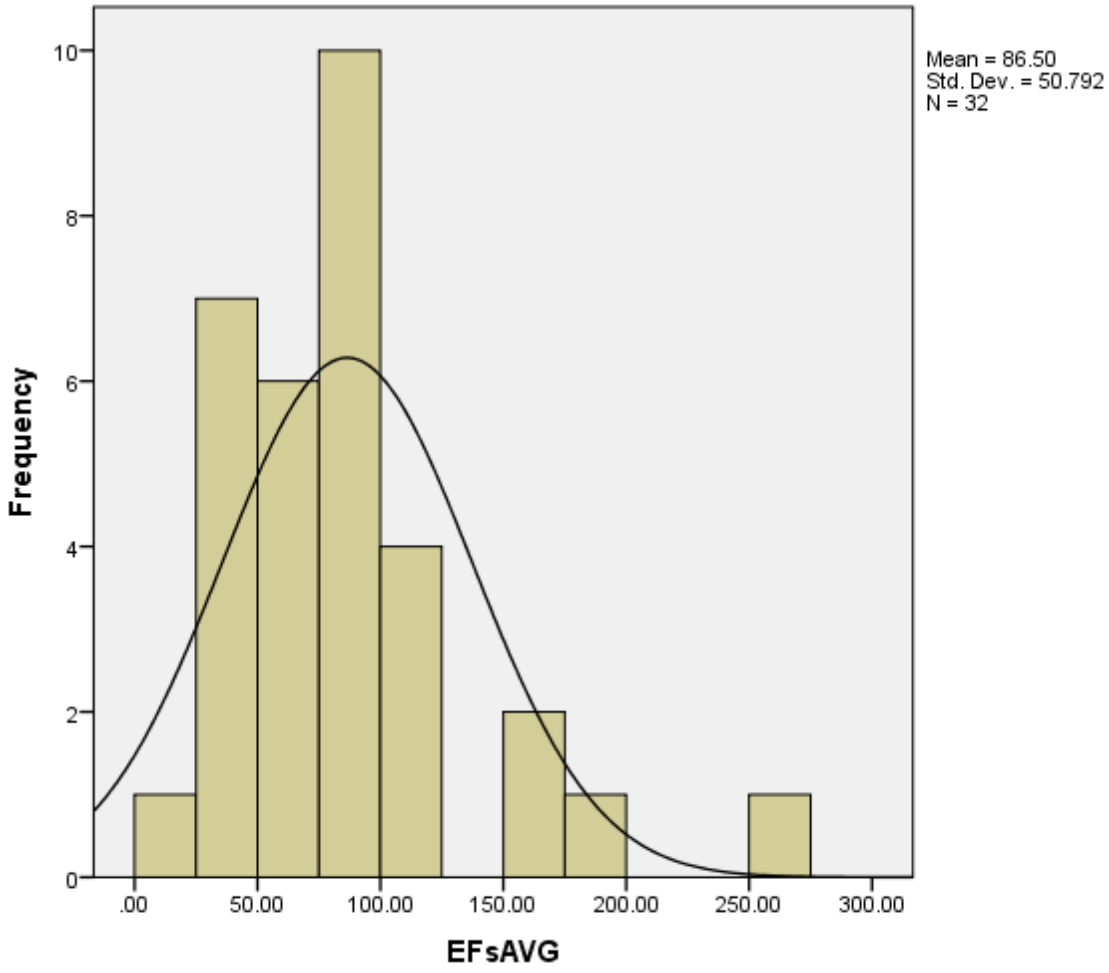
5) Histogram demonstrating the distribution of spatial working memory scores



6) Histogram demonstrating the distribution of verbal working memory scores

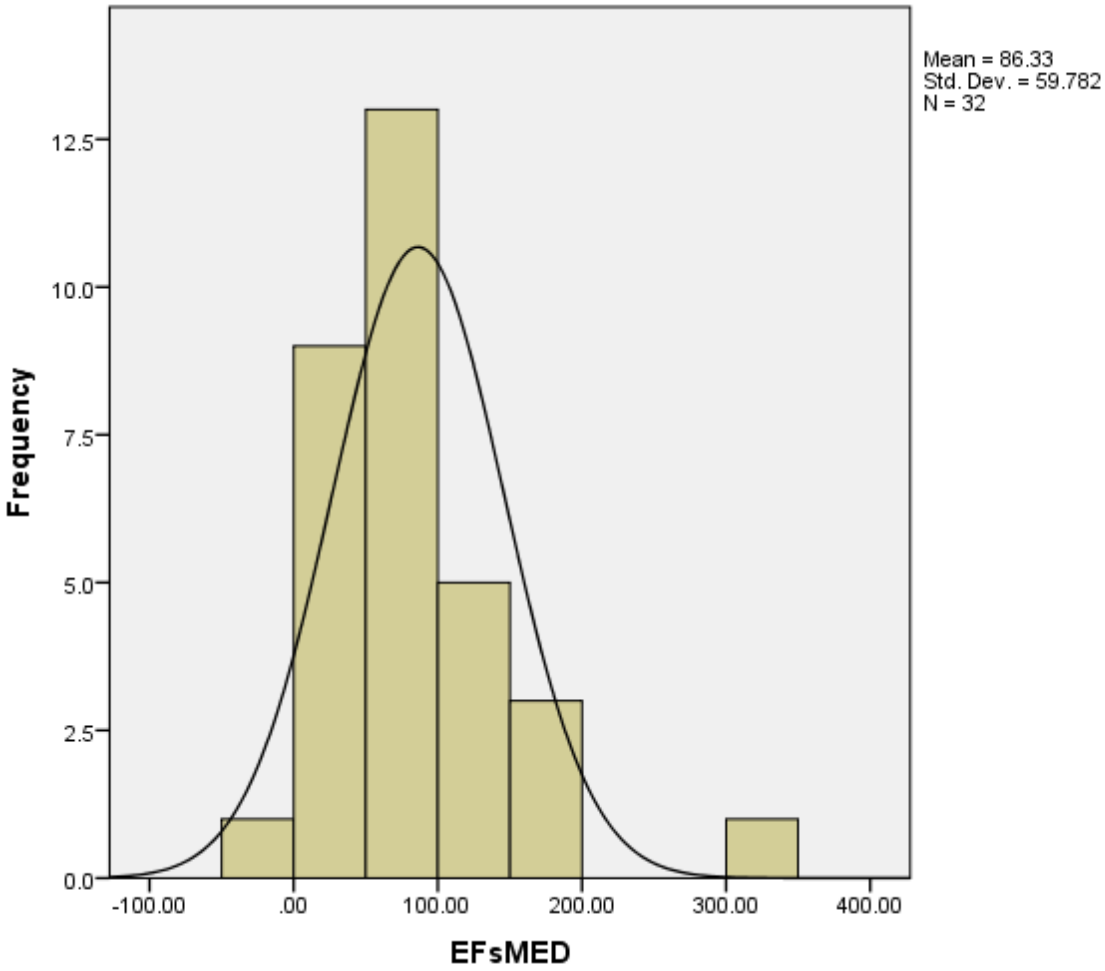


7) Histogram demonstrating the distribution of stroop scores (mean)

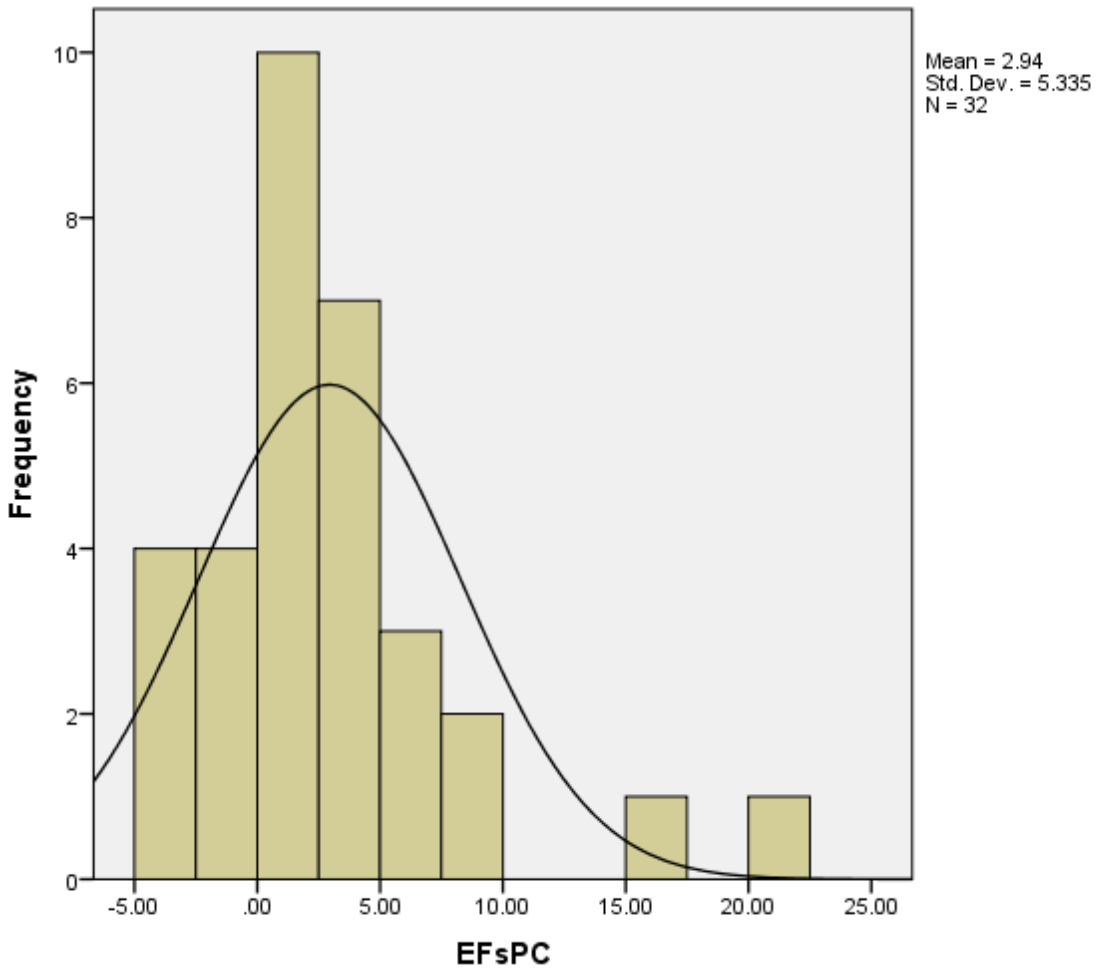


Appendix J

8) Histogram demonstrating the distribution of stroop scores (median)

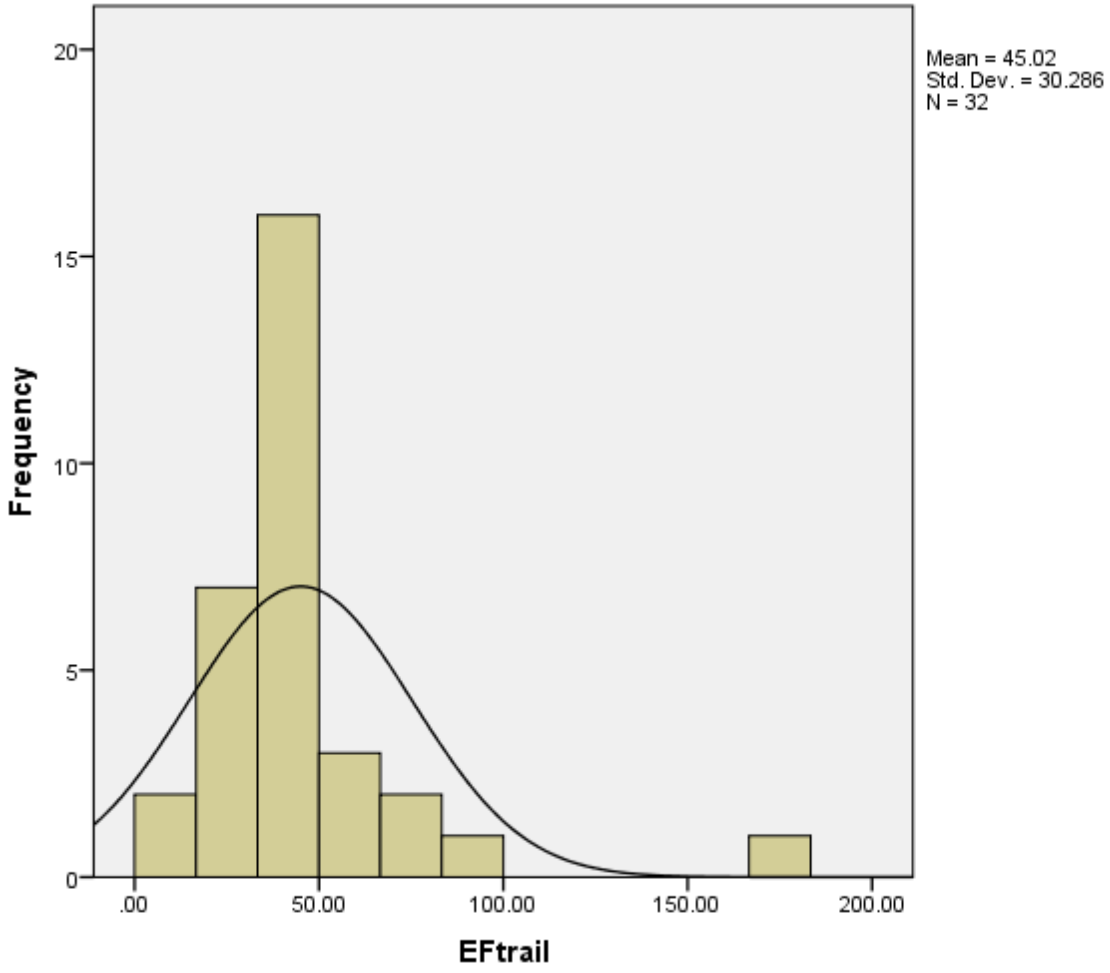


9) Histogram demonstrating the distribution of the percentage of errors made on the stroop task

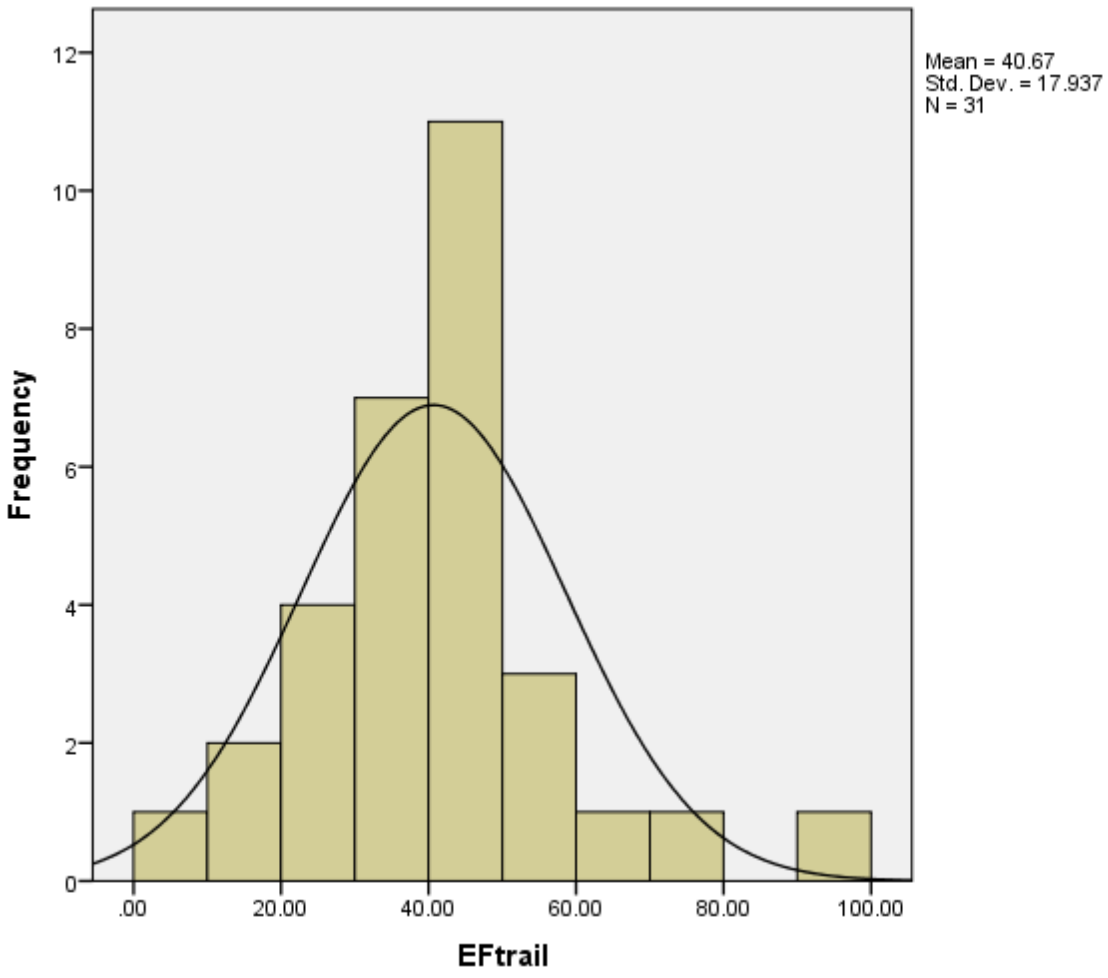


Appendix J

10) Histogram demonstrating the distributing of the trail making task scores



11) Histogram demonstrating the distribution of the trail making task scores following the removal of an outlier



Appendix J

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